WISCONSIN
UNIVERSITY OF WISCONSIN–MADISON

THOMSON REUTERS®

Global Food System Stability and Risk

At the Nexus of Defense and Development

Thomson Reuters

April 2018

NASA does not endorse or sponsor any commercial product, service, or activity; any mention of a product, service, or activity does not constitute NASA endorsement.

Authorship Team

Molly Jahn[1], "Jay" Buddhika Jayamaha[2], William S. Mulhern[3], Douglas E. Ross[4], Matthew A. Rose[5], Gregory F. Treverton[6]

Author Affiliations

[1]Professor, University of Wisconsin-Madison; Adjunct Research Scientist, Columbia University, Guest Scientist, Los Alamos National Laboratory; NASA Earth Observations for Food Security and Agriculture Consortium

[2]Postdoctoral Fellow, University of Wisconsin-Madison; Research Associate, Northwestern University

[3]Associate Research Specialist, University of Wisconsin-Madison

[5]Retired, National Geospatial Intelligence Agency

[5]Department of Defense/United States Army War College

[6]Professor of the Practice of International Relations, University of Southern California

Thomson Reuters Contributors

Brian Ulicny, Brian Romer, Kate Friedrich, Robert Buergenthal, Dawn Scalici

Acknowledgments

We thank the following colleagues for important discussions, review and support of this work: Carol Barford, Peter Brooks, Hriar Cabayan, Thomas Conroy, Nina Fedoroff, Randy Fields, Joseph Glauber, Philip Karsting, Marc Levy, Ed Majewski, George Meyers, Michael Obersteiner, Michael Puma, Will Reno, Rod Schoonover, Emmy Simmons, Bob Tetrault, Hakim Weatherspoon, Jen Ziemke, Ashley Zung,and a number of USG geospatial all source analysts.

The views expressed in this report are those of the authorship and do not necessarily reflect those of the U.S. Army War College, U.S. Army, or the Department of Defense.

Table of Contents

List of Figures

Foreword

Dr. Gregory F. Treverton, Report Chair

Professor of the Practice of International Relations, University of Southern California and former Chair, National Intelligence Council, ODNI

Last year, I had the privilege of leading the release of a major quadrennial report from the U.S. National Intelligence Council, Global Trends: The Paradox of Progress.[1] In this report, we highlighted six trends that are shaping this century, and changing the nature of power, peace and conflict. These same trends generate near term risks but also also create discontinuous opportunities to build resilience. We especially highlighted climate change and its attendant effects – more extreme weather events and increasing pressure on both water and food systems, as storms and droughts drive people to move, often into areas where they cannot be sustained or are unwelcome. At a minimum, insecurity about food will exacerbate other sources of political turmoil, especially, but not only in poorer countries. The long-term effects on food and water in Puerto Rico after Hurricane Maria's destruction and ongoing anxieties in the United States over the vulnerability of the power grid make clear that America itself is vulnerable.

In 2016, I was first introduced to some of the work that served as the basis for this paper through the negotiation of a Cooperative Research and Development Agreement (CRADA) between the U.S. National Geospatial Intelligence Agency and the University of Wisconsin-Madison focused on food security, food systems and national security interests. I had the opportunity to foreshadow both Global Trends and issues in this paper when I was asked to give a keynote address and to introduce a recent NIC assessment at the awarding of the World Food Prize in Iowa in 2016.[2] Based on results from the UW-Madison CRADA, Congress included in the 2018 National Defense Authorization Act a mandate to the US Secretary of Defense to conduct a study of vulnerabilities relevant to the US Defense Department missions and obligations that could derive from or be worsened by instabilities in global food systems.

I had long been interested in the national security issues surrounding food and water, which usually get discussed as "new" security issues but in fact are as old as humankind. The management of resources generally, and food more specifically, has always played a role in shaping human conflict and especially warfare. The conflict in Darfur, Sudan, for example, is at root a conflict over water. Yet even the language of "food security" conjures up acres and stockpiles and acre-feet of water. In fact, food production and distribution is by definition a complex and interconnected system – a central theme of this paper. Food and water are routinely used as weapons in many ways. During an earlier stint at the NIC, we prepared a paper looking ahead to possible humanitarian crises around the world. The requester was the military's transport command, which wisely wanted to know if places to which they would be asked to deliver relief supplies had air and sea ports. Sadly, since most humanitarian crises have their roots in conflict or drought, or some combination of the two, predicting them was no hard task.

Even if food and water are not used as weapons, a host of changes in the past twenty years – in the structure and functioning of markets, logistics, agricultural production, natural resource distribution and integrity, population and urbanization – have dramatically reshaped contemporary food systems with as yet unchartered implications. This report offers new frames, illustrated by scenarios, to apprehend how humanity's intersecting demands for food, water, energy, and minerals may set up systemic vulnerabilities, ones that cascade in unpredictable ways across the global system.

At the same time, though, it echoes Global Trends in highlighting new strategies to mitigate vulnerabilities and build resilience. Both the broader frame and new strategies are imperative if the globe is to avoid the types of crises portrayed in the paper's scenarios. I have been fortunate to be working at a time where these connections are relatively accessible, but I do not yet feel that the U.S. intelligence and defense communities fully appreciate the importance of considering contemporary structures and functions of the world's food systems and their implications for U.S. and global security.

[1]The report is available at https://www.dni.gov/index.php/global-trends-home.
[2]National Intelligence Council, Global Food Security, September 2015, available at https://www.scribd.com/document/286522581/National-Intelligence-Council-Intelligence-Community-Assessment-Global-Food-Security-22-September-2015.

Food/vegetable market in Jakarta, Indonesia Thomson Reuters

Executive Summary

Contemporary global food systems are complex, dynamic, rapidly adaptive, and intertwined—operating well outside every historical precedent. This condition has developed relatively quickly, outpacing both conventional statistical representations, and, likely, traditional strategies to mitigate large scale vulnerabilities.

An intense focus on efficiency since World War II and especially in recent decades has also likely had the typical effect of driving various types of resilience out of global food systems as a whole and setting up the potential for relatively foreseeable, cascading effects.

In 2015, governments, civic leaders, militaries, financial institutions, multilateral organizations and the private sector each in their own lanes, came together at the UN to make unprecedented commitments to "sustainable development" through the adoption of the Sustainable Development Goals. Many of these goals and their indicators, either directly or indirectly, affect or are affected by land use, food production, distribution, and diet-related health.

The "food system" frame puts a spotlight on these dynamic, complex interactions between traditionally disaggregated features of the same underlying systems. It is at these intersections, moving quickly in real time, where the greatest opportunities to stabilize the system may likely lie. It is also at these intersections where potential "cascades" of challenges, including natural hazards, conflict, dislocation and migration may work together to catastrophic result. Can large-scale scans of unconventional data, ranging from critical infrastructure and trade to sentiment, offer new ways to better "see" signatures of impending risk, threats, vulnerabilities and opportunities in global food systems and the more local systems that compose them? The food system frame also highlights the potential for deep convergence between economic development, humanitarian imperatives, and interests charged with peace-keeping and managing conflict.

This paper reviews the opportunities afforded in a world awash with real-time and near real-time data to better reflect and inform the ways in which both risks and opportunities in our food systems are managed.

