Journal of Sustainable Development; Vol. 12, No. 6; 2019
ISSN 1913-9063 E-ISSN 1913-9071
Published by Canadian Center of Science and Education

The Hunger of Nations: An Empirical Study of Inter-relationships among the Sustainable Development Goals (SDGs)

Paul D. Larson[1,2] & Natalie M. Larson[1]

[1] University of Manitoba, Winnipeg, Manitoba, Canada

[2] Hanken School of Economics

Correspondence: Paul D. Larson, CN Professor of SCM, University of Manitoba, Winnipeg, Manitoba, R3T 5V4, Canada. Tel: 1-204-474-6054. E-mail: larson@cc.umanitoba.ca

Received: September 7, 2019 Accepted: October 11, 2019 Online Published: November 28, 2019

doi:10.5539/jsd.v12n6p39 URL: https://doi.org/10.5539/jsd.v12n6p39

Abstract

The United Nations (UN) Food and Agriculture Organization (FAO) estimates that more than 820 million people suffer from chronic undernourishment, and it identifies poverty as the principal cause of hunger. According to the World Bank, 767 million people live on less than $1.90 per day, i.e. below the international poverty line. Other causes of hunger include conflict, political instability, food and agricultural policies and climate change. To these causes, this paper adds gender inequality. The study uses regression analysis of secondary data to test the impact of gender inequality, income and environmental performance on the hunger of nations. Statistical results confirm interrelationships among several of the UN Sustainable Development Goals (SDGs). Policy implications include a call to identify and address root causes of hunger and to adopt a long-term focus.

Keywords: hunger, gender inequality, climate change, sustainable development goals (SDGs)

1. Introduction

After some years of progress (i.e. decline), global hunger is on the rise (UN 2018). According to the FAO (2019), there are more than 820 million hungry people around the world today – and an estimated two billion people suffer from moderate to severe food insecurity. In response, amongst its Sustainable Development Goals (SDGs), the UN includes the ambitious SDG 2: Zero hunger – "end all forms of hunger and malnutrition by 2030."

Blesh et al. (2019) call for research "to identify interactions between SDG 2 and other SDGs," including SDG 1 (no poverty) and SDG 13 (climate action). Related to this call, Tayal (2019) observes that there is very little research into "the linkage between gender inequality and food insecurity." Inspired by the SDGs; this paper investigates the influence of national income, gender inequality and environmental performance on the hunger of nations, focusing on the developing countries.

The second section defines hunger, discusses its causes, and links these causes to the SDGs. This section includes development of several hypotheses. Next, the third section describes the variables and outlines statistical testing methods. Sections four and five present the statistical results and offer a summary discussion, respectively. The discussion focuses on implications for public policy and academic research.

2. Hunger

This section defines hunger and discusses causes of hunger.

2.1 What Is Hunger?

The FAO (2008) defines hunger as "an uncomfortable or painful sensation caused by insufficient food energy consumption." Hunger is "food deprivation." The FAO measure for hunger, *undernourishment*, is percent of a population whose dietary energy consumption is less than a pre-determined, country-specific threshold, in terms of kilocalories required to engage in sedentary or light activities.

Welthungerhilfe (2019) differentiates between three types of hunger: acute, chronic and hidden. Acute hunger (or famine) is undernourishment over a specified period. It is the most extreme form of hunger; and it often occurs in conjunction with droughts, wars and other natural and/or "man-made" disasters. Chronic hunger is long-term undernourishment. The body absorbs less food than it requires. While crises of acute hunger receive lots of news media attention, chronic hunger is far more widespread around the world. It is also linked to poverty.

Hidden hunger is a form of chronic hunger. Due to an unbalanced diet, critical nutrients (such as iron, iodine, zinc or vitamin A) are lacking. Consequences are not necessarily visible, at least initially, but over the long-term these nutrient deficiencies lead to serious diseases. Worldwide, two billion people suffer from chronic nutrient deficiency. Hidden hunger harms individuals – and it inhibits development of an affected region, as productivity and health of the people declines.

According to the National Research Council (2006, p. 48), *hunger* is an individual concept. It is a "potential consequence of food insecurity that, because of prolonged, involuntary lack of food, results in discomfort, illness, weakness, or pain that goes beyond the usual uneasy sensation." Beyond individuals, hunger can be aggregated to families, communities and nations.

