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14. ABSTRACT

This paper provides evidence in support of the establishment of enduring food insecurity fixes within the global food system. It assesses that the cost of hunger, food insecurity, and famine are far more than individual ones. By exploring the impacts of climate change, conflict, and corruption, the research here points to a pressing need for change in how we manage food aid specifically, and our global food system more generally. Applying ethical schools of thought to the impacts of food insecurity provides a clear picture of a problem in need of solving. Using emerging technologies in food production, and re-tooling the current system of food aid to better address issues for the long term, will allow food aid and food systems to be more effective. With the population of our planet's most food insecure places expected to grow rapidly over the next several decades, inaction to fix these problems is not an option. Food insecurity and all its related components cause problems ranging from physical to emotional, mental to social, and those problems have the potential to manifest into existential crises, with military implications, if left unchecked. Case studies and implementation cases provide examples of where these issues can be mitigated to advance domestic and global security interests.

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Abstract

This paper provides evidence supporting the establishment of enduring food insecurity fixes within the global food system. It assesses that the cost of hunger, food insecurity, and famine are far more than individual ones. By exploring the impacts of climate change, conflict, and corruption, the research here points to a pressing need for change in how we manage food aid specifically, and our global food system more generally. Applying ethical schools of thought to the impacts of food insecurity provides a clear picture of a problem in need of solving. Using emerging technologies in food production, and re-tooling the current system of food aid to better address issues for the long term, will allow food aid and food systems to be more effective. With the population of our planet's most food insecure places expected to grow rapidly over the next several decades, inaction to fix these problems is not an option. Food insecurity and all its related components cause problems ranging from physical to emotional, mental to social, and those problems have the potential to manifest into existential crises, with military implications, if left unchecked. Case studies and implementation cases provide examples of where these issues can be mitigated to advance domestic and global security interests.

Food Tech: Emerging Solutions to Enduring Problems

Our planet is one of relative equilibrium and calm compared to that of our cosmic cousins. We have neither the extreme heat of Mercury and Venus, nor the bitter, dark colds of Uranus and Neptune. Life teems on our little blue and green world and at the top of that heap stands firmly the bipedal champion and master of our domain. Humans have molded and shaped a world in which they have become the dominant force equal to nature and exceeding it at times. We have a remarkable ability to adapt and overcome hardships. We have explored the depths of oceans and the space around our Earth. We have expanded from a weak, exposed, relative newcomer in our planet's evolution to become, over a relatively small blip in the grand scheme of time, the undisputed ruler. Food has been at the forefront of this development from the start. Our ability to find it, cultivate it, and improve it has been the driver of our emergence. Yet not all is perfectly rosy in our story with food. Despite our relative mastery of industrial scale agriculture, groups of people around the world still struggle with food insecurity and famine. We send people and equipment into space, manipulate the elements to perform terrible and awesome acts, and have uncovered the basic building blocks of our very existence…yet still people starve. It is this idea, this curiosity of a world so advanced in so many ways, yet failing in such a basic need, that this paper explores.

Is food a basic human right? What are the implications to humanity of food insecurity and famine? Is there an ethical imperative for society to ensure all people have sufficient nutrition for survival; if so, how can that be enforced? If not, what are the repercussions? This paper explores the ever-present specter of food insecurity against a backdrop of ethical and practical considerations. It jointly seeks to identify gaps in policy and implementation of

programs intended to mitigate it. It highlights pre-existing and emerging technologies which have the potential to meaningfully contribute to the solution.

To establish a solid base upon which this research can be presented in a cohesive, digestible, and functional way we must first understand the problem. The Food and Agriculture Organization of the United Nations defines food insecurity as "lack [of] regular access to enough safe and nutritious food for normal growth and development and an active and healthy life."[1] The first section of this paper explores the origins of food insecurity and famine to better understand the historical backdrop which has led us to our current state. The second section identifies past and present programs and attempts to mitigate these issues. The third outlines ethical considerations of either trying to solve the problems or letting them resolve themselves over time. The fourth assesses the implications of food insecurity to the world. The fifth section introduces new and novel technologies in food production aimed at addressing issues laid out in the previous section. The sixth and final section outlines two implementation cases to merge the concepts from previous sections into exportable ideas for policymakers and agents of change. Additionally, it offers a means through which existing systems can contribute to that implementation. Even though this paper focuses on the problem of food insecurity and famine, it does not weigh down the reader with a seemingly unsolvable problem. It seeks to make palatable the idea that there are solutions in the world now and that breaking down the issues of food insecurity and famine into bite-sized pieces (pun intended) makes it easier to digest. Just as with an addiction, the first step to healing the wounds caused by food insecurity and famine is to admit that we do indeed have a problem.

[1] "Hunger," Food and Agriculture Organization of the United Nations, accessed June 7, 2022, https://www.fao.org/hunger/en/.

The History of Hunger

Nearly 44 million people around the world are either in various stages of famine or on the brink.[2] An additional 800 million or so are unsure where at least one of their meals in the next day will come from.[3] This may seem unfathomable to anyone aware that our species produces food far more than sufficient to feed every one of us and then some.[4] The problem it seems is less about producing the food, and more about getting it to those in need of it. There is an added layer of complication in exploring the roots of hunger. On a purely percentage basis, fewer people per capita are undernourished than at any point in history. So, a mathematically minded person might then make the case that hunger, and related issues like famine, are getting better. This fails to take in the sheer magnitude of the problem in terms of total individuals and misses the underlying threat of food insecurity. Yes, improvements in production and distribution have reduced the overall percentage of the population that is starving regularly, but food insecurity still impacts 1.8 billion people to varying degrees.[5]

Yuval Noah Harari, in his book *Sapiens: A Brief History of Humankind*, makes the case that the agricultural revolution, despite allowing for the exponential expansion of our species, was not the panacea for humanity's problems as many would claim.[6] A large part of this claim is based on the idea that life used to be based on the location and procurement of food, and that was based at the individual, familial, and village levels. Because growing food has transitioned into a largely industrial and commercial scale endeavor while overall production has increased, local

[2] "Fighting Famine: World Food Programme," UN World Food Programme, accessed June 7, 2022, https://www.wfp.org/fight-famine.
[3] Ibid.
[4] "Can We Feed the World and Ensure No One Goes Hungry? | | UN News," United Nations (United Nations), accessed June 7, 2022, https://news.un.org/en/story/2019/10/1048452.
[5] David Backer and Trey Billing, "Validating Famine Early Warning Systems Network Projections of Food Security in Africa, 2009–2020," *Global Food Security* 29 (2021): p. 1, https://doi.org/10.1016/j.gfs.2021.100510.
[6] Yuval N. Harari et al., *Sapiens* (Paris: Michel Albin, 2020).

food security is now based on the successful logistics' chains of multi-national corporations and governments. Complications such as climate change and war only serve to weaken an already delicate balance between abundance and famine. Some of the most famous famines in history, like those mentioned in the Abrahamic religions, were seen as God's wrath against humanity. But more recent ones, such as the Irish Famine of the mid 1800s, can be tied to over-reliance on a single variety of a single plant, exposing the fragility of an ecosystem lacking in diversity.