Driven by both traditional and gray zone conflict across a wide spectrum of intensity and stresses, 2017 saw one of the worst years for famine since World War II, and also one of the largest human migrations in the history of humanity. These trends set the stage for novel approaches to identify opportunities using familiar and new data and visualization techniques to illuminate and scrutinize major vulnerabilities that cut across many traditional boundaries toward securing more stable food systems, and therefore more peaceful, equitable and prosperous futures for all.

Introduction

The introduction of the conceptual frame of "food systems," a term applied from global to very local scales, has been a crucial advance resulting from post-9/11 applications of more sophisticated approaches to supply chain integrity and cybersecurity.

"Food systems" now join more familiar terms related to agricultural and food supply chains, critical infrastructures related to food production and distribution, agricultural productivity, resource use efficiency and the traditional economically-derived estimates of food security. This essential innovation in the way we perceive this critical aspect of modern society at the convergence of agriculture, manufacturing, technology, trade and logistics, national and human security and diet-related public health, brings into sharp focus a new analytical and operational frontier at the intersection of global security and development. A focus on food systems formally recognizes the obvious characteristics of complexity that underlie the many ways a person in a particular place does or does not have access to food and clean water adequate to maintain health, personal safety, civil order and community. The dynamic and complex nature of food systems, essential to understanding the most consequential trends in the 21st century, are not, by definition, captured by the traditional quantitative and more static reflections of "food security."

Defense, intelligence, and development, communities that are frontline in monitoring or surveillance of food systems understand that contemporary decision-relevant views of food system stability will require novel food system risk assessment frameworks.

As a direct result of globalization, food systems have been optimized under international trade regimes, subject to a wide array of dynamics and influences. Despite robust and steep gains in agricultural productivity and resource use efficiency for most of the 20th and early 21st centuries, 2017 was one of the worst years for food crises since World War II.[1] These crises impacted a cross-section of countries across development levels ranging from South Sudan to Puerto Rico. High and medium income countries faced food shortages as food systems failed due to extreme natural events.[2] Lower-income countries fared worse, given that they faced famine, incipient famine and severe food insecurity conditions as food systems failed due to the interactive effects of conflict and natural events that were compounded by bad governance, weak state institutions and chronically inefficient markets.

[1] Ferguson, Jane. 2017. "20 Million Starving to Death: Inside the Worst Famine since World War II." Vox, June 1, 2017. https://www.vox.com/world/2017/6/1/15653970/south-sudan-hunger-crisis-famine.
[2] Irfan, Umair, and Brian Resnick. 2018. "Megadisasters Devastated America in 2017. And They're Only Going to Get Worse." Vox, March 26, 2018. https://www.vox.com/energy-and-environment/2017/12/28/16795490/natural-disasters-2017-hurricanes-wildfires-heat-climate-change-cost-deaths.

Food systems also lie at the heart of United Nations Sustainable Development Goals (SDGs) adopted by every nation in September 2015 as the shared global agenda for the next 15 years.

Of the 17 global goals, SDG 2 specifically addresses "food security" in its traditional sense, instructing the global community to "end hunger, achieve food security and improved nutrition, and promote sustainable agriculture."[3] Over the past several decades, however, the global community has tended to equate maximizing cereal crop yields, and optimizing value chains to "food security," rather than on building locally or regionally resilient food systems in demonstrable long term balance with human needs related to health and wellbeing and with the natural resource base. Historically, the development of interconnected markets did hedge against local and regional agricultural stresses. More recently, it has been assumed that the highly complex agriculture value chains simultaneously increase efficiency of production, distribution and consumption while reducing risks. Yet the food price spikes in 2008 illustrated starkly, for both international development and security communities, that this assumption may not hold in all instances, with potential consequences in social unrest, political instability and conflict.

In view of the changes, public and private sector stakeholders are testing innovative methods to characterize and harness complexity and uncertainty inherent to this new frame of a "global food system." They are adopting the view that steering our local, national and global food systems is more like riding a bicycle than building the biggest pile of meals ready to eat (MREs), grain stocks or capital. At contemporary scales, a stockpile of virtually any magnitude can be depleted quickly and potentially commandeered. The alternative view suggests an opportunity to innovate dramatically on shorter temporal and smaller geographic scales as is already happening at the margins with "vertical agriculture" or edible insects. This type of diversification and decentralization is a classic defense strategy.

To illustrate the potential value of such a framework, four plausible food system failure scenarios are described below. Each example is crafted to illuminate intricate distributions of risks, threats and vulnerabilities across the systems in question, and how cascading effects in deeply integrated systems may subvert traditional "analog" conceptual categories. In each illustration, an amalgamation of societal, economic, political and security drivers that overlap development and defense sectors are consolidated to highlight the ways in which these interactions among relatively modest individual effects can set off larger scale system instability and failures and how such dynamics may be systematically operationalized and modeled to generate country or region-specific, decision-relevant data streams. These scenarios capture structural changes that have occurred over time and across geographies to better define and assess critical thresholds. Each illustration highlights how the traditional partnerships between actors in the defense and development/humanitarian sectors are evolving to create positive externalities and room for innovation to better monitor, assess and mitigate food system risk.

[3] United Nations. n.d. "Sustainable Development Goal 2." Sustainable Development Goal 2 Knowledge Platform. Accessed April 2, 2018. https://sustainabledevelopment.un.org/sdg2

Aerial View of Drought Conditions Thomson Reuters

GLOBAL AND REGIONAL FOOD SYSTEM RISK

Between Resilience and Vulnerability

"Food systems" are a series of interconnected, overlapping and intersecting socio-technical networks that link people with each other and to resources across multiple spatiotemporal scales.

Food systems are in essence canonical "complex systems," that is, by their very nature, they are never completely knowable and highly dynamic, with non-linear and emergent patterns strongly evident.

By definition, a food system therefore includes "all the elements (environment, people, inputs, processes, infrastructure, institutions, etc.) and activities that relate to the pre-production, production, processing, distribution, preparation, and consumption of food and the outputs of these activities, including socio-economic and environmental outcomes."[4] In addition to traditional and less conventional security concerns, "food systems operate within and are influenced by socio-cultural, economic, political, and environmental contexts".[5]

Risk is a social construct dating back several centuries with the advent of concepts of probability applied to what had previously been considered only the realm of the gods. "Systemic risk" is defined as an emergent property in many complex systems. In this frame, the risk of food system instability may emerge as a result of any of the constant tensions between food system resiliencies and food system vulnerabilities. For centuries food systems and food webs have been conceptually understood mechanistically with hierarchical order often termed "food chains." Under stable conditions, food systems function quite reliably as value chains, defining and reacting to market signals, seamlessly connecting people with resources and each other. Embedded complexity allows such systems to adopt, adapt and evolve, generating internal resiliencies within a wide spectrum of usual conditions. In moments of crisis, complexity tends to make networked properties of the "chain" more evident, allowing unforeseen resilience or susceptibility, and compounded knock-on effects, generating internal dynamics of vulnerabilities. Both recognized and unrecognized elements, including local, national and regional determinants act to shape responses of the system, the nature and dimensions of risk and/or opportunity in the system, and the dynamics of whether a system steers toward stability or collapse.

