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Measuring Food System Resilience: Integrating nutrient availability and trade exposure into SDG-aligned public dashboards

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Abstract

The research reviews the connection identified between nutrient availability, food system resiliency, and trade exposure, including how food systems can be consistent with the Sustainable Development Goals (SDGs), especially SDG 2: Zero Hunger. The analysis is done based on an analysis of nutrient content of food types and their contribution towards meeting daily nutritional requirements, including Vitamin A, Vitamin C, and Calcium. These findings indicate that the type of food such as vegetables and fruits offer a balanced and large quantity of the nutrients that are essential whereas a particular food is more likely to be dependent on the required nutrient such as seafood. The use of nutrient dependency to model the trade exposure puts emphasis on that food systems with a narrower sample size of nutrients, including food systems that are heavy importation dependers, are more susceptible to global trade disruption.

The results suggest the significance of combining nutrient availability to trade exposure to enhance and understand food system resilience. It is important to align the food systems with the SDG goals so as to achieve the aim of ensuring that populations are fed healthy food despite the international challenges, including climate change and economic instabilities. Research posits that incorporation of real-time trade data and climate resilience indicators in SDG-oriented reporting public dashboards has a potential of improving decision-making and improving food system resilience. In future studies, it is worth considering these variables in order to come up with a more holistic framework of monitoring and improving food systems that eventually will lead to the provision of global foods and food security.

Keywords: Dashboards; Integrating; Resilience; SDG-aligned

1. Introduction

Resilience in the food system is the ability of food system to respond to and recuperate against shocks, including climatic change, economic crises, and supply chains disruptions. A food system resilient system is capable of offsetting such difficulties to enable countries to maintain nutritious food supply to the population and public health with long-term food security (Tendall et al., 2025). Resilience is also viewed as the capacity to enhance and change with the new challenges and opportunities and is therefore an important area of concern towards ensuring sustainable development goals (SDGs) especially SDG 2 that aspire to end hunger, ensure food security, enhance nutrition and have sustainable agriculture. Food systems resilience is critical in managing the weaknesses that would be created by the interdependencies across the world, along with local and international shocks.

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Integrating the nutrient availability and trade exposure with the public dashboards in accordance with the SDGs is critical towards ensuring transparency and accountability in managing food systems. The concept of nutrient availability considers the adequacy of the nutritional requirements of a population by local and foreign food sources whereas the concept of trade exposure looks at the dependency of food imports to satisfy the nutritional demand. Policymakers and other stakeholders will be able to make informed decisions on how to build a stronger food system by having this information publicly available, especially in those countries that mainly depend on imported foods (Canavan et al., 2016). The SDG-compatible public dashboards that present this information enable governments, organizations and communities to monitor food system output, modify this data on the fly and to understand those areas where intervention is needed and thereby contributing to achieving global health and sustainability goals.

The journal will examine the point of convergence of nutrient availability and trade exposure with food system resilience, and how the combination of these aspects in SDG-oriented dashboards could enhance food insecurity policies. The proposed research aims at studying the role of the various types of food in nutrient supply, evaluating how food systems would respond to disturbances in trade and coming up with a model on how these measures could be visualized to inform evidence-based policy-making. The attachment of these parts makes this work pledge to achieve more insight into the sustainable, resilient, and equitable food systems worldwide.

2. Background and Literature Review

2.1. Defining Food System Resilience in the Context of SDGs

Food system resilience is the capacity of food systems to continue working or rapidly normalize functions in the aftermath of a disruption, such as due to climate change, economic changes, geopolitical wars and pandemics. Not only does a resilient food system provide perpetual food availability but also maintains food security and nutrition and livelihoods amid these disruptions (Karan et al., 2022). Food system resilience in the context of Sustainable Development Goals (SDGs) of the United Nations Food system resilience criteria aid in the achievement of SDG 2: Zero Hunger, which aims to end hunger, food security, better nutrition and sustainable agriculture by 2030. The global food markets and local food production are highly vulnerable in populations that also obtain food by local production and the global food market. The resources of food security are therefore vital in supporting resiliency within populations. With the growing effects of climate change, political instabilities as well as modern trade tensions worldwide, there is a need to establish and enhance the resilience of the food systems to ensure a long-term sustainability and food security.