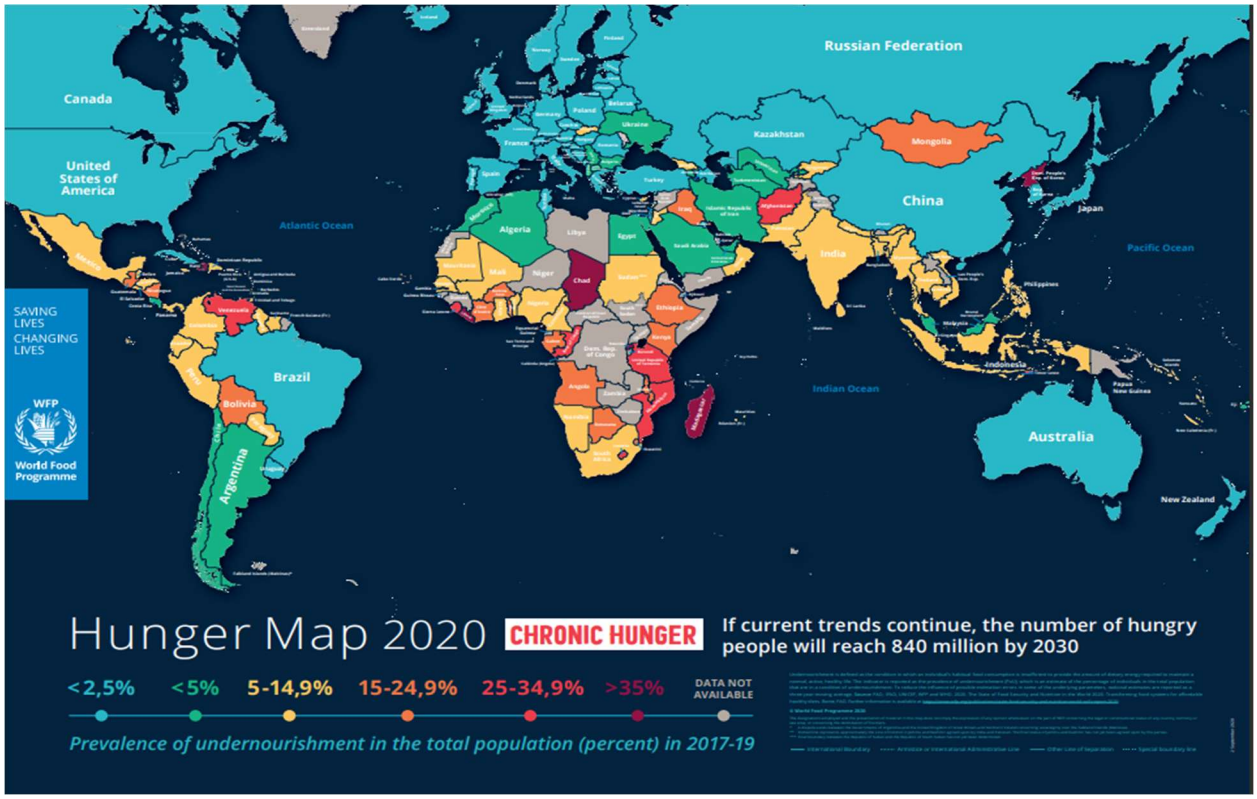
Regardless of what you believe to be the cause of famine, there is no debate that it has born a heavy toll on humans throughout history. The modern famine is a little different than its historical counterparts because food production is far more than sufficient to meet the needs of all humans on Earth. The issue today rests squarely in failing to address food insecurity before its insidious slide into famine. One could find themselves judging our species harshly for failing to address these problems with all the technology and power at our disposal, but that would be both inaccurate and unfair. The problem in fixing food insecurity and famine has not been absolute apathy from society, it has been in our inconsistent, short-sighted, and technology-limited approaches. The next section breaks down some of these attempts.

Fighting Famine

The war against food insecurity and famine has been waged throughout history. The question is in deciding who will win the war, people or food insecurity. Humans have adjusted their methods of food production to keep up with changing environments, learned new ways to increase yields, and understand more about our ecosystems on Earth than ever before. Still hunger and famine persist. In the time before rapid movement of people and cargo was possible, a famine in one part of the world would have meant certain death to many in that location. As we expanded our ability to both receive information and move rapidly around our world, our

collective efforts and success in bringing relief to areas suffering increased. The first truly global framework to address food insecurity and famine around the globe was born in 1961 when the World Food Program (WFP), a United Nations vehicle, was created.[7] Its first enduring development project began two years later in the Sudan, and it was "enshrined as a fully-fledged UN programme" in 1965.[8] Its charter has a message that the program will endure "as long as multilateral food aid is found feasible and desirable."[9] As you can see in Figure 1 below, there is no shortage of places requiring food aid.

Figure 1: World Food Program Hunger Map



[7] "History: World Food Programme," UN World Food Programme, accessed June 7, 2022, https://www.wfp.org/history.
[8] Ibid.
[9] Ibid.

As the most visible representation of the liberal world order, the United Nations has taken it upon itself to try to find an approach to stabilize the world in whatever ways necessary to ensure peace and prosperity. Food insecurity and famine are threats to this vision. They cause "destruction of livelihoods – to the point of destitution with large numbers of food-insecure people, increased severe malnutrition, disease epidemics, excess death and, frequently, the breakdown of institutions and social norms."[10] The WFP specifically highlights innovation and technology as a key means "to improve a wide range of food production challenges,"[11] and some of these concepts are introduced later in this paper. It is not only the United Nations working to stem the tide of food insecurity and famine around the world. Many state governments have programs with aims like those of the WFP, and oftentimes complement their efforts. The United States is one of those nations that leads the way.

A movement began in 1961 in which institutions increased food aid and expanded participation. At the same time the WFP was being established, the United States established its Agency for International Development (USAID).[12] The overarching goal of the agency was and is to generally "promote and demonstrate democratic values abroad, and advance a free, peaceful, and prosperous world."[13] Its efforts include several highly pertinent to food security such as "saving lives, reducing poverty,…and [to] help people emerge from humanitarian crises and progress beyond assistance."[14] Part of the effort to proactively achieve these goals was to attrit famine before it was too late. With this as the driver, USAID implemented a new system in

[10] Daniel Maxwell and Peter Hailey, "Analysing Famine," *Journal of Humanitarian Affairs* 3, no. 1 (January 2021): p. 16, https://doi.org/10.7227/jha.055.
[11] "Can We Feed the World and Ensure No One Goes Hungry? | | UN News," United Nations (United Nations), accessed June 7, 2022, https://news.un.org/en/story/2019/10/1048452.
[12] "USAID History," U.S. Agency for International Development, November 12, 2021, https://www.usaid.gov/who-we-are/usaid-history.
[13] Ibid.
[14] Ibid.