A country's level of development, for instance, remains a major macro-level determinant of food system risk. Populations of middle-income countries (MIC) and low-income countries (LIC) tend to be affected by endogenous chronic stressors such as weak institutional capacity and endemic corruption as well as direct issues of food supply, quality and distribution. When these more generally susceptible systems are subject to an acute shock such as violent conflict, rapid onset drought or flood, they can be pushed past an internal, unforeseen tipping point, rapidly steered toward crisis.[6] This dynamic was reflected by catastrophic famine and incipient famine conditions that ravaged Yemen, South Sudan, Somalia, and the Lake Chad Region during much of 2017.[7]

[4] Niles, Meredith, Jimena Esquivel, Richie Ahuja, and Nelson Mango. 2017. "Climate Change and Food Systems: Assessing Impacts and Opportunities." Washington, D.C.: Meridian Institute. http://www.merid.org/Content/Projects/Climate_Change_and_Food_Systems_Assessing_Impacts_and_Opportunities.aspx
[5] Ibid
[6] Mathys, Ellen, Lesley Oot, and Kavita Sethuraman. 2017. "USAID Office of Food for Peace Food Security Desk Review for Niger." Washington, D.C.: USAID/FHI 360/FANTA.
[7] International Crisis Group. 2017. "Instruments of Pain: Conflict and Famine." Briefing 52. Middle East & North Africa. Brussels. https://www.crisisgroup.org/middle-east-north-africa/gulf-and-arabian-peninsula/yemen/b052-instruments-pain-i-conflict-and-famine-yemen.

High-income countries (HIC), with enhanced institutional capacity and greater levels of development, more efficient markets and better emergency management agencies are generally viewed as better at implementing counter measures in response to instability but are still not immune to systemic risk and abject relatively large scale failure. This was tragically evident during the wildfires, floods, and most notably is still the case in parts of Puerto Rico, where serious disruptions still linger months after Hurricane Maria.[8] Puerto Rico experienced massive water and energy infrastructure damage in addition to major agricultural production shocks. According to Puerto Rico's Secretary of Agriculture, 80 percent of Puerto Rico's crop value was destroyed within a few hours of Maria making landfall.[9] Similarly, political unrest, hyperinflation and shortages of food and medicine led the Executive Director of the World Food Programme (WFP) to warn the world that Venezuela—and by extension neighboring Colombia—face a humanitarian crisis.[10]

As mentioned above, historically, and increasingly in the past two centuries, globally integrated markets and supply chains have allowed risks and failures to be spread through the global food system with greater ease. This same interconnectedness, however, can generate and amplify vulnerabilities, as has been repeatedly demonstrated in the past decade in other supply chains by the 2011 Thai floods[11] or the horrific consequences of Fukushima.[12] As food system risks and failures proliferate, actors from development, defense, humanitarian, faith-based and the scientific/technical innovation communities are coalescing efforts to frame out conceptions of a global food system that are adequate for this century. These efforts aim to negotiate and implement mechanisms to define, assess, monitor, mitigate and transfer risk toward avoiding the worst case possibilities that may result from our vast "success," and to create new spaces for humanity to innovate and prosper.

FIGURE 1

Food Resilience vs. Overall Readiness

Food Resilience is measured by projected change of crop yields, population change, food import dependency, rural population, agricultural capacity and child malnutrition. Readiness is measured by economic, governance and social readiness. Indicators include ease of doing business, political stability, rule of law, social inequality, infrastructure, education and innovation.

Source: Notre Dame Global Adaption Initiative

[8] Mazzei, Patricia, and Omaya Pascual. 2017. "'Days Were Lost': Why Puerto Rico Is Still Suffering a Month after Hurricane Maria." The Miami Herald and the Center for Investigative Journalism, October 20, 2017. http://www.tbo.com/news/weather/hurricanes/days-were-lost-why-puerto-rico-is-still-suffering-a-month-after-hurricane/2341773; CNN Wire. 2017. "Vital Aid Stranded at Puerto Rico's Main Port, Unable to Move Due to Ravaged Infrastructure." KTLA, September 28, 2017. http://ktla.com/2017/09/27/vital-aid-stranded-at-puerto-ricos-main-port-unable-to-move-due-to-ravaged-infrastructure/.

[9] Robles, Frances, and Ferré-Sardurní. 2017. "Puerto Rico's Agriculture and Farmers Decimated by Maria - The New York Times." New York Times, September 24, 2017. https://www.nytimes.com/2017/09/24/us/puerto-rico-hurricane-maria-agriculture-.html.

[10] Goodman, Joshua. 2018. "UN official warns of humanitarian "catastrophe" in Venezuela." The Seattle Times, March 12, 2018. https://www.seattletimes.com/nation-world/un-official-warns-of-humanitarian-catastrophe-in-venezuela/

[11] Reuters Staff. 2011. "Factbox: Thailand's Flood Crisis and the Economy." Reuters, November 2, 2011. https://www.reuters.com/article/us-thailand-foods-factbox/factbox-thailands-flood-crisis-and-the-economy-idUSTRE7A11BC20111102.

[12] Saito, Yukiko. 2013. "Supply-Chain Vulnerability: An Analysis of the Impact of Earthquakes Using Micro Data." VoxEU.Org (blog). December 15, 2013. https://voxeu.org/article/supply-chain-vulnerability-fukushima-evidence.

MOVING BEYOND "FOOD SECURITY"

A Frontier at the Defense-Development Nexus

In 2018, for the first time since the end of World War II, the United States Government in its National Defense Authorization Act (NDAA) formally recognized "global food systems" as a direct defense and national security concern.[13]

Although both public and private sector actors have long argued this point, the NDAA recognition is significant in several respects.

First, this study imperative forces a reevaluation of existing assumptions about the relationships between agricultural productivity, general food abundance and food system performance. Additionally, this legislation reflects and requires the emergence of new analytical and operational frontiers in "seeing" and "managing" global and national food systems from the vantage point of the U.S. Department of Defense (DoD). It also requires an evaluation of the adequacy of the extent to which current planning considers potential food system vulnerabilities, weaponization of food systems or information about food, via markets, media or other mechanisms.

The intersection of food and warfare is as old as warfare itself. The Law of Armed Conflict recognizes this fact and international order restricts the use of food as a weapon of war[14]. While this defines the currently prescribed international standard for weaponization of food, the history of the Allied effort during World War II is especially pertinent for illustrating the extreme importance of driving food systems toward sufficiency and stability. Extraordinary transnational dedication was exhibited by the Allies, especially the traditional English speaking alliance known as the Five Eyes (FVEY). Rounds of institutional experiments to mobilize food resources for all Allied purposes resulted in major institutional innovations as well as major scientific advances in nutrition, food preservation and transport. At the end of World War II, however, the U.S. interagency body managing the U.S. food system and allied food supply efforts—the Combined Food Board, one of several Combined Resource Boards—was disbanded. Food was subsumed under the broader United States-led trade agenda, falling under the rubrics of General Agreement on Tariffs and Trade (GATT).[15] The objective was creating efficient market conditions so that food value chains would function effectively, responding to market signals. Policy makers concerned with the developing world approached food in terms of combating caloric deficiencies by increasing overall agricultural productivity and trade. That approach evolved into what is today encapsulated by the concept of "food security," which since World War II has fallen under the purview of the humanitarian aid and international development community. During the Cold War, as a surplus agricultural producer, the U.S. relied on its abundant food stocks to achieve foreign policy objectives through the use of programs such as Food for Peace.[16] In the post-Cold War world, food was further subsumed under development and diplomatic mandates of U.S. international engagements.[17]

Through these post-war decades, the term, "food security" came to be used as a proxy for food system stability and human security, spurring extreme advances in crop and livestock yield potential and the use of energetically intensive exogenous inputs such as ground water irrigation and synthetic nitrogen fertilizer derived from fossil fuels. In the immediate post-war era where recovery from a globally catastrophic conflict also

[13] Thornberry, Mac. 2017. National Defense Authorization Act for Fiscal Year 2018. https://www.congress.gov/bill/115th-congress/house-bill/2810/text#toc-H6BE4DD7D95D24C-609893CFC47E168EEB.