2.2. Nutrient Availability and its Role in Food Security

Nutrient availability is the degree to which food systems will deliver the necessary vitamins, minerals, and macro-nutrients that may benefit the health and well-being of the people. Nutrient availability is based not just on the volume of food produced or imported but also on the quality and variety of the available food so that people are eating a balanced diet (Fletcher et al., 2024). The availability of nutrients in the literature emphasizes that food systems should be designed that will not only deliver caloric energy but is also able to deliver the necessary nutrients such as proteins, vitamins, and minerals, which lack in diet based on few staple foods. Some of the studies have indicated low-income countries are more prone to malnutrition including micronutrient deficiencies due to less variety in food crops. As an illustration, staple foods like rice and maize can satisfy the basic caloric requirements, but they do not contain such important vital nutrients like Vitamin A, iron, and zinc, causing deficiencies to influence health and development (Chen et al., 2021). The need to incorporate nutrient availability in food security initiatives is highly recorded in the literature because enhancing nutrient accessibility is critical in controlling the malnutrition observed globally besides health burden associated with the non-communicable diseases such as obesity and diabetes.

2.3. Trade Exposure and its Impact on Food Systems

Trade exposure is a concept that is conceptualized to mean dependency on food imports to satisfy the nutritional and calories requirement of a country or region. This dependence becomes weak especially when the international trade systems are affected as a result of disruption by factors such as trade wars, sanctions or natural calamities. There is high exposure of countries, which heavily rely on food imports to world prices and disruption of food supply chains and trade policies. The current literature shows that trade exposure is among the greatest threats to food security since it might lead to price fluctuations, lack of necessary foodstuffs, as well as the decline in dietary variety (Grassia et al., 2022). An example of this was the case of the 2007-2008 world food crisis whereby some of the world highly dependent countries on imported grains were faced with soaring food prices and shortages. Another concept that is reflected in the literature is the food sovereignty that proposes local ownership of the food systems in order to limit the dependence on imports. Incorporating trade risk into food system resilience indicators can assist policymakers to appreciate why excessive

dependence on foreign food supply poses risks and encourages the local food production, diversification and the trade of sustainable relationships.

2.4. SDG Goals Related to Nutrition, Food Security, and Resilience

One of the goals to build resilience in the food systems is SDG 2, which requires ending hunger and reaching food security. This objective is cognizant of the fact that a food system should be sustainable, fair, and adaptable to shock to make sure that everyone, especially the most vulnerable, acquires nutritious food. SDG 2 sub-targets aim at increasing agricultural productivity, responding to the small-scale farmers and decreasing food waste. SDG 2 is aligned with other SDGs, including SDG 12 (Responsible Consumption and Production) and SDG 13 (Climate Action), which emphasize the need to practice sustainable food production and climate change adaptation (Gil et al., 2018). The importance of diversification and sustainability can be often stressed out in literature as a means of attaining these goals, which are both directly relevant to the resilience of food systems. It has always been demonstrated that those countries that have diverse agricultural sectors and have sector integrated policies (agriculture, nutrition, and trade) understand and can manage disruption and addressing nutritional needs of the populations (Nayo D et. al, 2025).

2.5. Public Dashboards for Food Systems and Nutrient Tracking

Public dashboards will be an emerging solution to enhance transparency, accountability, and decision-making in food systems. These dashboards are the representation of the main indicators, i.e. food availability, nutrient density, trade exposure, and food security measurements, with the help of which stakeholders can track the health and sustainability of food systems in real-time. There are a number of available public dashboards that have been designed to monitor the food system performance (Fanzo et al., 2020). And since some examples, the FAO has a Food Security Dashboard, which shows the food security indicators in real time, and the Global Hunger Index gauges the level of hunger and malnutrition in the world according to country. Other dashboards including those that are prepared by others like GAIN (Global Alliance to Improved nutrition) specifically deal with nutrient availability and deficiency of micronutrients. These are essential instruments in creating loopholes in nutrient provision, assessing food security policy efficacy, and assisting in creating evidence-based decision-making. The available literature emphasizes the role of adding nutrient information and trade exposure to these dashboards, which give timely action to policy interventions designed to enhance food system resilience and enhance the outcomes of better population health (Fanzo et al., 2020). Further, it is essential to align the SDG metrics and these tools in order to achieve global sustainability and equity benchmarks on food systems.