1985 called the Famine Early Warning System (FEWS) which would "produce regular Outlook Reports with current situation assessments and future projections of food security across much of Africa and select countries in Central America, the Caribbean, and Central Asia."[15] FEWS merges data from a variety of sources to produce best guesses on where famine would strike next. It categorizes countries and regions in terms of their Acute Food Insecurity levels with Level 1 being Minimal and Level 5 as Famine. Ideally, having this "early warning" can give governments and non-governmental organizations sufficient time to head off worsening crisis, but that is not always the case. Geopolitical issues, infrastructure weakness, corruption, and war, as is the case in Yemen right now, can reduce the ability of external players to mitigate fallout. Beyond this, domestic politics can play a key role in determining what aid and how much of it makes it to the areas in FEWS' reports. USAID in 2018 alone "provided over $3.7 billion in emergency and development food assistance to the poorest corners of the world."[16] This amount of money vectored outside the United States rightfully comes under heavy scrutiny to ensure it is spent appropriately. There are numerous schools of thought about an organization's or state's obligations to materially impact situations where people other than their own are suffering. The next section explores the ethical considerations of that aid.

The Greater Good?

In his speech at the inception of USAID, President John F. Kennedy laid out the ethical mandate serving as the impetus for its creation:

[15] Backer and Billing, p. 1
[16] "Frequently Asked Questions: Food Assistance," U.S. Agency for International Development, July 12, 2021, https://www.usaid.gov/food-assistance/faq.

> "There is no escaping our obligations: our moral obligations as a wise leader and good neighbor in the interdependent community of free nations – our economic obligations as the wealthiest people in a world of largely poor people, as a nation no longer dependent upon the loans from abroad that once helped us develop our own economy – and our political obligations as the single largest counter to the adversaries of freedom."[17]

His belief that the United States is duty-bound to provide aid to those less fortunate has at its core Catholic doctrine based on Kennedy's own religious beliefs. All the major world religions convey to their adherents that the giving of alms is a requirement of being an effective believer. Whether the Islamic pillar of Zakat or the Catholic call to be charitable to your neighbors, much of the modern understanding of giving is rooted in religious backgrounds. For these people it is indeed a moral imperative to provide aid to those experiencing suffering. The arguments for the most effective methods with which to accomplish this are where the debate must then lay. But what about people who are either areligious or choose to separate supernatural imperatives from human ones?

The belief in one's duty to do what is moral reaches far beyond religious roots. Immanuel Kant referred to a "categorical imperative" wherein "morality is a principle of practical rationality."[18] The knowledge of what constitutes the moral thing is hardwired in most peoples' DNA according to Kant. That is not to say that people always choose the moral path, but rather that they must fight against doing that which is not moral.[19] Were you to ask a person if allowing

[17] Ibid.
[18] Robert Johnson and Adam Cureton, "Kant's Moral Philosophy," Stanford Encyclopedia of Philosophy (Stanford University, January 21, 2022), p. 1, https://plato.stanford.edu/entries/kant-moral/.
[19] Ibid.

a child to starve to death when they have the means to prevent it was moral, most would respond that it is not. By that same understanding, suffering from hunger, physical impairment from malnutrition, and social unrest leading to destruction and death would all qualify as outcomes that humans are duty bound to prevent when able. The debate over whether helping the less fortunate is based in a religious calling or an intrinsic sense of duty like that of Kant both influence vectors toward providing aid. Beyond these, however, there is also utility to doing so.

Kant speaks of the rationality of morality, but that belief fails to address the concept of what provides the greatest good. People are capable of eschewing even an inherent penchant toward doing the moral thing if the outcome does not benefit them as much as doing the immoral thing. The concept of utility and the ethical school of thought of Utilitarianism are similar, but not identical. People can choose to follow that which is best (has the most utility) for themselves, or for their family, their community, or society in general. In the Utilitarian mindset, "the morally right action…is the one that produces the greatest overall positive consequences for everyone."[20] There is, however, inherent difficulty in applying weight to the components of a utilitarian equation and in accurately assessing first, second, and third order effects of one's actions. Luckily, we already know the first, second, and third order effects of food insecurity and famine. Those will be more thoroughly discussed in the next section but suffice to say one would be hard-pressed to argue that not taking action to fight food insecurity and famine is the better course of action for all. Both are created by, and often lead to, chaos. That chaos locally leads to instability in surrounding areas which impacts the overall stability of our systems and undermines the greater good. As Jeremy Bentham and John Stuart Mill would argue, this chaos

[20] Lawrence M. Hinman, *Ethics: A Pluralistic Approach to Moral Theory* (Belmont, CA: Thomson/Wadsworth, 2013), p. 124.

is anathema to the Utilitarian truism "that we ought to maximize the good, that is, bring about 'the greatest amount of good for the greatest number.'"[21]

From a purely business perspective, consider the implications of food system collapse. Dr. Molly Jahn, to codify the likely effects of such a scenario, approached actuaries and insurance adjusters to gain their perspective. They agreed "that the food system is highly consolidated, largely opaque, and –because it has been maximized for short-term productivity and efficiency—vulnerable to age-old issues such as fluctuating weather, environmental instability, and disease." She continues with emerging threats like cyberattacks and other malicious activities all of which can lead to devastating consequences. Her assessments, along with a team of insurance adjusters from Lloyd's of London, point to a scenario where even a minor upset in the global food system can lead to "hunger, riots, and political instability, and financial panic in different parts of the globe."[22] We can see in this scenario that what begins as a problem for some leads to problems for many. By this measure, mitigating food insecurity and famine is essential to minimizing suffering and has the greatest benefit for the most people.

More discussions of ethics will be interwoven throughout the rest of this paper, but I argue that the specific school of ethical thought to which you adhere is less important than a thorough understanding of the problem at hand. The next section elaborates on this concept by laying out the impacts of food insecurity on individuals and society; using any of the ethical frameworks discussed above one can see that doing nothing to resolve it is not an option.