Insufficient intake of nutrients needed by the human body leads to malnutrition. The most critical type of malnutrition is protein-energy malnutrition (PEM), a lack of calories and protein. The body converts food into energy; energy contained in food is measured by calories. Protein is needed to perform many bodily functions, such as development and maintenance of muscles. Since PEM can be lethal, it is usually the primary concern in discussions about world hunger (https://www.worldhunger.org).

For an individual, the hunger end-game is *starvation*, a prolonged, severe deficiency in the calories needed to maintain the body. To survive, the starving body attempts to moderate its metabolism and re-allocate energy distribution to its vital systems. Non-essential processes slow down as caloric expenditure is reduced. With a lack of nutrients, organs such as the heart, lungs, ovaries and testes weaken and shrink. Blood pressure falls as the heart rate slows and *heart volume* – the volume of fresh blood pumped per beat – declines. The immune system becomes impaired and kidney function is compromised. The person starts to feel cold, as the body's heat regulation needs are reduced. Less energy is deployed toward rebuilding muscles, and physical exhaustion ensues (Lieberson 2004).

A typical healthy man weighing 70 kilograms has sufficient fuel reserves (in the form of carbohydrates, fats and muscles) to starve and still meet his caloric needs for 1 to 3 months. During such periods of caloric deficiency, the body prioritizes its energy sources. It switches from readily available glucose, to stored carbohydrates, to fat derivatives and then to proteins. In the final stages of starvation, the body begins to eat itself through *catabolysis* – breakdown of fat and muscle tissue – to stay alive. At this point, the body is closing in on organ failure – and death (Berg et al. 2002).

2.2 What Are the Causes of Hunger?

This sub-section briefly discusses primary causes of hunger, leading to several hypotheses. The FAO (2017; 2018; 2019) and its partners have identified the following causes: poverty, war and conflict, political instability, food and agriculture policy, and climate change.

The connections between poverty and hunger are well known (Tyagi 2017; Young 2005). Poverty is the principal cause of hunger (WHES 2018). Poverty makes it much more difficult for people to buy food or to produce food for consumption. In a downward spiral, hunger is also a cause of poverty. By compromising health, energy levels and mental functioning, hunger fuels poverty as it reduces an individual's ability to learn and to earn money by working (Orner 2014; Scrimshaw 1994).

Hunger is also linked to conflict and political violence (Hammond 2018). Armed conflict interferes with food production, due to destruction of land and logistics infrastructure. It also often increases the cost of food, making it less affordable for hungry people. Political instability typically brings economic decline, reducing strength of a nation's currency, yielding higher food prices and lower availability. Job losses further compromise affordability of food (FAO 2017; 2018; 2019).

Lack of productive agriculture technology in developing countries contributes to substantial differences in food production volume compared to developed countries (Samberg 2018). Further, agricultural policies and practices designed to increase crop yields can have unintended consequences, e.g. land and soil degradation (Watts 2017), and depletion or pollution of available groundwater (Zalidis et al 2002). These outcomes can compromise future food production capacity, since resources may be non-renewable.

Climate change is another cause of food shortages, malnutrition and hunger (Wheeler and von Braun 2013; WHES 2018). Extreme weather, desertification and other land degradation, water scarcity and rising seas are compromising efforts to eliminate global hunger (UNCC 2018). According to the FAO (2018), "all dimensions of food security and nutrition" may be affected by climate variability and extreme events. Unstable weather patterns bring drought, hurricanes and flooding, harming livelihoods and raising local food prices. Climate change also contributes to political instability and mass migration.

Rosenzweig and Parry (1994) argue that developing countries will "bear the brunt" of the climate change impact on food supply. Climate change exerts a negative impact on agricultural productivity (FAO 2019). If climate change comes with a decline in agricultural production and supply of food, while demand for food grows along with population, food prices will increase. Rising food costs, coupled with poverty, bring increasing global hunger (Chutney 2019).

Gender inequality is an additional cause of hunger (FAO 2019). Robinson (2015) suggests that "no society can develop – economically, politically, or socially – when half of its population is marginalized." According to Hossain (2017), the roots of hunger are inequalities in terms of social, political and economic power – including "women's lack of power in the household and society."

Tayal (2019) suggests that gender equality is critical for achieving all other SDGs. Drawing on data about twenty Sub-Saharan nations, she finds gender inequality to be associated with food insecurity. Gender inequality is operationalized in terms of disparities in education, health and workforce participation. Gender inequality in earnings is also pervasive (UN 2018). These disparities impact food security and hunger. Countries with greater food security have lower poverty levels, higher GDP per capita and greater gender equality (FAO 2019).