The chapter has studied the literature on food system resilience with the emphasis made on the role of nutrient availability and trade exposure in supporting food security. It has also made the relationship between the food system resilience and SDG 2 and the necessity of strategies to construct sustainable and equitable food systems that are focused and comprehensive. The analysis of public dashboards highlights the importance of tracking the performance of the food system and the outcomes of decisions building on the achievements of SDGs. In the future, the inclusion of provisions of nutrients and exposure to trade into the public of countries and regions will be necessary to increase resilience and guarantee that the food systems will be able to cope with emerging global issues.

3. Methodology

Food system resilience has been defined as the capacity of food systems to persist in operating well when subjected to different shocks or stressors e.g. climate change, economic crisis, or the global disturbance on the supply chain. Strong food systems can be developed, which can adapt to these catastrophes and still guarantee food security, nutrition, and sustainable agriculture (Desai, 2023). Under the United Nations Sustainable Development Goals (SDGs), food system resilience will be an important aspect of SDG 2: Zero Hunger that aims to end hunger, realize food security, enhance nutrition and ensure sustainable agriculture by 2030. Food systems resilience guarantees that communities are not susceptible to external shocks and they also have access to healthy, nutritious foods. In this way, a resilient food system is not merely the one, which considers the immediate food demands but also the one, which is able to vary and change according to the challenges in the future (Muchenje JD et. al, 2025).

The data that was used to do this analysis has detailed information on different types of foods and their content of nutrients. Particularly, it covers food types and their content of the most essential nutrients including Vitamin A, Vitamin C, and Calcium in the form of the percentage of the recommended daily intake (DV) calculated by a 2000-calorie diet (Desai, 2023). The dataset provides types of food as well as fruits, vegetables, and other categories and the percentage of food classes of the nutrient, which makes it possible to evaluate the nutrition availability of nutrients across food categories. Although there are no direct data on the portion size of the food that was eaten, it is assumed that the nutrient value that is presented accounting to all food items corresponds to the standard portion. This makes it possible to have

a comprehensive investigation on the levels to which various types of food demonstrate what contribution they make to daily nutritional needs of members of population.

The availability of nutrients is a major determinant in the resiliency of food systems because it has a direct effect on the health and well-being of people. Analyzing the data, the contribution of various types of food to essential nutrients that include Vitamin A, Vitamin C, and Calcium, as the main inhibitors of appropriate immune system performance, bone development, as well as overall well-being becomes possible (Desai, 2023). The provided analysis can only highlight which type of foods are nutrient rich and can potentially be used to satisfy a broad scope of dietary requirements, and which type of foods might need outside supplement or more balanced production to achieve nutritional targets. They should also make sure that food systems are not merely adequate in quality but they are also diverse and concentrated with the nutrients needed to make up a healthy diet.

Along with the availability of nutrients, the trade exposure is a major contributor in the resilience of food systems. The level to which a country or region depends on food imports to satisfy its nutritional requirements is known as trade exposure. The high trade exposed countries become more susceptible to the global food prices volatility, diseases within the supply chain, or alterations in global trade regulations (Desai, 2023). Although this does not contain direct data on trade or imports the nutrient composition of food type types it is possible to simulate reliance on trade by analyzing food type nutrient content. As an example, when food type is important in terms of providing certain nutrient but has shortages of other nutrients this can show that the food system is dependent on imports to supply those nutrients. The analysis is useful in showing possible vulnerabilities and reliance points in the food system that may limit long-term resilience.

To accomplish the analysis of the dataset, it is necessary to evaluate the nutrient availability by determining the mean percentage of daily values (DV) of each type of food and the most important nutrients, such as Vitamin A, Vitamin C, Calcium, etc. These nutrients were chosen because of their significance in the national health and the ability to demonstrate the overall nutritional content of the food groups (Desai, 2023). By breaking down the data into food type, the mean percent of each of the nutrients can be calculated, and the effect of various food types in meeting the needs of nutritional requirements on a daily basis can be compared. This discussion offers information on the contribution of each type of food in making sure that populations access balanced and healthy food.