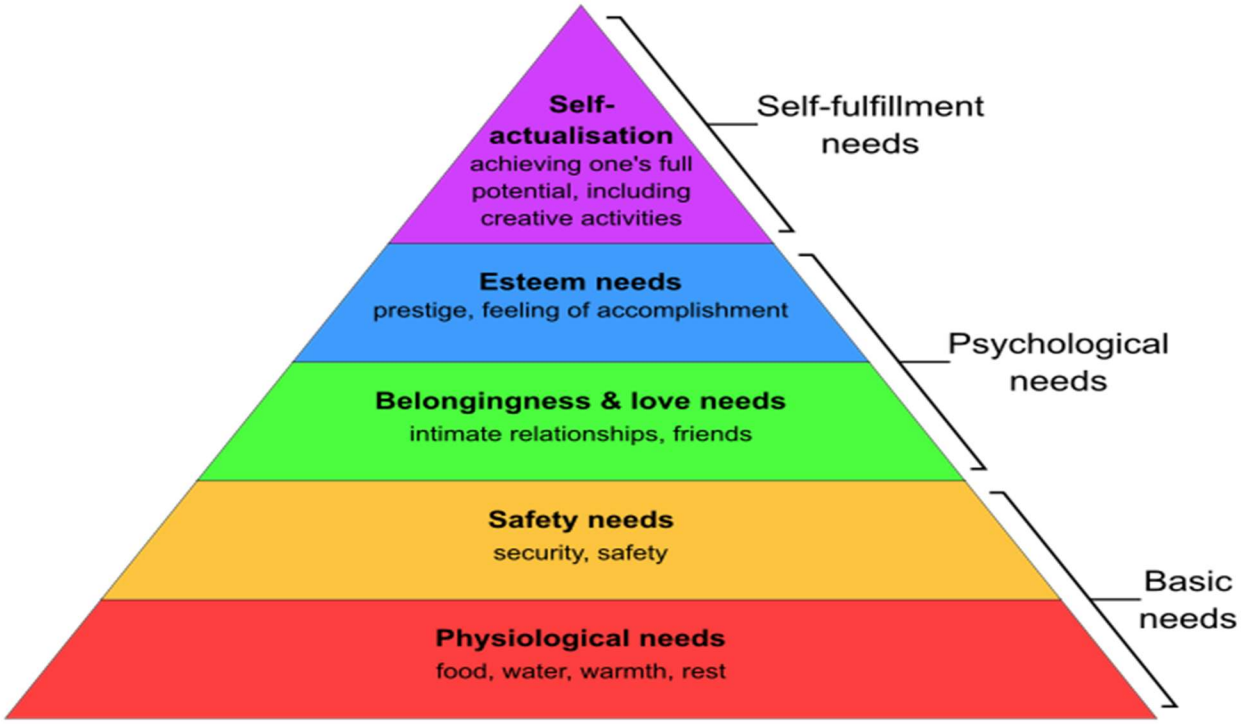
[21] Julia Driver, "The History of Utilitarianism," Stanford Encyclopedia of Philosophy (Stanford University, March 27, 2009), https://plato.stanford.edu/archives/win2014/entries/utilitarianism-history/, p. 1.
[22] Molly Jahn, "How 'Multiple Breadbasket Failure' Became a Policy Issue," Issues in Science and Technology, February 15, 2021, https://issues.org/global-food-security-molly-jahn-darpa/, pp. 82 - 84.

So What?

A common refrain from those with a nationalist bent is that a problem in another country or part of the world is not "our" problem. They talk about the world as if it is a collection of independent biomes that are only tangentially related to our own existence. Reality is in fact far from that worldview. Consider the global world order to be a machine. It is an imperfect machine but nevertheless it has worked well for the better part of the last 80 years to reduce overall levels of war and violence, while lifting hundreds of millions of people out of poverty. Now imagine the machine uses a lubricant of sorts to continue operation. Much like the cars parked in your driveways or the bus you take to school, those lubricants need to be free from impurities to last longer and provide necessary protection to the machine's parts. If a car's oil is contaminated it can no longer do what it needs to do and inevitably the engine will fail. So too will the global world order if the contaminants of food insecurity and famine and the issues that emerge from their existence are not dealt with appropriately. This section dives into the greatest impacts of food insecurity by addressing them from the individual and global security levels.

When a person is food insecure, there are more than just physical symptoms. Maslow's "Hierarchy of Needs," (Figure 2) offers us a way to conceptualize what is made unattainable when a person does not have enough food to eat.

Figure 2: Maslow's Hierarchy of Needs



When basic needs are not met, the ability to meet psychological needs is either limited or non-existent, to say nothing of self-fulfillment. The earlier section of this paper regarding the ethics related to food insecurity addresses this to an extent, but it is important to re-emphasize what it means here. In the absence or scarcity of a basic need, a person is at best severely limited and at worst, will not survive. We therefore must acknowledge that to continue to allow people to exist in a state of food insecurity means to accept that they will not have the same opportunity as a person who does not want for food. Neither will they have the freedom to express themselves in their fullest capacity. Frederico Garcia Lorca articulated this idea beautifully when he wrote:

"The day hunger disappears the world will see the greatest spiritual explosion humanity has ever seen"

Food is fuel for both mind and body, and without it the human machine will never function as intended. It is critical for those not suffering from food insecurity and hunger to understand that "people who are food insecure are disproportionately affected by diet-sensitive chronic diseases such as diabetes and high blood pressure, and…food insecurity is also linked to many adverse effects to overall health."[23]

Particularly problematic is food insecurity's impact on children. According to Feeding America, "not having enough healthy food can have serious implications for a child's physical and mental health, academic achievement and future economic prosperity."[24] The building blocks of healthy societies are healthy people, so it is troubling that there is "an association between food insecurity and delayed development in young children; risk of chronic illnesses like asthma and anemia; and behavioral problems like hyperactivity, anxiety and aggression."[25] Children all over the world, but especially in those areas most impacted by food insecurity, are having their development hurt by a problem not of their making, and it is hurting them, their communities, and beyond.

With almost no exceptions, when you overlay a map of food insecurity with a heatmap of crime hotspots, you see that they coincide with each other. Whether the former drives the latter or exists because of it is irrelevant. The bottom line is that food insecurity, like all insecurity, drives people to find ways out of it. The cost of hunger is far more than an individual one. In developing countries, food insecurity and malnutrition harm human development and affects the ability of those states and communities to stand up against transnational criminal organizations

[23] "Tough Choices. Devastating Consequences.," Feeding America, accessed June 7, 2022, https://www.feedingamerica.org/hunger-in-america/impact-of-hunger.
[24] Ibid.
[25] Ibid.

(TCOs) and terrorist groups. In the case study portion of this paper, you will read more on Boko Haram in Nigeria and how food insecurity, among other weaknesses in that country, aids their proliferation. The costs associated with the chaos and devastation of terrorist groups like Boko Haram and TCOs are astronomical in both human and capital measures. The United Nations Office on Drugs and Crime (UNODC) estimates that in 2009, TCOs alone did business equivalent to 1.5 percent of global GDP, right around the 870-billion-dollar mark.[26] The human toll is slightly harder to estimate but includes death from illicit drugs like meth and fentanyl. These totaled more than 100,000 in the US alone according to the CDC.[27] Something must change in the way this problem is being approached because the status quo is not working well enough. Fighting food insecurity with enduring, local systems can and should be part of the fix. Thanks to technology, there are realistic mechanisms through which this can be accomplished.