This discussion on causes of hunger inspires the following hypotheses:

H1: Countries with lower levels of gender inequality suffer from less hunger.

H2: Countries with less environmental degradation suffer from less hunger.

H3: Countries with higher income suffer from less hunger.

2.3 The SDGs

The causes of hunger reveal critical interrelationships among several SDGs (UNDP 2019):

- Goal 1: *No poverty* – end poverty in all forms and dimensions by 2030. The UNDP links poverty to reduced access to nutritious food, clean drinking water and sanitation.
- Goal 2: *Zero hunger* – end all forms of hunger and malnutrition by 2030. Hunger and malnutrition are barriers to development in many nations.
- Goal 5: *Gender equality* – "end all discrimination against women and girls is not only a basic human right, it's crucial for sustainable future." The UNDP notes that 35 percent of women have experienced physical and/or sexual violence. Further, women earn an estimated 77 percent of what men earn for the same work.
- Goal 13: *Climate action* – to mobilize US $100 billion per year by 2020 to enable developing countries to better adapt to climate change and invest in low-carbon development. Average annual economic losses from climate-related disasters are estimated to be hundreds of billions of dollars.

While much has been written on the SDGs (Myklebust 2019), few published papers address empirical relationships among the SDGs. For each SDG, the UN specifies multiple targets and indicators. SDG 1 (no poverty) comes with seven targets and twelve indicators, such as the proportion of population living below the international poverty line (currently U.S. $1.90/day) and national poverty lines. SDG 2 (zero hunger) has eight targets and 14 indicators, e.g. undernourishment, food insecurity and malnutrition. Likewise, SDG 5 (gender equality) considers nine targets and 14 indicators of gender discrimination and inequality. Finally, SDG 13 (climate action) includes five targets and eight indicators (UN 2019).

Noting considerable consensus among scholars that the SDGs are interrelated, Ngankam (2019) studies synergies among several SDGs in South Africa. Not surprisingly, he reports evidence of synergy between SDG 7 (reducing energy consumption/increasing energy efficiency) and SDG 13 (reducing CO_2 emissions). Ngankam also reports synergy between indicators of SDG 8 (economic growth) and SDG 13. These synergies are more interesting, since economic growth implies more industrial activity.

Similarly, Nilsson, Griggs and Visbeck (2016, p. 320) make this observation: "Implicit in the SDG logic is that the goals depend on each other — but no one has specified exactly how." For instance, they note that education for girls (part of SDG 4) should improve maternal health (part of SDG 3), while contributing to poverty reduction (SDG 1), gender equality (SDG 5) and economic growth (an aspect of SDG 8). Nilsson et al. (2016) also describe features of SDG interactions, including strength of an interaction, uni- vs. bi-directionality of an interaction, and whether an interaction is positive (i.e. synergistic) or negative (i.e. antagonistic). For instance, the connection between poverty and hunger is widely thought to be strong, bi-directional and synergistic.

Pradhan et al. (2017, p. 1169) also argue the SDGs "are implicitly interdependent," while noting a lack of

"data-driven analysis of interactions between" SDG indicators. They conceptualize synergies as positive correlations and trade-offs as negative correlations between pairs of indicators within and between SDGs. Spearman's rho (ρ) > +0.6 is taken to imply synergies between two SDG indicators and $\rho < -0.6$ suggests there are trade-offs to be considered. Related to the current study, Pradhan et al. (2017) found a notable synergy between SDG 1 (no poverty) and SDG 5 (gender equality). While not among the top ten synergies identified, SDG 1 (no poverty) and SDG 2 (zero hunger), as well as SDG 5 (gender equality) and SDG 2 (zero hunger) had largely synergistic interactions. However, there were a mix of synergies and trade-offs between SDG 13 (climate action) and SDG 2 (zero hunger).

3. Methodology

The methodology involves regression analysis of secondary data. Users of secondary data need to be concerned with the timeliness and precision of their data. Further, they ought to assess whether the data under consideration match their research questions, and evaluate reliability and validity of potential indicators (Greenhoot and Dowsett 2012; Smith 2008). Thus, Ellram and Tate (2016) advise researchers to use established data sources and to carefully consider matters of construct validity. According to Houston (2004), construct validity of secondary data starts with content validity (whether the indicators appropriately align with the constructs of interest); and ends with nomological validity (whether the indicators fit within a theoretically-derived network of constructs).