[14] Solis, Gary D. 2010. The law of armed conflict: international humanitarian law in war. Cambridge [Eng]: Cambridge University Press.

[15] Collingham, Lizzie. 2012. Taste of War: World War II and the Battle for Food. Penguin.

[16] Riley, Barry. 2017. The Political History of American Food Aid: An Uneasy Benevolence. Oxford University Press.

[17] Finney, Nathan. 2010. "A Culture of Inclusion: Defense, Diplomacy, and Development as a Modern American Foreign Policy." Small Wars Journal 26: 1–6; Department of State, United States Agency for International Development, and Department of Defense. 2012. "Diplomacy, Development, Defense Planning Guide." 3D Planning Guide. Washington, D.C.: USAID. https://www.usaid.gov/sites/default/files/documents/1866/3D%20Planning%20Guide_Update_FINAL%20%2831%20Jul%2012%29.pdf.

offered great economic opportunity for the United States, food production and manufacturing was itself industrialized. Many of the advances pioneered in World War II related to nutrition and food processing were introduced into the commercial sector resulting in an unprecedented explosion of globalized, highly processed food.

Among many implications of these developments, two in particular have been highlighted recently as having direct implications for national security.

First, the epidemic of youth obesity and diabetes now means "approximately 71% of the 34 million 17-to-24-year-olds in the United States" are not fit for military service.[18] Second, after World War II, despite the agonizing lessons of the American dust bowl, American natural resources, essential for long term, stable agricultural production have in some instances been degraded, lost to development or depleted, with related shifts in soil organic carbon and soil health, aquifer depletion, degraded surface water quality affecting fisheries, or otherwise negatively affected by intensified extreme weather events characteristic of the last several decades.

Thus, for a number of decades post World War II, the concept of food system stability as a frontier for defense stagnated, replaced with a focus on whatever could be learned about global grain stocks and on U.S. agricultural strategies – for instance, those that depleted American aquifers to send subsidized grain exports in the form of livestock and grain commodities to our major trade partners, notably China.

In the meantime, vulnerabilities related to geopolitics of consolidated patterns in shipping infrastructure and the potential civil fragility and the vulnerabilities to extreme ideology have begun. This is especially true in the past decade and, in particular, the past couple of years, spurring further discussion of the "food security-national security" nexus.

Moreover, the contemporary global strategic context is replete with revisionist state actors and gray zone conflict that are actively challenging the global order.[19] These actors are relying on both military and non-military forms of power to shape events and communicate with combatants as well as other citizens and civil society.

Vulnerabilities in food systems, ranging from distributional choke-points to automated supply chains that have never been securitized remain defenseless and open to overt and covert capture by malignant state and non-state actors.

On the other hand, traditional development and humanitarian concerns have returned with a vengeance. It is well established that levels of development correlate inversely with civil war propensity and civil wars.[20] Once violence sets in, security and under-development co-correlate generating "Conflict Traps".[21] In the past decade, "the number of major civil wars has almost tripled." "From 2011 to today, there has been a six-fold increase in battle deaths" globally, raising the number of developing countries in conflict traps.[22] This marked uptick in global conflicts and death is being mirrored by an increase in the frequency and severity of food system shocks in regions of strategic importance to the United States—Latin America, the Middle East & North Africa (MENA) region and in Sub-Saharan Africa (SSA), particularly in the Sahel which stretches from Senegal through to Mauritania, Mali, Burkina Faso, Niger, Nigeria, Chad, Sudan and Eritrea.[23]

[18] Feeney, Nolan. 2014. "Pentagon: 7 in 10 Youths Would Fail to Qualify for Military Service." Time, June 29, 2014. http://time.com/2938158/youth-fail-to-qualify-military-service/.
[19] Standish, Reid. 2018. "Inside a European Center to Combat Russia's Hybrid Warfare." Foreign Policy (blog). January 18, 2018. https://foreignpolicy.com/2018/01/18/inside-a-european-center-to-combat-russias-hybrid-warfare/; Jackson, Van. 2017. "TACTICS OF STRATEGIC COMPETITION: Gray Zones, Redlines, and Conflicts before War." Naval War College Review; Washington 70 (3): 39–61.
[20] Fearon, James D., and David D. Laitin. 2003. "Ethnicity, Insurgency, and Civil War." American Political Science Review 97 (1): 75–90.
[21] Petraeus, David, and James Amos. 2006. "Army Field Manual 3-24: Counterinsurgency." Field Manual. Washington, D.C.: Department of the Army. https://www.hsdl.org/?abstract&did=468442; Collier, Paul, and World Bank. 2003. Breaking the Conflict Trap: Civil War and Development Policy. World Bank Publications
[22] Einsiedel, Sebastian von, Louise Bosetti, James Cockayne, Cale Salih, and Wilfred Wan. 2017. "Civil War Trends and the Changing Nature of Armed Conflict." Changing Nature of Conflict. United Nations University Centre for Policy Research. https://cpr.unu.edu/civil-war-trends-and-the-changing-nature-of-armed-conflict.html.
[23] For a detailed discussion on the link between political instability and food systems, see Simmons, Emmy. 2017. "Recurring Storms: Food Insecurity, Political Instability, and Conflict." Food Insecurity, Political Instability, and Conflict. Washington, D.C.: Center for Strategic and International Studies. https://www.csis.org/analysis/recurring-storms-food-in-security-political-instability-and-conflict.

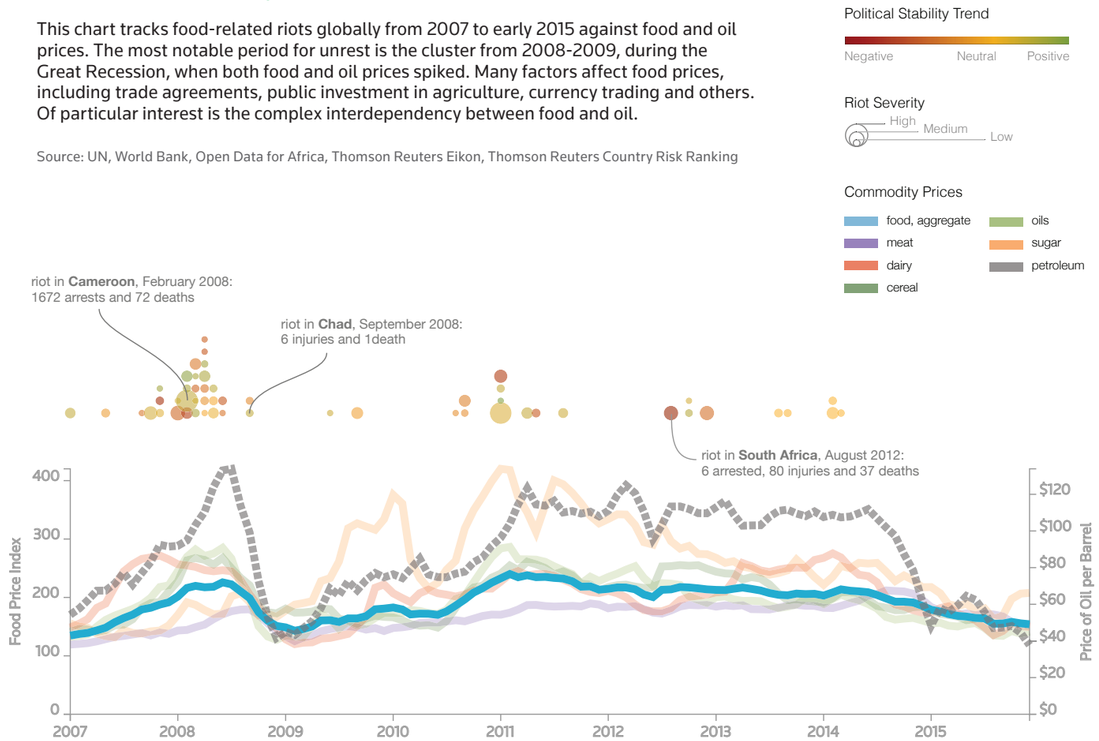
In this challenging strategic and development context, the break in the clouds is a world awash with data. These data can provide key insights for action when our questions are framed obstructively, managing the obvious vulnerabilities that come with increased transparency.