No Longer Science Fiction

When I was a child, I watched "The Jetsons" almost every day on TV. I was fascinated by the idea that you could fly a car to work and school, have a robot do your chores, and live in the sky. But the thing that was most exciting was the ability to just push a button and have the meal of your choosing delivered right on your plate. Whether consuming a pill triggers even a semblance of the joy obtained from eating solid food is debatable, on-demand nutrition is certainly an enviable situation. As mentioned earlier, roughly 1.8 billion people suffer from some degree of food insecurity. According to FEWS data, most severe cases (levels 3 through 5) are in

[26] Kevin Town, "Transnational Organized Crime: Let's Put Them out of Business," Transnational organized crime: the globalized illegal economy, accessed June 7, 2022, https://www.unodc.org/toc/en/crimes/organized-crime.html.
[27] "Drug Overdose Deaths in the U.S. Top 100,000 Annually," Centers for Disease Control and Prevention (Centers for Disease Control and Prevention, November 17, 2021), https://www.cdc.gov/nchs/pressroom/nchs_press_releases/2021/20211117.htm.

Africa and the Middle East.[28] Climate, conflict, and corruption, a trio of influences I have coined as the 3Cs, are all working together to make the Horn of Africa one of the most food insecure region on Earth. Previous efforts to help solve problems in places like this have been limited to delivery of food and money in hopes of bridging the gap sufficiently to save lives. This is a noble and necessary action, but one that fails to attack the root of the problem. Emerging technology in food production offers potential solutions.

One of the weaknesses of the current scheme of food production globally is reliance on areas colloquially referred to as "bread baskets." These are areas where cereal grains such as wheat are grown, and they produce surplus crops able to be exported to areas of the world like the Horn of Africa. An especially pertinent example of this is Ukraine, which is "a surplus food producing country."[29] According to FEWS' analysis "specific food security impacts of the war in Ukraine are currently highest for Ethiopia, Sudan, and Somalia, in East Africa; Nigeria and Burkina Faso in West Africa; Madagascar and Zimbabwe in Southern Africa; Nicaragua in Central America; Yemen; and Afghanistan."[30] It is easy to see why reliance on a handful of "bread baskets" is an impermanent solution to solving food insecurity. Enter the brave new world of high-tech agriculture.

Greenhouses have long been used to cultivate plants in general, but only recently have they began serving as commercial-scale sources of edible plants and vegetables. Emerging advancements in greenhouse technology, specifically in vertical farming, hydro- and aeroponic

[28] "Famine Early Warning Systems Network," Home | Famine Early Warning Systems Network, accessed June 7, 2022, https://fews.net/.
[29] "Famine Early Warning Systems Network," War in Ukraine Likely to Exacerbate Food Insecurity in FEWS NET-Monitored Countries | Famine Early Warning Systems Network, accessed June 7, 2022, https://fews.net/war-ukraine-likely-exacerbate-food-insecurity-fews-net-monitored-countries.
[30] Ibid.

production, and robotics, have made growing vegetables and edible plants in areas previously deemed inhospitable, possible. Growing lush vegetation in a desert area would have, until only recently, been impossible. Vertical indoor farming now makes it possible because it "can reduce water requirements by up to 90 percent and eliminate the need for chemical crop protection."[31] According to Professor of Digital Agriculture at the Technical University of Munich, Senthold Asseng, "vertical farming allows multiple harvests of a crop in a year and can make a substantial contribution to global food security."[32] This rapidly advancing technique for exponentially expanding the density of crops within a smaller footprint than traditional farms offers numerous advantages both in consistency and logistics. Beyond saving water, which is particularly important in desert climates most likely to feel the pangs of hunger from food insecurity and famine, producing nutritious crops locally ensures they will get to consumers in a consistent manner. In addition to the environmental and distribution benefits of "hyper-local" agriculture, job creation is an important advantage.

Part of the problem with the current global food chain, is it "makes it difficult to comprehend where food comes from and how it is produced."[33] So to does it complicate the labor picture and equity regarding the socio-economic implications discussed in the previous section. To truly drive home the point, it is sufficient to understand that in places like Africa job creation in agriculture would be a huge benefit for a continent steeped in poverty. To this end, the Alliance for Food Sovereignty in Africa is striving to bring the continent into the 21st century

[31] Cristen Hemingway Jaynes, "Vertical Farming Saves Water and Land and Could Help Global Food Security, Expert Says," EcoWatch (EcoWatch, April 14, 2022), https://www.ecowatch.com/vertical-farming-water-land-global-food-security.html.
[32] Ibid.
[33] Kathrin Specht et al., "How Will We Eat and Produce in the Cities of the Future? from Edible Insects to Vertical Farming—a Study on the Perception and Acceptability of New Approaches," *Sustainability* 11, no. 16 (September 2019): p. 4315, https://doi.org/10.3390/su11164315.

by taking control over its agricultural well-being. They have conducted over seventy studies all pointing to the need "to promote better nutrition and health,"[34] and enabling that through a concerted effort to "advance food sovereignty and build resilient ecosystems and communities."[35] Localizing food production previously thought impossible would serve these efforts immensely. The concept of "food sovereignty" should not be seen as completely detaching from the world's food engine, but re-tooling a broken system in Africa to become equally invested members in the global scheme. Despite these remarkable benefits, it is still important to address the potential shortcomings of indoor and vertical farming.

Melvin Kranzberg established a set of six "laws" he believed best encapsulate the interaction of technology with the world it both impacts and by which it is impacted. His third law, "technology comes in packages, big and small," is certainly relevant to the discussion of modern food technology.[36] While an individual greenhouse can be as large or small as required to meet a local need, the infrastructure and components required to operate such technology are numerous. They include electrical power, material distribution, education, and network and data integration. Thomas Hughes calls these "interacting, interconnected components…systems" rather than Kranzberg's "packages."[37] They, rather than the standalone greenhouse or vertical farm, represent the most difficult attribute of the future farmscape. An example of one of the most cited reasons for not adopting indoor and vertical farming is the high amount of electricity required to run the lights required to grow the plants and to control the environment within the greenhouse. Many parts of the world still rely on so-called "dirty" power to provide that energy.

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[34] "Evidence for Agroecology," AFSA (AFSA, June 11, 2021), https://afsafrica.org/evidence-for-agroecology/.
[35] Ibid.
[36] Melvin Kranzberg, "Technology and History: 'Kranzberg's Laws,'" *Technology and Culture* 27, no. 3 (1986): https://doi.org/10.2307/3105385, p. 549.
[37] Ibid., pg. 550

Most of the areas that experience food insecurity and famine, however, are uniquely suited to benefit from the most abundant and cleanest energy around: solar.

Africa in particular is a place "where sunshine is not only abundant but also much more reliable than elsewhere."[38] Yet renewable energy like solar and wind accounts for 3 percent of the continent's power generation as of 2018."[39] With a population around 1 billion people and an expected population of nearly 2 billion by 2050,[40] Africa is currently in need of and will dramatically increase the need for clean, cheap energy in the future. On a positive note, the International Renewable Energy Agency reports that "prices for renewable energy have fallen substantially in the past few years, especially for solar power, whose cost decreased 77 percent between 2010 and 2018."[41] The point here is that while cost is very often cited as the primary restriction on implementing new technologies, places with the most need are potentially the areas where it makes most sense to do so. In the case of vertical farming and solar production, Africa offers the proverbial two birds, one stone solution.