Variables needed to test the hypotheses – hunger, gender inequality and environmental performance – are drawn from secondary data sources, as described below. All three indices (GHI, GII and EPI) are computed by well-established sources, for the purpose of measuring the respective constructs to enable comparisons across countries. The indices have also been used in prior research. There is a strong sense of content validity, i.e. that these indicators match the constructs of interest in the current study. These indices are current, calculated using enduring methods, and quantitative – enabling statistical testing of their inter-relationships. Ultimately, testing the hypotheses is needed to establish nomological validity of this secondary data set.

Since the dependent variable (GHI) is continuous, hypotheses are tested using regression analysis. This section next describes the dependent and independent variables, along with their sources.

3.1 Global Hunger Index (GHI)

The dependent variable is the Welthungerhilfe/Concern Worldwide GHI (von Grebmer et al. 2017; 2018). The GHI measures hunger at the national level, enabling cross-country comparisons, using four indicators:

- Undernourished people as a percent of the population;
- Proportion of children < 5 who are wasted (have low weight for their height);
- Proportion of children < 5 who are stunted (have low height for their age);
- Mortality rate of children < 5, which reflects poor nutrition and sanitation.

For each indicator, a standardized score is calculated on a 100-point scale. These scores are equally weighted and then aggregated to arrive at the GHI for each country in the dataset. Thus, GHI scores can range from 0 (zero hunger) to 100 (worst possible hunger scenario). The index does not include "rich" countries, such as Sweden and the United States, where hunger is assumed to be very low. The 2018 GHI is available for 119 nations.

All data used to calculate the GHI come from well-established, reputable sources. While the FAO provides data measuring undernourishment, child mortality data are drawn from the UN Interagency Group for Child Mortality Estimation. Data on child wasting and stunting come from a UNICEF/World Health Organization (WHO)/World Bank joint database (von Grebmer et al. 2018). The 2018 report contains only one mention of *gender (in)equality*, suggesting that gender equality could help reduce child stunting.

3.2 Gender Inequality Index (GII)

According to the United Nations Development Programme (UNDP), gender inequality is a major barrier to human development. Women and girls face ongoing discrimination in the areas of health care, education, representation in politics and participation in the workforce. The result is compromised development of capabilities, and reduced freedom of choice. Constructed by the UNDP, the GII estimates gender inequality on three critical aspects of human development: health, empowerment and labour market participation. Higher GII scores mean greater gender inequality. The most recent index is computed for 160 countries, revealing gender gaps and possible public policy options for overcoming obstacles faced by women (UNDP 2018b).

Data used to compute the GII come from the following sources: the International Labour Organization (ILO), Inter-Parliamentary Union (IPU), United Nations Department of Economic and Social Affairs (UNDESA),

United Nations Educational, Scientific and Cultural Organization (UNESCO) and the UN Maternal Mortality Estimation Group. Computing the Index involves aggregating data within gender groups using geometric means, and then aggregating across the two groups with a harmonic mean. This accounts for overlapping inequalities across the three dimensions. The means of each indicator are used to calculate the GII as a deviation from the standard of equality. For any given nation, the Index can range from 0 ("gender equality") to 1 (maximum inequality). The current GII ranges from 0.039 (Switzerland) to 0.835 (Yemen), and the global average is 0.441 (UNDP 2018a).

3.3 Environmental Performance Index (EPI)

The 2018 EPI is constructed as a hierarchy, in which two policy objectives (environmental health and ecosystem vitality) are linked to ten issue categories. Three issue categories – air quality, water and sanitation, and heavy metals – align with environmental health. Ecosystem vitality is represented by the other seven issues categories: biodiversity and habitat; forests; fisheries; climate and energy; air pollution; water resources; and agriculture. Finally, there are 24 specific indicators connected to the issue categories. While some issues have single indicators (e.g. tree cover loss as an indicator for forests), other issues have multiple indicators (e.g. SO_2 emissions and NO_x emissions as indicators of air pollution). For more details, see Wendling et al. (2018).

Sources of data for the EPI include international organizations, government agencies and research institutions. Datasets are assessed on the following criteria: environmental relevance to most countries; use of an established (peer-reviewed or endorsed) methodology; subject to or available for third-party verification; completeness, in terms of global coverage; and quality, i.e. accuracy, reliability and validity. If necessary, indicators are standardized for cross-country comparability and transformed in cases of skewness. Finally, indicators are re-scaled to span from 0 to 100 (Wendling et al. 2018). The 2018 EPI is calculated for 180 countries.