Food systems include the pre-production, production, processing, distribution, preparation, and consumption of food shaped by socio-economic and environmental conditions. In each step, actors and organizations involved generate quintillion bytes of unstructured data. These data sets can be leveraged to inform and improve the ways in which our current system is understood and monitored, both for vulnerabilities and to strengthen resiliencies with a holistic focus on the system property of stability. This will entail developing a framework and a proper taxonomy for the classes of events and their signatures, governance of this shared and pooled risk, and an elaborated articulation of multifaceted systemic risks together with negotiated and agreed processes to generate and monitor data overtime. Moreover, it will also require a recognition of the need for some consensus or at least dialogue regarding the security, legal, ethical and moral issues that emerge in monitoring data intensive, real-time processes that shape the day-to-day reality of individuals and communities and the food systems upon which they depend.

FIGURE 2
Global Food Riots vs. Prices, 2007-2016

This chart tracks food-related riots globally from 2007 to early 2015 against food and oil prices. The most notable period for unrest is the cluster from 2008-2009, during the Great Recession, when both food and oil prices spiked. Many factors affect food prices, including trade agreements, public investment in agriculture, currency trading and others. Of particular interest is the complex interdependency between food and oil.

Source: UN, World Bank, Open Data for Africa, Thomson Reuters Eikon, Thomson Reuters Country Risk Ranking



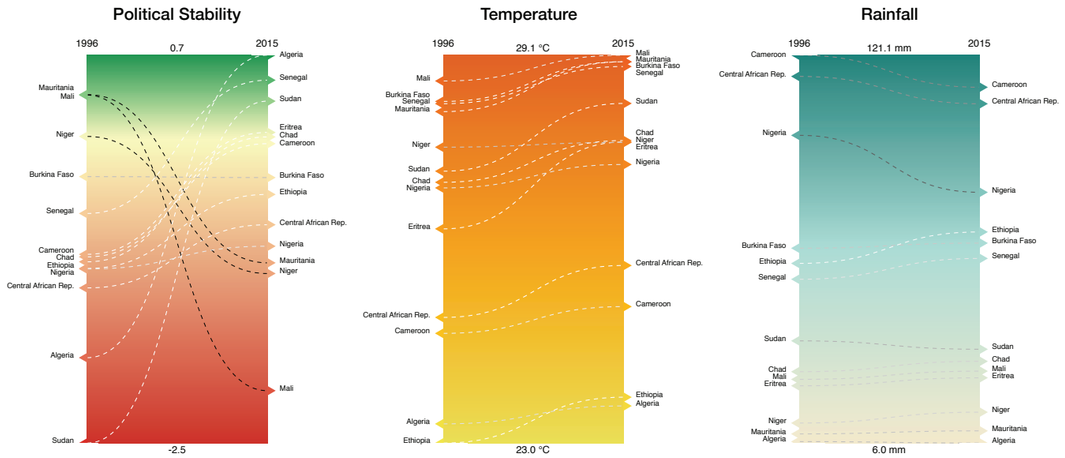


FIGURE 3
Two Decades of Change in the Sahel

Although political stability has increased for most Sahel nations, only a handful of countries end up having a positive rating in this dimension; most have become less negative. Average annual temperature has gone up for nearly all countries. The change in annual average rainfall has been mixed. Nigeria has the biggest loss and Ethiopia the biggest gain.

Countries in the Sahel have tended towards political instability over the past 20 years, but there has been improvement in many countries. In nearly all Sahel countries, the average yearly temperature has increased, while Nigeria, Cameroon and Central African Republic have seen decreases in yearly average rainfall.

Source: World Bank

RISK ASSESSMENT & THE INFORMATION TERRAIN

Transcending Traps in a World Awash with Data

Continuing technological innovations coupled with increasing levels of globalization—integration of markets, increased flow of goods and services, surveillance imagery, and all the human commentary, text, signals, etc. generated by billions of connected people—generates terabytes of unstructured data every day. Properly interpreted and harnessed, holistic reflections of essential features of these data streams can provide decision makers at every level with invaluable insight about market conditions and the national security implications of food system vulnerabilities. It is axiomatic that markets function effectively when economic agents have access to better and timely information. Actors in the defense and humanitarian sectors planning for emergencies also recognize that they can better develop pre-emptive counter measures or better plan for contingencies with timely information.

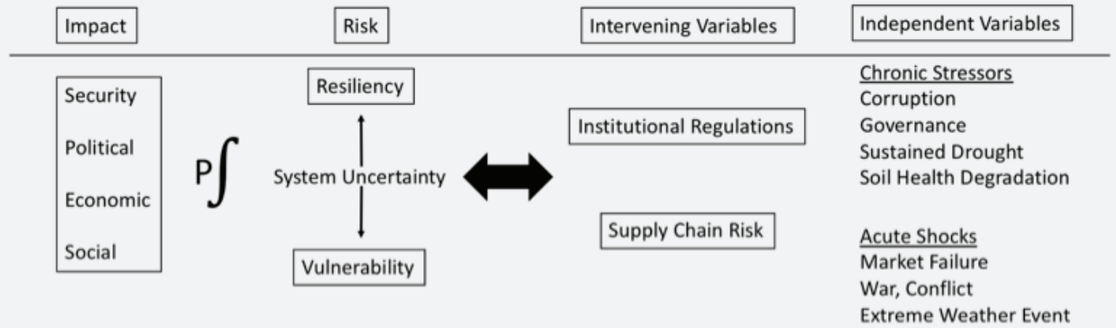
However, the challenge is effectively translating the massive amount of disparate data being collected into actionable information. Transcending the data traps and better navigating the information terrain requires an agreed upon framework on where to look (the specific contours of information terrain and the level of analysis), how to look (setting up a logically consistent monitoring framework) and what to look for (the specific monitors, reconnaissance and surveillance features) in a food system. This restructuring will require shifting existing frames of analysis which have traditionally exclusively focused on monitoring outcomes (food insecurity/ crisis conditions) to monitoring processes that constitute and shape food systems. Developing a holistic risk assessment framework will be a first step towards overcoming the manifold challenges of analysts in a world awash with big data.