Implementation Cases: An Inexhaustive List

Much of this paper focuses on Africa, and for good reason. It represents both the current most food insecure area in the world as well as the one likely to suffer most in the coming years. But it is critical that efforts to mitigate food insecurity are not solely focused on Africa. For one, doing so would miss opportunities to improve the lives of people all over the world. Each unique example should have a bespoke solution. There is no one-size-fits-all fix for solving food-related issues. Secondly, emerging technologies require testbeds to ensure implementation of effective

[38] Gregor Schwerhoff and Mouhamadou Sy, "Powering Africa with Solar Energy – IMF F&D," IMF, accessed June 7, 2022, https://www.imf.org/en/Publications/fandd/issues/2020/03/powering-Africa-with-solar-energy-sy, p. 56.
[39] Ibid.
[40] Ibid., p. 54
[41] Ibid., p. 55

systems in areas with a no-fail requirement. A good example of this would be implementing the emerging technology in the United States, a relatively food secure place, to work out kinks before attempting to solve a far more difficult problem set in a place like Africa. Lastly, as in all constructs developed by humanity, belief in the objective and its utility is essential. What I mean by this is that there must be buy-in from those backing the effort before it can ever become reality. For this to become reality, both an effective plan and the means to execute it must be present. The following three implementation cases will speak to each of the points above. Consider each as both a standalone possibility, as well as complementary to one another and other efforts not included here. Because much of the information about food insecurity for this paper relies heavily on the African experience, it is only right that we start the cases there.

Growing Concerns in Nigeria

Africa is a vast continent with dozens if not hundreds of different levels and types of food insecurity. Parts of the continent are food stable, but undernourished. Others exist in a constant state of worry about from where their next meal will come. The most worrying part of the food security equation in Africa is the booming population growth. While worldwide percentages of food insecurity and malnourishment have shrunk over the last century, growing populations mean that even with those lower percentages, substantial numbers of people are still suffering. According to the United Nations, "more than half of global population growth between now and 2050 is expected to occur in Africa."[42] Within that already staggering projection is a troubling one wherein "the population of sub-Saharan Africa is projected to double by 2050."[43] The problem is that this area already struggles with food production, distribution, and storage.

[42] "Population," United Nations (United Nations), accessed June 7, 2022, https://www.un.org/en/global-issues/population.
[43] Ibid.

Without meaningful changes it will get even worse. To break down the problem and envision a workable solution, let us focus on a single country in Africa where the population is expected to not just double by 2050, but overtake the United States as the third most populous country in the world: Nigeria.

As you can see from the World Food Program Hunger Map on page five, Nigeria falls in the low-middle level. This means that between 5 and 15 percent of the population is undernourished. As discussed in the "So What" section of this paper, the ramifications of under- and malnourishment are significant with stunted growth, chronic illnesses, and behavioral issues among them. In a country with an expected four hundred million people by 2050, if the numbers do not improve Nigeria alone is looking at between 20 and 60 million people not getting enough to eat and suffering to varying degrees. Neither an ethical nor a rational model can reconcile numbers of that scale against a model of inaction. The price of doing nothing would be calamitous and will be discussed in the next few paragraphs.

It might seem to an average citizen of a developed, Western economy that a crisis in Africa would have little to no impact on their day-to-day life. Besides oil production, Nigeria produces and exports little that makes its way to the West. But when one takes a macroeconomic view of Nigeria, and Africa as a whole, it "should be a hub of activity in the global economy."[44] Growth is the name of the game in most modern economic models, and nowhere is growth more possible than in Africa. Emerging markets are essential to existing mature markets' healthy function in the international system. So, from a purely economic standpoint it makes sense to help Africa, and its most populous country Nigeria, ensure a smooth, healthy pattern of growth.

[44] "Africa as the Last Frontier: Why It Matters in the Global Economy," Wilson Center, accessed June 7, 2022, https://www.wilsoncenter.org/event/africa-the-last-frontier-why-it-matters-the-global-economy.

For that to happen, its people need to have sufficient food. The case study later in the paper will address that, but first there are two equally prominent issues for the states that fund the WFP, USAID, and other organizations aimed at stopping food insecurity to consider.

The status quo of the international liberal world order is being threatened by revisionist powers like Russia and China. The latter state especially has made vast investments into the continent and especially in coastal, oil-rich nations like Nigeria. The strategic importance to China of a secure source of fuel and potential future alliances and even basing for its assets is immense. The United States and other developed nations keen on keeping Chinese expansionism in check should take note of the ways to help countries like Nigeria "move away from resource-fueled development"[45] and that starts by helping establish a redundant, defensible, and effective system through which they can feed their burgeoning population. There is another equally if not more important issue to consider when weighing the importance of enduring aid to Nigeria.

If the Global War on Terrorism has taught us anything, it should be that waging traditional war against organizations like ISIS and Al-Qaeda is challenging, if not unwinnable. Both of those terror groups have paralyzed much of the Middle East and caused irreparable harm to the lives of innocent people around the region and the world. The specter of terrorism does not only lie in the Middle East. Boko Haram for example "is a Nigeria-based group that seeks to overthrow the current Nigerian Government and replace it with a regime based on Islamic Law."[46] That should sound familiar to anyone who has heard the proclamations of ISIS attempting to usurp existing governments in the Middle East and replace them with their

[45] Ibid.
[46] National Counterterrorism Center | Groups, accessed June 7, 2022, https://www.dni.gov/nctc/groups/boko_haram.html.

caliphate. Winning a war against these types of entities requires a top-to-bottom attack not just on their leadership and infrastructure, but on their very ability to craft a message of recruitment.

If you think that Boko Haram and other terrorist organizations in Africa are "their" problem, consider the August 2011 "vehicle-bomb attack on UN headquarters in Abuja—killing at least 23 people and injuring more than 80."[47] Boko Haram "claimed responsibility for the attack and promised future targeting of US and Nigerian Government interests."[48] Terrorists build a base of fighters by exploiting missing components of Maslow's Hierarchy. Food insecurity is just one of the areas that terrorists exploit by offering food and money for families. Finding solutions to that weakness means fewer avenues for terrorists to recruit which means fewer targets they can attack and an easier problem for law enforcement and military forces to solve. With these issues identified, we can now address some mechanisms to attrit them.