The 2018 EPI report contains only one mention of "gender in(equality);" suggesting that "Clean water and sanitation are essential for many SDGs such as those related to health, gender equality, economic growth, and climate action" (Wendling et al., 2018, p. 55). The report also notes a positive relationship between EPI and GDP/capita among included nations. Prosperity appears to be related to improved environmental performance.

4. Results

Table 1 reveals the regression results. The three independent variables – GII, EPI and log (GDP/capita) – explain 75 percent of the variance in GHI (R-square = .745) and overall fit between the data and model is significant (F = 73.219; p-value = .000). The results provide evidence indicating a lack of autocorrelation in the regression residuals, as the Durbin-Watson statistic (1.614) is between 1.5 and 2.5.

The histogram provides evidence that the standardized residuals are normally distributed, as they are centered on zero and range almost exclusively between (plus/minus) two standard deviations. Further, the normal P-P plot of standardized residuals supports the assumption of linearity. Finally, the scatterplot of standardized residuals vs. predicted values is centered on zero and ranges mostly between (plus/minus) two standard deviations, with respect to both the X and Y axes, providing evidence of homoscedasticity.

Table 1. Regression results

Model*	Std. Beta	t-statistic	p-value	partial η^2	VIF
(Constant)		4.839	.000		
GII	.374	4.237	.000	.193	2.296
EPI	-.252	-2.943	.002	.104	2.160
log(GDP/capita)	-.339	-3.550	.001	.144	2.686

*Dependent variable = GHI

R-square = .745; F = 73.219 (p-value = .000)

Table 1 also shows the variance inflation factors (VIFs) to assess possible multicollinearity among the independent variables. According to Akinwande et al. (2015), VIF between 5.0 and 10.0 indicates high correlation that may be problematic, and VIF > 10 suggests the regression coefficients are poorly estimated due to multicollinearity. Note the VIFs range between 2.0 and 3.0, assuaging concerns of possible multicollinearity

among the predictors.

This regression confirms support for the link between gender inequality (GII) and global hunger (GHI). The t-statistic (4.237; p-value = .000) is significant at the .01 level of alpha. Gender inequality and the hunger of nations appear to go hand-in-hand. Environmental performance (EPI) is also significantly related to hunger (t = -2.943; p-value = .002). Poor environmental performance is another obstacle to eliminating hunger. Finally, as expected, the link between GDP/capita and hunger is also significant (t = -3.550; p-value = .001). This evidence supports the hypothesized close connection between poverty and hunger.

In summary, the regression results support the following hypothesized relationships:

- Gender inequality is linked to hunger.
- National income (GDP/capita) is inversely linked to hunger.
- Environmental performance is inversely linked to hunger.

The results confirm important inter-relationships among the sustainable development goals (SDGs); specifically no poverty (SDG #1), zero hunger (SDG #2), gender equality (SDG #5) and environmental performance, including climate change action (SDG #13). Reducing poverty, promoting gender equality and protecting the environment appear to be steps on the path toward zero hunger.

To address concerns over possible omitted variable bias, an additional regression analysis is conducted with political stability (PS) as a control variable. "Political stability and absence of violence" is a measure of the perceived likelihood that the government will be destabilized or overthrown, including by politically-motivated violence and terrorism. It is a World Bank Worldwide Governance Indicator (http://info.worldbank.org/governance/wgi). This indicator is calibrated in standard normal distribution units (i.e. with mean = 0 and standard deviation = 1). The measure ranges from approximately -2.5 to 2.5, with higher values implying greater stability. It is also part of the FAO suite of food security indicators.

With political stability added to the regression model, R-square increases slightly to .753 and overall fit, though still significant, declines (F = 56.480; p-value = .000). Moreover, political stability is not a significant predictor of hunger (t = -1.530; p-value = .065) at the .05 level of alpha, probably because the other three predictors already explain 75 percent of the variance.

5. Implications

This final section discusses implications of the study for public policy and academic research.

5.1 For Policy

The results confirm important inter-relationships among several sustainable development goals (SDGs). Regarding public policy and sustainable development, the findings suggest government policy makers, NGO leaders and donors should include a focus on eliminating gender inequality as they work to end poverty and hunger (FAO 2019). This is the long game, solving a lingering large problem rather than treating its symptoms. In addition, investments in environmental protection can facilitate movement toward zero hunger. While sending food and money may reduce hunger this year, eliminating the exploitation of women and nature may be needed to end hunger by 2030.