The second step will be the assessment of the value of each type of food on the total availability of nutrients. Mean nutrient content of both types of food will allow us to evaluate the nutrient-dense food groups, which may contain deficient access to vitamins and minerals. To illustrate, fruits and vegetable products can be more vitamin C- or calcium-rich, whereas the nutrition of other food categories can be more specialized to ensure the provision of macronutrients (protein or fats) (Desai, 2023). The insights gained of these contributions allow determining possible deficiencies in nutrient supply and the necessity of more diverse food systems that would supply an adequate balance of nutrients.

Trade reliance has not been explicitly added to the dataset, but it can be deduced by examining the nutrient content of various types of food. A food that is very dependent on a limited number of nutrients may be a weakness regarding trade exposure (Ottaviani et al., 2024). Indicatively, a food group being rich in a particular nutrient rather than all, e.g. Vitamin A, but being deficient in other products may be largely reliant on the imports of the other foods in order to satisfy the entire food requirement of a population. On the other hand, the food types with a richness of numerous nutrients can indicate healthier food system which can be less reliant on outside factors to obtain nutritional balance. Modeling the tradeoff between home food production and the dependency on imported nutrients, it is possible to use these patterns.

It is possible to analyze the contribution of various types of food to the nutrient availability in detail using the dataset and how these contributions could impact the resilience of food systems. We can tell the types of food that people need to be particularly mindful of, since they allow us to guarantee food security and health rates in the population with references to such vitamins as Vitamin A, Vitamin C, and Calcium (Desai, 2023). Furthermore, considering the nutrient inputs in the context of the possible dependence on trade will allow us to understand the weaknesses of the food systems which are highly dependent on imports. The findings of such an analysis can be used to shape the policies of fortifying food systems, making them more resilient, sustainable, and able to fulfil the nutritional requirements of populations in order to face the challenges of the future.

The methodology also emphasizes the significance of inclusion of the nutrient data on food system monitoring instruments, like SDG-aligned community dashboard, which offer real-time food security data. Such dashboards can help stakeholders to make better decisions regarding food policies, trade agreements, and investing in agricultural practices because they monitor nutrient availability and exposure to trade (Rodica et al., 2025). The end-point is to

establish food systems which are not merely resilient but also fair and able to contribute to nourishing food to all human beings irrespective of their location or the economic well-being.