Risk Assessment Framework & Food System Risk Index

The case has been made for a more holistic risk assessment framework that can be further developed and refined to capture the variegated nature of risks and the probabilistic relationships that shape systemic risk. It also provides a baseline multi-use data aggregation platform capable of capturing, monitoring and assessing features of a system considered most important for decision-making. Ideally, such a framework can be leveraged to model probabilistic scenarios that can capture the thresholds, where systemic vulnerabilities give way to actual failures. The objective is to capture complexities inherent to food systems and contingent inferences about systemic uncertainty in an adoptable and scalable manner across time and space. This framework must be built to account for how system risk is a function of the interactive effects of country-specific chronic stressors and acute stressors shaped by transnational regulatory regimes and supply chain risks.

The impact of food system risks ultimately has security, political, economic and societal implications.

FIGURE 4
Risk Assessment Framework



Note: This list of chronic stressors and acute shocks is not meant to be exhaustive, but rather a list of plausible examples.

The risk assessment framework that forms the basis for a multi-use data aggregation platform can ideally be developed into an overall Food System Risk Index (FSRI) or series of food system risk indices that capture specific aspects of system risk.

A FSRI will capture cross-national and cross-regional variations in risk with the ability to fine-tune data to monitor sub-national variations to fulfill specific client needs. It will incorporate prevailing climatic trends, changing weather patterns, environmental conditions, infrastructure capacity, market forces and socio-economic structures. It will serve as near real-time information platform, capable of deriving intelligence for preemptive interventions as well as intelligence on disaster relief following catastrophic system failures.

The development of a FSRI will necessitate a reevaluation of current analytical techniques, which have proved unable to accurately reflect the risk resulting from the expansion and integration of global markets in high-income countries.

A FSRI viewed as legitimate and salient should be useful to defense, intelligence and development sectors. By mandate and habit, the defense, intelligence and development communities prioritize the ability to monitor processes, isolate choke-points, and pre-empt, obviate and or set in place advance preparations to mitigate impacts of crises. These processes require credible, verifiable data streams that can be transformed into actionable intelligence by highly skilled analysts. In moments of crisis, these same data streams and intelligence insights will be invaluable to the humanitarian community. They can be utilized by practitioners in the disaster relief sector to conduct need assessments and inform logistics processes to optimize delivery of emergency aid.

IMPLICATIONS OF FOOD SYSTEM FAILURES

Scenarios at the Defense-Development Nexus

Increasing globalization and complex interdependencies[25] have created understudied implications at the defense-development nexus. Four scenarios outlined below are designed to illustrate how interdependencies in the global food system can quickly devolve into crises with severe strategic ramifications.

These qualitative descriptive scenarios are a mixture of actual outcomes and illustrations of plausible futures.

Each scenario is accompanied by drivers highlighting the complex interactions between the overlapping political, economic, military, social and environmental processes that drive food system vulnerabilities and risk toward collapse. The inherent complexity of each scenario emphasizes the need for a holistic conceptualization of systemic risk, while the drivers provide a baseline set of analytical categories from which to derive country, regional or sector-specific data and indicators to inform monitoring, surveillance and analysis.

Scenario 1

Multiple Breadbasket Failure (MBBF)[26]

A "breadbasket" is an agricultural production area in which one of the world's three main cereal crops - rice, wheat, or maize - is grown.

A "breadbasket failure" is a major yield reduction in annual crop cycle of a breadbasket region that will directly impact the global food system.

Multiple Breadbasket Failure (MBBF) can result from either a failure in multiple crop yields or failures across multiple production areas, generating food price volatility at best, and food price shocks at worst. Currently, a relatively small area of land, 23 percent of total cropland, accounts for a large proportion of total global cereal crops: maize (70.3 percent), wheat (69.3 percent) and rice (84.5 percent).[27] As agricultural systems continue to consolidate, they become increasing susceptible to MBBF. The effects of MBBF events are not isolated to agricultural systems, they have direct bearing on national security in advanced industrial countries and compound existing defense and development concerns in medium and low-income countries.

Multiple Breadbasket Failure events emerge as compounded outcomes at the interplay of chronic stressors and acute shocks inherent to the food system. The interaction of long-term structural drivers like urbanization, increasing global affluence and global climate change increase the susceptibility of the system to sudden shocks. Acute shocks predominantly come in two forms—natural disasters (severe drought, flooding and hurricanes) and human decisions (i.e. the possibility of major transnational geoengineering projects such as dams, e.g., in the Nile or Mekong water systems, or human error induced radiation contamination, intra-state conflict between regional powers etc.).[28] Chronic stressors and acute shocks can directly impact primary cereal crop yield, with knock-on political, social and economic ramifications. These secondary effects will result from disruptions and/or shortages in global and regional food supply. Impacts of MBBF will be exacerbated in low income countries replete with layers of country specific chronic stressors, such as poor governance and weak institutions.

[25] Keohane, Robert O., and Joseph S. Nye. 2000. "Globalization: What's New? What's Not? (And So What?)." Foreign Policy, no. 118: 104–19. https://doi.org/10.2307/1149673; Kennedy, Gina, Guy Nantel, Prakash Shetty, and Food and Agriculture Organization of the United Nations. 2004. "Globalization of Food Systems in Developing Countries: Impact on Food Security and Nutrition." FAO Food and Nutrition Paper 83: 1–300; Messer, Ellen, and Marc J. Cohen. 2007. "Conflict, Food Insecurity and Globalization." Food, Culture & Society 10 (2): 297–315; Eichengreen, Barry J. 1998. Globalizing Capital: A History of the International Monetary System. Princeton University Press; Frieden, Jeffry A. 2007. Global Capitalism: Its Fall and Rise in the Twentieth Century. WW Norton & Company; Leimgruber, Walter. 2018. Between Global and Local: Marginality and Marginal Regions in the Context of Globalization and Deregulation. Routledge.

[26] Janetos, Anthony, Christopher Justice, Molly Jahn, Michael Obersteiner, Joseph Glauber, and William Mulhern. 2017. "The Risks of Multiple Breadbasket Failure in the 21st Century: A Science Research Agenda." Pardee Center Research Report. Boston, MA: The Frederick S. Pardee Center for the Study of the Longer Range Future.

[27] Ibid

[28] Bernstein, Richard. 2017. "China's Mekong Plans Threaten Disaster for Countries Downstream." Foreign Policy (blog). September 27, 2017. https://foreignpolicy.com/2017/09/27/chinas-mekong-plans-threaten-disaster-for-countries-downstream/

Pig Carcasses Found Dead in Main Water Supply
Reuters/Stringer

Driver
Population Growth, Increased Urbanization, Changing Consumption Patterns

Global population is predicted to reach between 9 and 10 billion by mid-century.[29] Growth will be concentrated in major urban centers within the developing world.[30] While urbanization tends to increase gradually in high-income countries, it is much more rapid in low-income countries. A comparison of net-immigration rates into New York versus Karachi or Lagos illustrates this stark contrast. In addition to increasing population and urbanization, 2050 is projected to be marked by steady increases in global affluence. Increasing affluence and urbanization lead to change in dietary habits with greater emphasis on highly processed foods and animal protein, introducing new environmental and human health concerns.[31] Increasing market demand for animal protein and ability of producers to provide is exacerbated by poor public and private disease control measures, especially when an acute zoonotic disease outbreak occurs. The 2013 Chinese swine culling, where over 16,000 pig carcasses were dumped into tap water rivers, illustrates how mismanagement exacerbated a regional outbreak.[32] This change in demand also tends to increase consolidation of global, regional and national supply chains, increasing the susceptibility of these systems to respond to perturbations.