Poverty, hunger, gender inequality and environmental degradation also appear to be linked to human migration (Hammond 2018), population growth (Gogia et al. 2018; Young 2005) and water security (Tyagi 2017). Achieving the SDGs might require identification of and focus on root causes – rather than down-stream effects. If hunger is the horrific downstream effect, then gender inequality and population growth may be among the upstream root causes. Zero hunger will never be achieved as long as these root causes remain. As the FAO (2019) observes, "policies that address gender inequality in employment opportunities and educational attainment may also have an impact on food insecurity."

5.2 For Research

This study is among the first to empirically include environmental performance and gender inequality in the world hunger conversation. Climate action is a critical aspect of environmental performance. The EPI includes several greenhouse gas (GHG) emissions indicators – i.e. CO_2, methane, N_2O and black carbon emissions. These are closely linked to climate change. The EPI contains several other indicators with conceptual connections to hunger, such as biome protection, drinking water, fish stock status, sustainable nitrogen management and wastewater treatment. One future research opportunity is to identify or develop a more targeted climate change/environmental index for the purpose of explaining national levels of hunger.

Another future research opportunity would include more variables (e.g. dimensions of national culture) among the predictors of hunger. Further, there are opportunities to focus on individual nations or a small group of nations to understand unique cultural and political challenges in the fight against poverty, hunger, environmental degradation and gender inequality. For instance, Madagascar is briefly profiled in the following paragraphs.

An island nation off the coast of Mozambique, Madagascar is almost the size of Germany and Poland combined. It has a population of nearly 25 million people. In 2018, Madagascar was one of the hungriest countries in the world, ranking 116th out of 119 countries with a GHI of 38.0. The level of hunger in Madagascar is alarming; an estimated 43 percent of the population is undernourished. Further, almost half of the children under five years old are malnourished (https://www.welthungerhilfe.org/our-work/countries/madagascar/).

Madagascar's 2018 GDP per capita (in current US$) was only ~$461, fifth from the bottom among nations of the world (https://data.worldbank.org). Over 90 percent of the people live below the World Bank national poverty line. Madagascar's economy shrank significantly after a recent, 5-year political crisis. The country depends primarily on agriculture (e.g. vanilla exports) and secondarily on tourism. Livelihoods of most Malagasy are severely threatened by environmental degradation and the effects of climate change.

With an EPI of 33.73, Madagascar ranks 175th out of 180 countries. While it is known for its strange animals (e.g. woolly lemurs) and beautiful landscapes, the country has endured considerable environmental damage. Much of its rainforest has been taken down, and topsoil for growing food crops is eroding. Among the world's poorest countries, day-to-day survival in Madagascar depends on natural resources. Madagascar's primary environmental problems are:

- Deforestation and destruction of habitat
- Agricultural fires
- Erosion and soil degradation
- Over-exploitation of resources, including hunting and over-collection of endemic species
- Introduction of invasive alien species.

Deforestation in the country is largely due to: "slash-and-burn" agriculture, logging and dependence on fuelwood and charcoal for cooking fires (https://www.wildmadagascar.org/kids/19-environment.html).

Gender stereotypes and customs linger in Madagascar; e.g. *moletry*, marrying young girls to older men in exchange for cash or other gifts to the bride's family. Such traditions endure due to the economic situation faced by families. Malagasy women often lack the income and resources to survive independently (Jackson 2017). The case of Madagascar confirms the connections between hunger, poverty, gender inequality and the environment.

Finally, future research is also needed to better understand the interaction between hunger, obesity and food waste. The World Food Program (WFP) lists food waste among the causes of hunger (http://www.wfp.org/hunger/causes). Over-eating and obesity can be viewed as a form of food waste. Further, there appears to be a paradoxical link between obesity and food insecurity in some countries (Dhurandhar 2016), such as the United States.