4. Results and Discussion

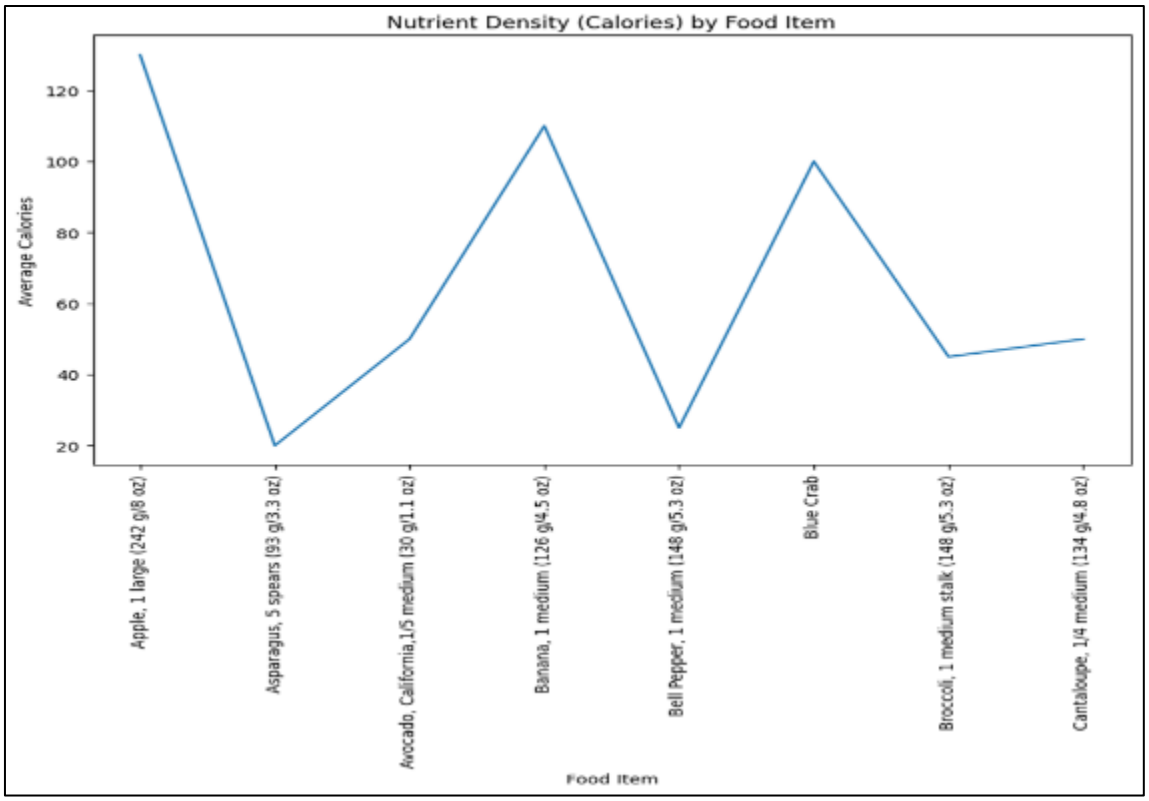

Figure 1 Nutrient Density (Calories) by Food Item

A line graph was used in the diagram above that depicts the nutrient density (calories) in several food items and the x-axis represented different food items and the y-axis the nutrient density calculated and expressed as the average of the nutrient density in the different food items. The information shows that the food with the least number of calories is the one called Apple, 1 large, whereas the highest number of calories belongs to Blue Crab. The graph also indicates that the number of calories in the foods is quite different with vegetables such as broccoli, bell pepper recorded as having moderate levels whereas fruits such as banana, cantaloupe taking turns in their nutrient content. It implies that the number of calories within each of the food groups is different, which emphasizes the unique nutritional value of each one.