Nigeria is reliant on imports for some of its nutritional requirements. FEWS NET, the USAID's key early warning food insecurity and famine assessment tool, highlights "high transportation costs coupled with the high global food prices related to the Ukraine crisis" as partly to blame for Nigeria's current middle level of food insecurity.[49] Adding to these issues is persistent "conflict in northwest and northcentral states" which prevents effective harvesting of existing crops.[50] Omodero, et al. offers the "revival and enhancement of the agricultural sector…" as the "only effective antidote to the rising challenge of hunger in the country."[51] Systems like vertical greenhouses, capable of growing nutritious crops all year, in all climates, in

[47] Ibid.
[48] Ibid.
[49] "Famine Early Warning Systems Network," Nigeria | Famine Early Warning Systems Network, accessed June 7, 2022, https://fews.net/west-africa/nigeria.
[50] Ibid.
[51] Cordelia Onyinyechi Omodero, Dorcas Titilayo Adetula, and Francis Odianonsen Iyoha, "Agricultural Revamping via Major Capital Outlay: the Antidote to Food Insecurity Challenges in Nigeria," *Academy of Entrepreneurship Journal* 26, no. 4 (2020): p. 1

a disaggregated manner, mean less centralized reliance on complicated distribution chains. Aid organizations are already trying to find lasting solutions to food insecurity in Nigeria, especially "the worsening complex humanitarian crisis in the Northeast."[52]

USAID, for example, focuses on a multi-layered approach including "developing assistance to help ensure long term recovery in the region."[53] By targeting assistance into vertical greenhouses like the one below, less emergency aid will be required in the future.

Figure 3: Eden Green Vertical Farm

[52] "Nigeria," U.S. Agency for International Development, September 22, 2020, https://www.usaid.gov/nigeria.
[53] Ibid.

As Eddy Badrina, CEO of Eden Green Technology puts it, "this facility symbolizes a paradigm shift for how capital investment is being leveraged to do the most good where it's needed."[54] Producing healthy vegetables and leafy greens right where they are needed reduces stress on the emergency relief supply chain. Like butter spread over too much bread, finite aid needed in too many areas results in all areas receiving less than necessary. With effective, enduring food infrastructure emplaced in areas currently without them, emergency aid can more effectively target places with the most dire circumstances, The goal of food aid is to help areas suffering from food insecurity and famine to overcome their ill effects and get to a position of lasting food security. What was impossible only years ago is now, with the advancement of greenhouse technology and "sufficient capital expenditure,"[55] a very real possibility. States like Nigeria represent one of the most tenuous areas in the world in terms of food insecurity, but even places like the United States suffer from its effects. Our next case study focuses on the urban food desert and its far ranging consequences for people living in them and society in general.

Planting In A Food Desert

It may shock people to learn that nearly 12 million children in the United States faced persistent hunger in 2020.[56] Those children come from the 10.5 percent of US households that were food insecure for at least part of the year and of those almost 4 percent experienced high levels of food insecurity.[57] An additional wrinkle in this story is the uneven distribution of food

[54] Allison Dupuis, "New Greenhouse & $12M Expansion," Eden Green Technology (Eden Green Technology, November 4, 2021), https://www.edengreen.com/blog-collection/eden-green-technology-breaks-ground-on-new-texas-greenhouse-continues-with-12-million-strategic-expansion.
[55] Omodero, et al., p. 3
[56] "Hunger Deprives Our Kids of More than Just Food," Feeding America, accessed June 7, 2022, https://www.feedingamerica.org/hunger-in-america/child-hunger-facts.
[57] "Food Security and Nutrition Assistance," USDA ERS - Food Security and Nutrition Assistance, accessed June 7, 2022, https://www.ers.usda.gov/data-products/ag-and-food-statistics-charting-the-essentials/food-security-and-nutrition-assistance/#:~:text=The%20prevalence%20of%20food%20insecurity,had%20very%20low%20food%20security.

insecurity in this country. Single-parent families experience a greater degree than homes with two parents, and Black and Latino children "are more than twice as likely to face hunger as white children."[58] In their article, "Barriers to Food Security and Community Stress in an Urban Food Desert," Jessica Crowe, Constance Lacy, and Yolanda Columbus explore the world of an urban food desert and "describe how residents…access food, the barriers they experience in accessing nutritious, affordable food, and how community food insecurity exacerbates prior social, built, and economic stressors."[59] This case study explores their analysis and marries it with topics explored in previous sections while laying out potential solutions.

Crowe et al., through inputs from focus groups conducted in areas defined as food deserts, predominantly among "poor, less educated, African American and Latino"[60] citizens, provides insight into the environments of people living there. Additionally, they explore empirical evidence from studies conducted on urban environments regarding housing, services within those neighborhoods, and the impacts of food security related issues. Since this case study focuses on mitigating food insecurity specifically, the other issues will only be used for supporting evidence. One of the main topics the authors explore is the impact of suburban expansion to grocery store placement. As suburban landscapes grew, and "white middle class families left the city for the newer suburbs, the grocery stores followed."[61] The reason for the shift was because "suburbs, with their residents with higher buying power, were attractive to chain supermarkets for both their markets and locations."[62] While this seemingly made sense

[58] "Hunger Deprives"
[59] Jessica Crowe, Constance Lacy, and Yolanda Columbus, "Barriers to Food Security and Community Stress in an Urban Food Desert," *Urban Science* 2, no. 2 (2018): p. 1, https://doi.org/10.3390/urbansci2020046.
[60] Ibid., p. 14
[61] Ibid., p. 3
[62] Ibid.

from a business perspective, it left a gaping hole in the urban food chain, primarily in low-income, minority communities. The fallout from this grocery store exodus is multi-faceted.

On one hand, large grocery stores have a far greater selection of fresh, nutritious items like produce. When large stores are absent, smaller, higher-priced stores fill the void. They have smaller selections of fresh produce, and what they do have is more expensive. Residents of lower-income urban areas must then choose whether to travel further to get better selections and lower prices, spend more at the closer stores, or cut healthy but expensive items like fresh produce from their shopping list in favor of less healthy, cheaper food.

Another issue with the lack of grocery stores in impoverished areas relates to traveling to get more and healthier options. Many people who live in these areas either have no vehicle or must take inefficient and sometimes dangerous public transit.[63] There is, because of this schism between private market profit and lower-income urban grocery placement, a gaping hole in communities that desperately need access to healthy, affordable food. Here it is essential to find enduring practical fixes like in Nigeria.

In 2020, the United States Department of Agriculture spent 122 billion dollars on food and nutrition assistance.[64] Because of the density and demographics of urban areas, cities received much of the funding. While increasing spending on social programs has a tendency of stirring debate among politicians and everyday citizens, there is both pragmatism and an ethical imperative in fixing the urban food desert problem. Moving some food production into the neighborhoods where it is most needed is a step toward it. Food deserts and food insecurity cause problems that cover the spectrum from physical to emotional, mental to social. These could be

[63] Ibid., p. 11
[64] USDA Food Security

improved by introducing vertical farm greenhouses, hydroponic, aeroponic, and robotic systems to grow fresh, nutritious food.

First, going back to the "So What" section of this paper, recall that malnutrition leads to a variety of childhood ailments including but not limited to developmental impairments, behavioral problems, educational issues, and physical and emotional stress.[65] Bringing nutritious, lower cost produce to poor urban neighborhoods could drive full-spectrum health improvements.[66] Second, unemployment and underemployment is more common in urban areas than suburbia. Introducing systems that require employees to function means local employment increases, as well as increased exposure to Science, Technology, Engineering, and Math (STEM) fields. Finally, while impossible to say for certain, improving the overall health of citizens in poor, urban areas, and bolstering job opportunities within their communities, it is likely that the need for food aid like the SNAP program administered by the USDA will be reduced. Again, this case is not offered as a moral imperative, despite arguments for it, but as a pragmatic, utilitarian one wherein the costs associated with implementation are outweighed by the long-term gains for all. The final portion of this section offers a means through which both preceding cases can be made more palatable to cost-sensitive politicians and their constituencies.