References

Akinwande, M. O., Dikko, H. G., & Samson, A. (2015). Variance Inflation Factor: As a Condition for the Inclusion of Suppressor Variable(s) in Regression Analysis. *Open Journal of Statistics, 5*, 754-767. https://doi.org/10.4236/ojs.2015.57075

Berg, J. M., Tymoczko, J. L., & Stryer, L. (2002). *Biochemistry* (5th ed.). New York: W. H. Freeman. Retrieved from https://www.ncbi.nlm.nih.gov/books/NBK21190/

Blesh, J., Hoey, L., Jones, A. D., Friedmann, H., & Perfecto, I. (2019). Development pathways toward 'zero hunger.' *World Development, 118*, 1-14. https://doi.org/10.1016/j.worlddev.2019.02.004

Chutney, W. (2019). *The Impact of Global Climate Change on World Hunger.* Hunger Notes. Retrieved from https://www.worldhunger.org/the-impact-of-global-climate-change-on-world-hunger/

Dhurandhar, E. J. (2016). The Food-Insecurity Obesity Paradox: A Resource Scarcity Hypothesis. *Physiology & Behavior, 162*, 88-92. https://doi.org/10.1016/j.physbeh.2016.04.025

Ellram, L. M., & Tate, W. L. (2016). The use of secondary data in purchasing and supply management (P/SM) research. *Journal of Purchasing & Supply Management, 22*(4), 250-254. https://doi.org/10.1016/j.pursup.2016.08.005

FAO. (2008). *An Introduction to the Basic Concepts of Food Security.* EC - FAO Food Security Programme. Retrieved from www.foodsec.org

FAO. (2017). *The future of food and agriculture: Trends and challenges.* Rome: Food and Agriculture Organization of the United Nations. Retrieved from http://www.fao.org/3/a-i6583e.pdf

FAO. (2018). The state of food security and nutrition in the world: Building climate resilience for food security and nutrition, Rome: Food and Agriculture Organization of the United Nations. Retrieved from http://www.fao.org/3/i9553en/i9553en.pdf

FAO. (2019). The state of food security and nutrition in the world: Safeguarding against economic slowdowns and downturns, Rome: Food and Agriculture Organization of the United Nations.

Gogia, J., Sharma, N., & Sikarwar, N. (2018). Accomplishing Food Security: Major Constraints and Policy Framework. *International Journal of Social Sciences Review, 6*(12), 2078–2085.

Greenhoot, A. F., & Dowsett, C. J. (2012). Secondary Data Analysis: An Important Tool for Addressing Developmental Questions. *Journal of Cognition and Development, 13*(1), 2-18. https://doi.org/10.1080/15248372.2012.646613

Hammond, L. (2018). Forced Migration and Hunger. In von Grebmer, K. et al., Global Hunger Index, Bonn: Welthungerhilfe and Dublin: Concern Worldwide, October, pp. 24-33.

Hossain, N. (2017). Inequality, Hunger, and Malnutrition: Power Matters. In von Grebmer, K. et al., Global Hunger Index, Washington, DC: International Food Policy Research Institute, Dublin: Concern Worldwide and Bonn: Welthungerhilfe, October, pp. 25-29.

Houston, M. B. (2004). Assessing the validity of secondary data proxies for marketing constructs. *Journal of Business Research, 57*(2), 154-161. https://doi.org/10.1016/S0148-2963(01)00299-5

Jackson, T. (2017). Women's Empowerment in Madagascar. The Borgen Project, December 9. Retrieved from https://borgenproject.org/womens-empowerment-in-madagascar/

Lieberson, A. D. (2004). How Long Can a Person Survive without Food? *Scientific American*, November 8. Retrieved from https://www.scientificamerican.com/article/how-long-can-a-person-survive-without-food/

Myklebust, J. P. (2019). Research is more focused on Sustainable Development Goals. *University World News*. Retrieved from https://www.universityworldnews.com

National Research Council (2006), *Food Insecurity and Hunger in the United States: An Assessment of the Measure.* Washington, DC: The National Academies Press. https://doi.org/10.17226/11578

Ngankam, B. T. (2019). Sustainable Development Goals Synergies/Trade-offs: Exploring Long- and Short-Run Impacts of Economic Growth, Income Inequality, Energy Consumption and Unemploy-ment on Carbon Dioxide Emissions in South Africa. *Journal of Sustainable Development, 12*(4), 40-52. https://doi.org/10.5539/jsd.v12n4p40

Nilsson, M., Griggs, D., & Visbeck, M. (2016). Policy: Map the interactions between Sustainable Development Goals. *Nature, 534*, 320–322. https://doi.org/10.1038/534320a

Orner, M. (2014). The Effects of Hunger. The Borgen Project, July 1. Retrieved from https://borgenproject.org/effects-hunger/

Pradhan, P., Costa, L., Rybski, D., Lucht, W., & Kropp, J. P. (2017). A Systematic Study of Sustainable Development Goal (SDG) Interactions. *Earth's Future, 5*(11), 1169–1179. https://doi.org/10.1002/2017EF000632

Robinson, M. (2015). Why gender equality is key to sustainable development. World Economic Forum, March 10. Retrieved from www.weforum.org

Rosenzweig, C., & Parry, M. L. (1994). Potential impact of climate change on world food supply. *Nature, 367*, 133-138. https://doi.org/10.1038/367133a0

Samberg, L. (2018). How new technology could help to strengthen global food security. World Economic Forum, March 19. Retrieved from https://www.weforum.org/agenda/2018/03/food-security-s-social-network

Scrimshaw, N. S. (1994). The consequences of hidden hunger for individuals and societies. *Food and Nutrition Bulletin, 15*(1), 1-25.