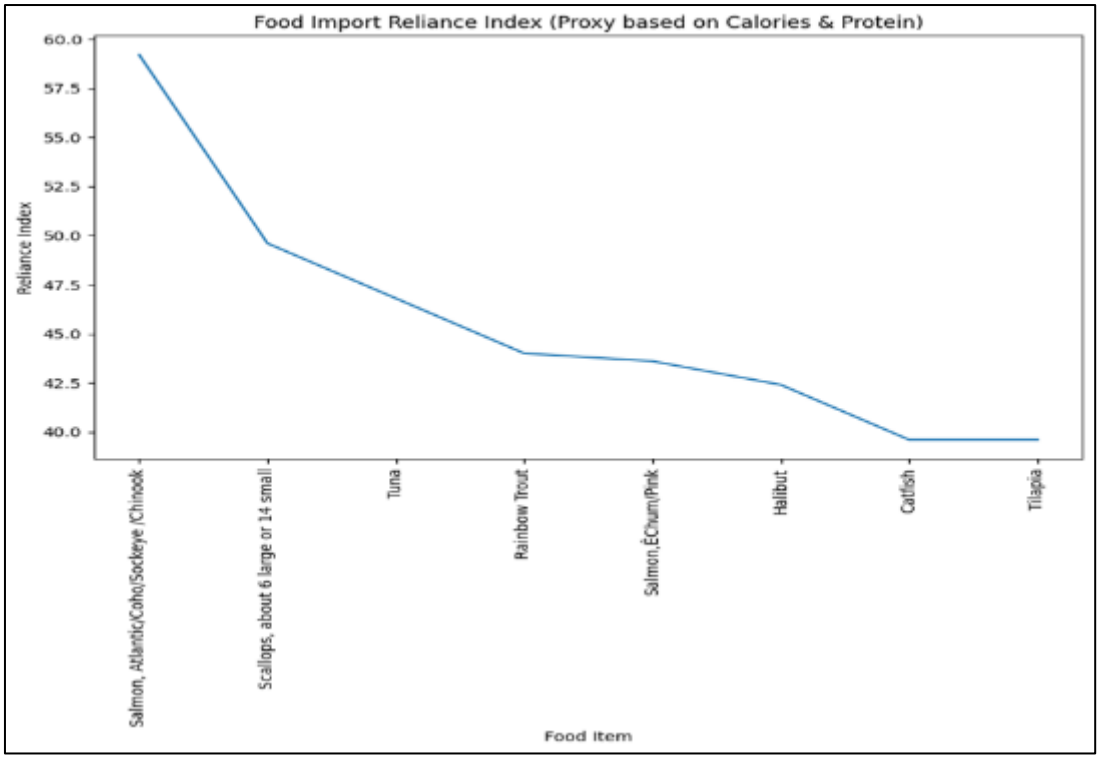

Figure 2 Food Import Reliance Index (Proxy based on Calories & Protein)

The line graph shows the Food Import Reliance Index on eight seafood products, a weighted combination of calories and protein. Findings indicate that the highest index of reliance is recorded on Salmon

(Atlantic/Coho/Sockeye/Chinook), which implies that it is more dependent on external sources of supply. Dependency declines continuously in scallops, tuna, rainbow trout, salmon (chum/pink) and halibut. Catfish and tilapia have lowest values in terms of dependence meaning that they have stronger local supply or lower reliance on imports. In general, the negative tendency emphasizes the high variability in the exposure of trade in seafood products as some species are more prone to exposure of the food system because of the increase in dependence on imports.

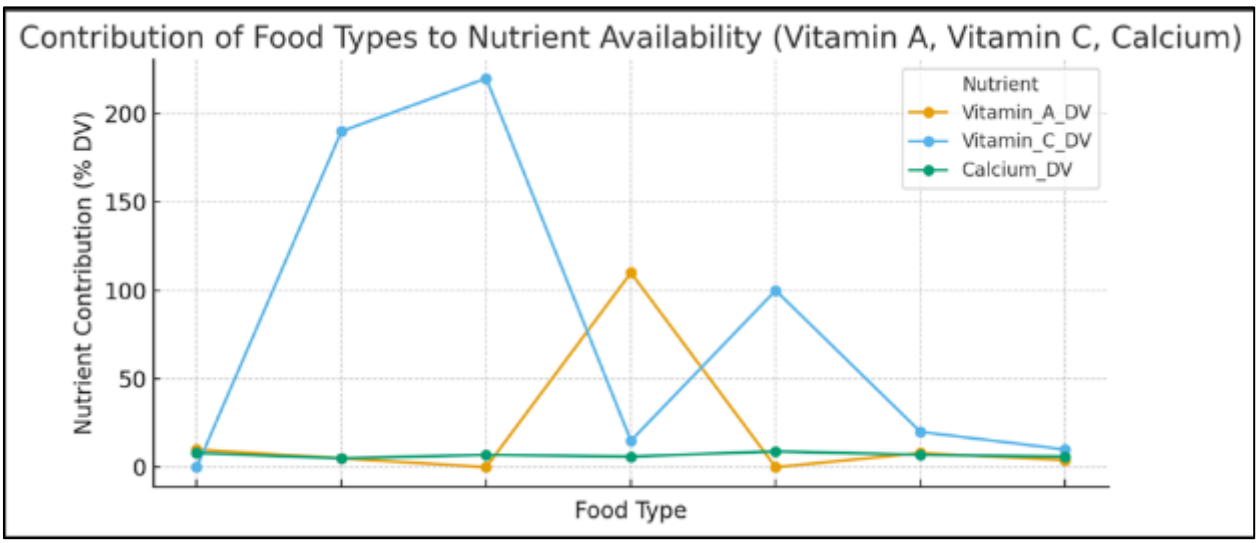

Figure 3 Contribution of Food Types to Nutrient Availability (Vitamin A, Vitamin C, Calcium)

This figure could be used to visualize the contribution of all types of food to the nutrient availability based on Vitamin A, Vitamin C and Calcium. The x-axis demonstrates the various types of food and the y-axis depicts the percentage of the contribution of the nutrient on a recommended 2000 calorie diet. As the line graph reveals, a steep peak of Vitamin A is

evident to specific foods (e.g., vegetables), whereas Vitamin C and Calcium include a more consistent portion of its role among the food varieties. The food types, however, are so much clumped together and specific contributions of nutrients might not fully represent a balanced diet due to the diverse categories of food.