The Instruments of Power

Many readers may be familiar with, or at least have heard of, the concept of the Diplomatic, Informational, Military, and Economic (D.I.M.E) instruments of power. The United States has long been the standard bearer of these concepts within the international liberal world order. But the waters of international politics are muddying and no longer are the US or its

[65] Child Hunger
[66] Crowe, et al., p. 14

partners able to establish the status quo across these instruments. Dr. Molly Jahn, et al., explores food security and food systems through the lens of United States Special Forces considerations and identifies these systems as "an unconventional, poorly understood risk surface subject to both intentional and unintentional disruptions."[67] They identify the fragility of a global food system predicated on things like key nodes of transportation and consistency throughout the entire chain of production.[68] Disaggregating food production to an extent, as laid out in the case studies above and throughout this paper, exponentially increases the resiliency of our food system. Because of this, the United States military and its allies should be heavy participants in establishing this new norm. For this paper, however, I will focus specifically on the United States military and how it can enact positive changes to food security around the globe.

Employing the military in humanitarian crises is commonplace. From earthquakes in Haiti to tsunamis in the Pacific, tornadoes in the Midwest to hurricanes in Louisiana, the military frequently responds to areas in need of immediate assistance. But why not use the military to establish lasting food security in places that desperately need it, all while bolstering the diplomatic credibility of the United States? With powers like China seeking to supplant the United States in the international world order, or at the very least gain parity in influence, it is more important than ever to ensure stability in the global system. It is also crucial to maintain and establish new alliances and partnerships with other states. Secretary of State Antony Blinken

[67] Molly Jahn et al., "Contemporary Global Food Systems as Contested Space: Implications for Special Operations Forces," in *Strategic Latency Unleashed: The Role of Technology in a Revisionist Global Order and the Implications for Special Operations Forces* (Lawrence Livermore National Laboratory: Center for Global Security Research, 2021), p. 148
[68] Ibid., p. 151

believes we should be "striving at all times to ensure that American diplomacy is serving our national interests in what is a rapidly changing and increasingly complex world."[69]

While deploying military forces under the auspices of a preemptive humanitarian assistance project might be looked at sideways by some, the need is too great to be conservative. Consideration must of course be given to messaging associated with this endeavor. For example, believers in Kantian ethics may view a military deployment as violating the categorical imperative of free will in execution of the moral action.[70] Similarly, a utilitarian-minded individual may argue against the resources required to action this type of plan. In turbulent times, like those we are experiencing now with war in Ukraine, simmering tensions between nuclear powers, climate change, pandemic, and a whole litany of other issues, it is easy to see the merit in insulating oneself and those closest to them from the churn. But both mindsets fail to grasp the time-scale benefits of solving the food insecurity problem now.

For those Kantians concerned with the motivations behind military involvement, it is essential to realize the overarching benefits to domestic and global security in achieving food security. This is inherently the duty of the military, to make safer the populations they are charged to serve. Whether all members of a deployed force all possess the same level of moral motivation to cure the malignancy of hunger and its metastases covered in the "So What" section of this paper is irrelevant. They serve to protect and there is no better way to do so than to stabilize and bolster the institutions and apparatuses that make our modern world a good place to live.

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[69] "Secretary Antony J. Blinken on the Modernization of American Diplomacy - United States Department of State," U.S. Department of State (U.S. Department of State, April 4, 2022), https://www.state.gov/secretary-antony-j-blinken-on-the-modernization-of-american-diplomacy/.
[70] Kant's Moral Philosophy, p. 2

Utilitarian concerns of resource scarcity are misguided. There is no better time to resolve hunger and food insecurity than the present. With the drawdown of forces in the Middle East and Afghanistan, personnel resources are more available now than at any time in the last two decades. The United States military has until now rightly focused their attention on combat readiness but what defines that readiness has manifested into something different. The modern military needs more soldier-statesmen to win battles that exist in gray zones. Education beyond traditional warfighting methodologies is crucial. To promulgate food systems like the vertical greenhouse example in this paper, the military will need to establish subject matter expertise in its ranks. As Jahn, et al. discuss in their work on food systems and special operations forces (SOF), they "should consider the control and management of food systems in any preparation for operations and war plans."[71] What better way to gain an intimate understanding of the complexity of deployable food systems and the overarching framework required to sustain operations than to practice by helping solve one of humanity's enduring problems? Education will be essential to establishing this ability.

Partnering with commercial and university resources to build this knowledge base is crucial. Of note, the goodwill and publicity generated by these partnerships will mutually benefit all parties involved. Diplomacy will also play a huge role in gaining traction to establish new technologies in places where corruption and lack of infrastructure is commonplace.

[71] Jahn, et al., "Contemporary Global Food Systems". p. 155

Conclusion

Climate change, revisionist powers seeking to change the world order to their liking, polarized politics without comparison in recent times, and a host of other maladies plague our world. Dystopian fiction has long centered around a world in chaos, one in which food and water are scarce, but violence and calamity are plenty. Where once alien invasions and super-viruses that turn people into zombies reigned supreme in public imaginations, there is now a new type of future being written. In the movie "Interstellar" the crisis that lifts our collective gaze to the stars is not an alien one, but one of our own making. Our collective inability to produce food in an increasingly hostile environment sends us on a search for solutions in the stars. Our changing climate, regardless of its catalysts, certainly has the potential to cause problems of extreme magnitude for our food supply if we fail to capitalize on emerging technological answers.

There is both an ethical and pragmatic imperative driving us to make substantive changes leading to a more food secure world. The bottom line is that our food systems' status quo is failing to keep pace with the myriad threats it faces. It calls for new and innovative approaches, not limited to those which are politically convenient. Bureaucracy must not be allowed to act as a reverse salient to "technologically 'sweet' solutions" like those available in the battle against food insecurity.[72] As mentioned in the first paragraph of this paper, humans have a remarkable ability to adapt and overcome obstacles. While the emerging technology discussed in this paper is certainly not a panacea for our continued struggle with food security, it presents hope for a future in which insecurity is scarce rather than food. As much as the problems caused by hunger, food insecurity, and famine compound and have impacts reaching far beyond the areas they

[72] Kranzberg, p. 551

attack, so too do the benefits of resolving them. People sufficiently fed can grow and thrive where they live. The communities they populate become more productive and secure. The global world order is strengthened by states made whole through thriving communities. We are both duty-bound to act as well as to realize the utilitarian benefits in doing so. These are not unattainable goals or pipedreams; they are well within our grasp. We need only to reach out to make them reality.

"The war against hunger is truly mankind's war of liberation" – JFK

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