Smith, E. (2008). *Doing secondary analysis. Chapter 4 in Using Secondary Data in Educational and Social*

Research. Berkshire: Open University Press.

Tayal, D. (2019). Gender inequality, reproductive rights and food insecurity in Sub-Saharan Africa – a panel data study. *International Journal of Development Issues, 18*(2), 191-208. https://doi.org/10.1108/IJDI-10-2018-0165

Tyagi, A. C. (2017). ICID Vision 2030: A Water Secure World Free of Poverty and Hunger. *Irrigation and Drainage, 66*, 896–897. https://doi.org/10.1002/ird.2216

UN. (2018). *The Sustainable Development Goals Report.* New York: United Nations.

UN. (2019). *Sustainable Development Goals Knowledge Platform.* New York: United Nations. Retrieved from https://sustainabledevelopment.un.org/#

UNCC. (2018). *UN Warns Climate Change Is Driving Global Hunger.* Bonn: United Nations Climate Change, September 12. Retrieved from https://unfccc.int/news/un-warns-climate-change-is-driving-global-hunger

UNDP. (2018a). *Human Development Indices and Indicators: 2018 Statistical Update.* New York: United Nations Development Programme.

UNDP. (2018b). *Technical Notes. Human Development Indices and Indicators: 2018 Statistical Update.* Retrieved from http://hdr.undp.org/sites/default/files/hdr2018_technical_notes.pdf

UNDP. (2019). *Sustainable Development Goals (SDGs).* New York: United Nations Development Programme. Retrieved from https://www.undp.org/content/undp/en/home/sustainable-development-goals.html

von Grebmer, K., Bernstein, J., Brown, T., Prasai, N., Yohannes, Y., Towey, O., … Hossain, N. (2017). *Global Hunger Index: The Inequalities of Hunger.* Washington, DC: International Food Policy Research Institute, Dublin: Concern Worldwide, and Bonn: Welthungerhilfe, October.

von Grebmer, K., Bernstein, J., Patterson, F., Sonntag, A., Klaus, L. M., Fahlbusch, J., … Hammond, L. (2018). *Global Hunger Index: Forced Migration and Hunger.* Bonn: Welthunger-hilfe and Dublin: Concern Worldwide, October.

Watts, J. (2017). Third of Earth's soil is acutely degraded due to agriculture. *The Guardian*, September 12. Retrieved from https://www.theguardian.com/environment/2017/sep/12/third-of-earths-soil-acutely-degraded-due-to-agriculture-study

Welthungerhilfe. (2019). *Hunger: Facts & Figures, Deutsche Welthungerhilfe, Köln-Bonn.* Retrieved from https://www.welthungerhilfe.org/hunger/

Wendling, Z. A. et al. (2018). *Environmental Performance Index.* New Haven, CT: Yale Center for Environmental Law & Policy. Retrieved from https://epi.yale.edu/

Wheeler, T., & von Braun, J. (2013). Climate Change Impacts on Global Food Security. *Science, 341*, 508-513. https://doi.org/10.1126/science.1239402

WHES. (2018). *Hunger Notes.* Washington, DC: World Hunger Education Service. Retrieved from https://www.worldhunger.org/world-hunger-and-poverty-facts-and-statistics/

Young, A. (2005). Poverty, hunger and population policy: linking Cairo with Johannesburg. *The Geographical Journal, 171*(1), 83–95. https://doi.org/10.1111/j.1475-4959.2005.00151.x

Zalidis, G., Stamatiadis, S., Takavakoglou, V., Eskridge, K., & Misopolinos, N. (2002). Impacts of agricultural practices on soil and water quality in the Mediterranean region and proposed assessment methodology. *Agriculture, Ecosystems & Environment, 88*(2), 137-146. https://doi.org/10.1016/S0167-8809(01)00249-3