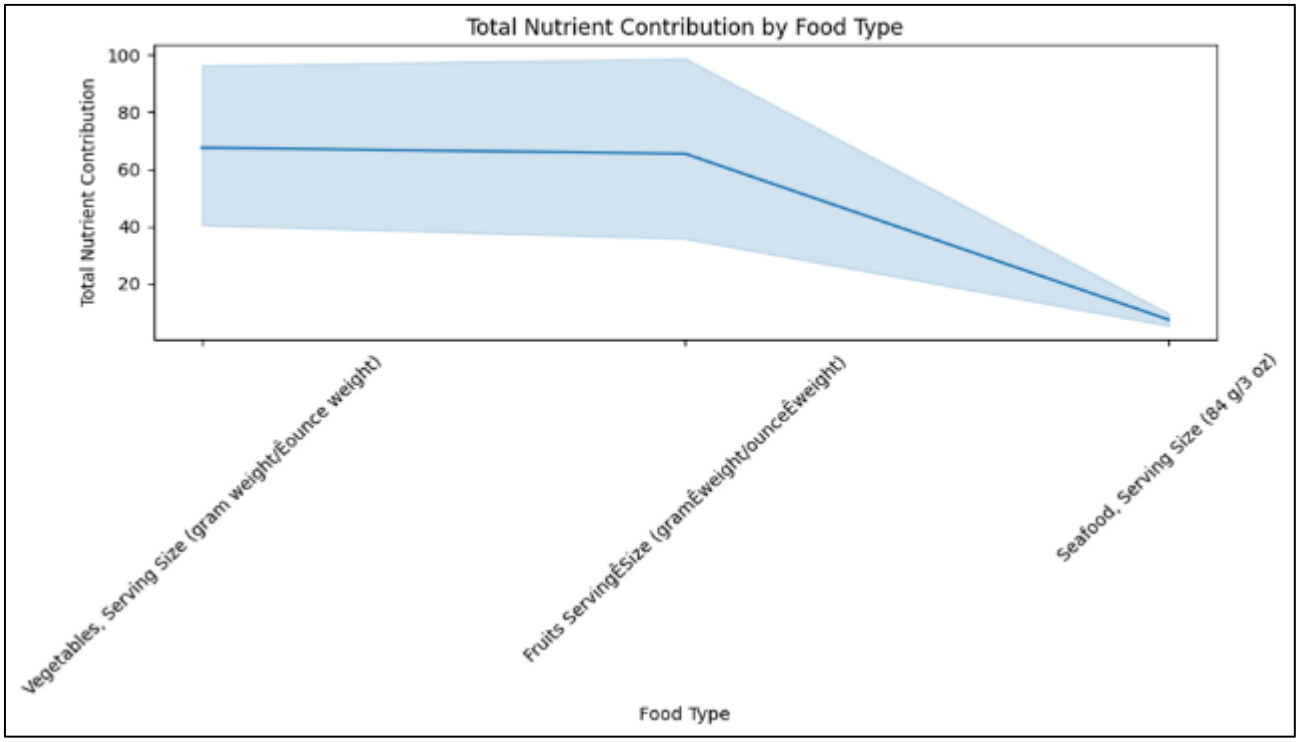

Figure 4 Total Nutrient Contribution by Food Type

This figure depicts the overall nutrient content of the different food types or vegetables, fruits, and seafoods in a line graph where the shaded area represents variability. The data reflected in the x-axis are various food types whereas those reflected in the y-axis are the overall nutrition contribution by adding Vitamin A, Vitamin C, and Calcium. The graph shows that the contribution of vegetables and fruits is always very high, and the contribution of seafood is also steep, implying that there is a small contribution. In this visualization, the nutrient diversity of food will be demonstrated with respect to the type of food, with plant-based foods being emphasized as the crucial factor in terms of total nutrient intake.