The interaction of these three drivers—increasing population, urbanization and changing consumption patterns—will continue to put pressure on food systems in urban centers already struggling with chronic stressors. Minor disturbances in agricultural production or food supply could be quickly compounded, generating MBBF events. This risk is most acute in the Global South where current and soon-to-be megacities like Lagos and Karachi are ill-equipped to handle the variegated pressures of population, urbanization and changing consumption patterns.

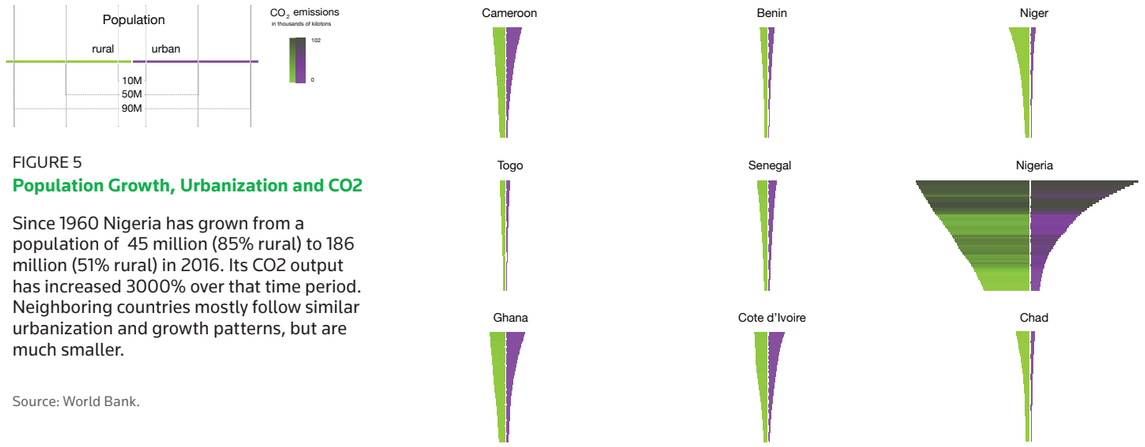


FIGURE 5
Population Growth, Urbanization and CO2

Since 1960 Nigeria has grown from a population of 45 million (85% rural) to 186 million (51% rural) in 2016. Its CO2 output has increased 3000% over that time period. Neighboring countries mostly follow similar urbanization and growth patterns, but are much smaller.

Source: World Bank.

[29] "World Population Projected to Reach 9.7 Billion by 2050 | UN DESA | United Nations Department of Economic and Social Affairs." n.d. Accessed April 2, 2018. 2015-report.html.
[30] "World's Population Increasingly Urban with More than Half Living in Urban Areas | UN DESA | United Nations Department of Economic and Social Affairs." n.d. Accessed April 2, 2018. world-urbanization-prospects-2014.html.
[31] King, Richard. 2011. "Global Food Crisis: Changing Diets Could Cause More Problems than Rising Population." The Guardian, June 1, 2011. http://www.theguardian.com/global-development/poverty-matters/2011/jun/01/global-food-crisis-changing-diets.
[32] Davison, Nicola. 2013. "Rivers of Blood: The Dead Pigs Rotting in China's Water Supply." The Guardian, March 29, 2013. http://www.theguardian.com/world/2013/mar/29/dead-pigs-china-water-supply.

Urban Growth of Lagos, 1960-2012

FIGURE 6
Urban Growth in Lagos

Source: Future Cape Town

Driver
Global Climate Change

Global climate change and its associated effects compound the impacts of a first driver—a combination of population growth, urbanization including human migration, and changing consumption patterns—increasing the severity of Multiple Breadbasket Failure impacts. Rising temperatures and sea level, as well as the intensification of the global hydrologic cycle, primarily driven by anthropogenic emissions, are increasing food system risk globally. Prevailing weather and climate impact livelihoods, dwellings (Pacific regional powers are creating active contingency plans to assist climate refugees when some of the South Pacific islands will soon go under water), food and fuel consumption.

As such, global climate change and its associated effects on extreme weather patterns are fundamentally altering peoples' way of life so much so that in 2017, the U.S. Secretary of Defense identified climate change as a singular national security concern.[33] The pace of structural change caused by global climate change is projected to intensify. The most potentially destructive acute events are likely to include sustained and rapid-onset droughts, increasingly severe heatwaves, floods, and hurricanes. If any one of these events directly impacts a core cereal producing region, the likelihood of an MBBF event will dramatically increase.

[33] Werrell, Caitlin, and Francesco Femia. 2017. "Secretary Mattis Clear-Eyed on Climate Security Risks." The Center for Climate & Security (blog). March 14, 2017. https://climateandsecurity.org/2017/03/14/secretary-mattis-clear-eyed-on-climate-security-risks/.

Scenario 2

Multi-State Food Crisis (MSFC)

A multi-state food crisis (MSFC) is an instance where a population spanning multiple geographic areas is facing Integrated Phase Classification (IPC) food insecurity level 3 (crisis), 4 (emergency), or 5 (famine).[34]

Unsurprisingly, medium and low-income countries remain most susceptible to MSFC. In 2017, several U.S. strategic partner countries in Sub-Saharan Africa faced severe MSFC. The challenges of MSFC were particularly evident in the Lake Chad Basin, where locals (most notably in Northeast Nigeria) faced famine conditions throughout the summer.[35] The convergence of chronic stressors and acute shocks in the Lake Chad Basin magnified existing vulnerabilities in regional food systems. The cumulative impact precipitated a catastrophic MSFC, deemed the worst humanitarian crisis since 1945.[36] In addition to the immediate impact on human hunger and malnutrition, this MSFC generated mass migration—creating substantial populations of both internally displaced persons (IDPs) and refugees across national borders. A combination of international intervention and mobilization of local partner capacity managed to prevent the crisis from deteriorating into a complete human catastrophe. However, the short-term measures do not address the underlying structure that enabled the crisis to develop.