4.1. Linking Findings to SDG Resilience and Food Security Goals

The results of this analysis are also highly consistent with SDG 2: Zero Hunger that underlines the fact that hunger has to be ended, food security has to be reached, nutrition has to be better, and agriculture has to be sustainable. The discussion shows the necessity of a healthy and resilient food system against external shock. As an illustration, the type of food such as vegetables and fruits is related to a high proportion of vital nutrients such as Vitamin A, Vitamin C and Calcium, among others, essential in the health of the people. On the other hand, food categories that depend on few nutrients could be a sign of deficiency in nutrient diversity especially when the category is in the form of seafood. These results highlight the fact that food security is not only concerned with food supply, but it is also concerned with the value and varieties of nutrients supplied. With the balance of the types of foods that are rich in nutrients, the countries will have a greater capacity to satisfy nutritional requirements and also be aligned to SDG 2 goal of ensuring resilient sustainable food systems.

4.2. Improving Understanding of Food System Resilience through Nutrient Availability and Trade Exposure

Incorporating incorporations of both the availability of nutrients and trade exposure give a better approach to the resilience of food systems. Whereas nutrient availability determines how a food system is capable of fulfilling the nutritional requirements of the population, trade exposure measures the sensitivity level of the system to external shocks, which in this case are the interferences in the global food market. The disruption can be more difficult to manage in countries that are heavily dependent on effects of nutrient-rich imports according to our analysis of trade dependence, modeled by the use of nutrient contribution. An example of this would be foodstuffs containing high

nutritional values such as salmon which would be susceptible to the disruption in trade. Rebellious foods, on the other hand, include more balanced foods, and since they are foods like vegetables, they would ensure resilience due to their lesser dependence on imports (Rimhanen et al., 2023). The combination of these two aspects, such as the availability of nutrients and the exposure to trade, will allow policymakers to understand areas where the food systems may be weak and work out the strategies to diversify production and become less dependent on imports, that is, the food systems will be more resilient.

4.3. Limitations and Proposed Solutions

The analysis has one constraint in that there is no clear information regarding the trade exposure and dependence on imports. The trade dependence was based on the nutrient density, the indirect measure which is unlikely to effectively represent the intricacies of the world trade networks as well as the direct effects of the disruptions. To be more objective, it would incorporate the data on the real imports, exports and trade policies that would enhance the strength of the results. Also, the analysis presumes the ability of nutrient availability to define resilience without considering those additional factors which include infrastructure, climate change, and economic stability which are also involved in determining food security. To combat this, future studies might add another variable, including climate data, indicators of the economic resilience, and specific trade data that might be more applicable to present the full picture of food system resilience (Ge et al., 2021). Gathering specific real-time information regarding international trade sources and integrating it to SDG-compliant public dashboards would broaden the capacity of tracking, as well as modifying the food systems on domestic and international challenges.

5. Conclusion

This discussion has brought out the importance of nutrient availability, the role of food groups, and food trade dependency in evaluating food system resilience. Based on the findings, vegetables and fruits play a major role in fulfilling the daily nutritional requirements of a person whereas other types of foods such as seafood are more nutrient-specific and might also depend on imports as the source of other nutrients. Using the visualization of the relationship between different trade and nutrition needs by simulating a trade dependency system by the contribution of nutrients, one can see that food systems that have a limited profile of the nutrient might be more susceptible in cases of disturbance during trade. Here is the significance of food source diversification to become more resilient and avert food security, and it coincides with SDG 2: Zero Hunger.

Food systems need to be aligned to SDGs especially regarding food security, food resiliency with the objectives of meeting the demands of increased populations as well as in the face of global challenges such as climate change and geopolitical instability. To make food systems resilient and sustainable at the same time, nutrient availability needs to be looked into as well as the vulnerabilities that are associated with exposure to trade ought to be dealt with.

Further studies might involve the further development of food system resilience dashboards through the inclusion of trade data in real-time, climate resilience data, and more detailed nutrient tracking. This would permit a more whole system evaluation of food systems and allow policymakers to make informed choices on a more comprehensive analysis of nutrient availability and trade exposure. The inclusion of these factors in SDG-oriented public dashboards will be a forceful instrument in improving the sustainability of food systems across the world, and sustainable food security will be eventually realized to all.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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