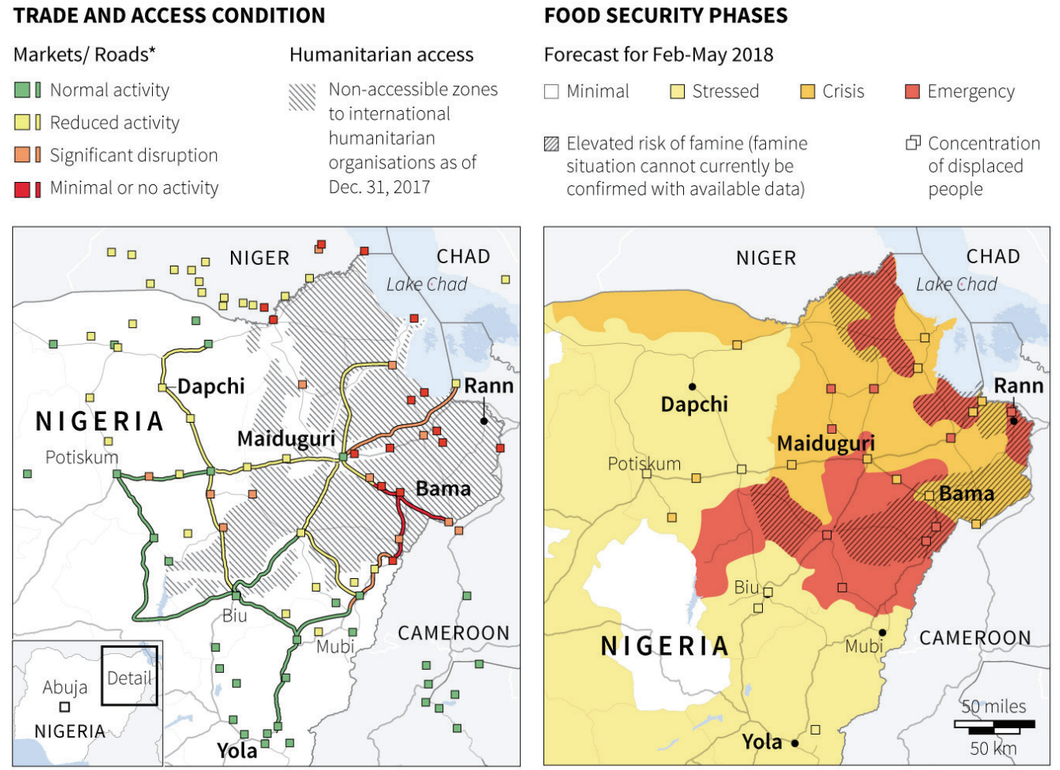
Persistent food system vulnerabilities in the Sahel also elevate the risk of food system failures that threaten to spill over and expand into Niger, Chad and Cameroon—countries where the United States and European Union (EU) have a sizable (and an ever increasing) military presence, conduct military advice and assist programs, and engage multiple violent non-state actors (VNSA).[37] MSFCs lead to social disruptions and create acute social grievance environments that have direct security and defense concerns. Compounding matters, many regions susceptible to multi-state food crisis host multiple low intensity conflicts that transcend national borders.

While a MSFC is less likely to take hold in a HIC short of great power conflict, they are not immune to the secondary effects of MSFCs in far off regions. If MSFCs become more frequent and/or severe, advanced countries will likely be affected by food price spikes and/or volatility, increased demand for humanitarian assistance and a significant uptick in the flow of migrants from MICs and LICs. That said, the developing world will continue to bear the brunt of impact of MSFCs, in the form of mass migration, social unrest, political instability and possible regime collapse.

[34] FEWSNET. 2017. "Overview of the Integrated Phase Classification (IPC)." USAID. http://www.fews.net/sites/default/files/IPC%20Overview_May_2017_final.pdf.
[35] UN OCHA. 2017. "Nigeria – North-East." Humanitarian Emergency Situation Report 11. https://reliefweb.int/report/nigeria/nigeria-north-east-humanitarian-emergency-situation-report-no-11-15-may-2017.
[36] Associated Press. 2017. "World Faces Worst Humanitarian Crisis since 1945, Says UN Official." The Guardian, March 11, 2017. http://www.theguardian.com/world/2017/mar/11/world-faces-worst-humanitarian-crisis-since-1945-says-un-official
[37] Campbell, John, and Peter Pham. 2014. "Does Washington Have a Stake in the Sahel?" Expert Brief. Washington, D.C.: Council of Foreign Relations. https://www.cfr.org/expert-brief/does-washington-have-stake-sahel.

Nigeria's humanitarian crisis

Areas of Nigeria rendered inacessible by Islamist insurgency Boko Haram may be in famine, an aid agency said.



*Nov. 2017 data.

Note: The Integrated Food Security Phase Classification (IPC) scale, drawn up in 2004, has five categories of food shortage, of which famine is the most serious. It defines famine as a situation in which at least one in five households has 'extreme lack of food' and in which the population is suffering 'significant mortality', or at least two hunger-related deaths per 10,000 people per day. Before famine, the IPC scale describes food 'emergencies', 'crisis', 'stressed' and 'minimal' in descending order of seriousness.

Sources: Famine Early Warning Systems Network; United Nations Office for the Coordination of Humanitarian Affairs (OCHA).

G. Cabrera, 14/03/2018 REUTERS

FIGURE 7
Nigeria's Humanitarian Crisis

Driver

Endemic Corruption, Institutional Capacity, Bad Governance

Seamless functioning of food systems is fundamentally dependent on efficient market mechanisms built on integrated supply chains and state institutions that provide stable public goods, such as security and consistent impartial enforcement of contracts. The international development community has long been aware – but unable to break – the iron triangle of endemic corruption, weak state institutions and bad governance in developing countries.[38] In LICs and some MICs, the preconditions necessary for seamless functioning of food systems are either absent or remain extremely weak. The inability of the international development community and local (well-intentioned) political actors to break this triangle makes the food systems in LICs more susceptible to sudden shocks and has a higher probability of tipping from instability to crises.

Driver

Inter-State and Intra-State Conflict

Food system stability is reliant on peaceful conditions. In the fall of 2017, the UN Food and Agriculture Organization identified conflict, along with climate change, as the two major drivers of food insecurity around the world.[39] Ongoing low-intensity conflicts in Nigeria and the Lake Chad Region, South Sudan, Somalia and Yemen directly bears on observed food system instability. In addition, conflict alters state-society relations, tears the social tapestry and alters resource distribution patterns. As violence becomes the arbiter of political and economic disputes, institutional configurations are fundamentally altered. Subsequently, food systems become easy hostages of circumstance, susceptible to capture by VNSA or state-affiliated proxies.

Binary Code on Computer Screen
Thomson Reuters

[38] Fombad, Charles M. 2000. "Endemic Corruption in Cameroon: Insights on Consequences and Control." In Corruption and Development in Africa, 234–60. Palgrave Macmillan, London.https://doi.org/10.1057/9780333982440_13
[39] FAO, IFAD, UNICEF, WFP, and WHO. n.d. "The State of Food Security and Nutrition in the World." Building Resilience for Peace and Food Security. Rome: FAO. http://www.fao.org/3/a-I7695e.pdf.

Scenario 3

Exploitation of the Food System by VNSA

Recent food crises in Sub-Saharan Africa illuminate the increasing ability of ideologically-driven and profit-seeking VNSA to both manipulate and profit from food system failures.

Ignoring international norms and laws, VNSA and tribal interests find strategic depth by weaponizing food systems, allowing them to continue to exert control of non-combatant populations, and to engage in acts of terrorism and low intensity military operations. U.S. National Security agencies are engaged in ongoing efforts to monitor VNSA activity in theaters with direct relevance to the U.S. DoD missions. Substantial enhancement of monitoring efforts is necessary, however, to better capture VNSA activity within food systems since very little attention is currently paid to how VNSA leverage food system vulnerabilities and risks in U.S. partner nations in Sub-Saharan Africa.

Sahelian countries have an assortment of VNSA—ranging from highly localized, parochial groups of armed non-state actors to highly networked VNSA with transnational and/or tribal linkages.[40] The transnational nature of prominent VNSA directly contributes to political instability in Nigeria, Niger, Chad, Mali and the Central African Republic. In fact, tribal-linked VNSA directly contributed to a violent coup in Mali.[41] In addition to the direct impact of VNSA on food systems, their activity has secondary effects in inducing population migration. Movement of people within and among geographies creates massive and unexpected shifts in demand for staple crops, alters processes of resource distribution, and adds pressure to an already fragile food system.

This in turn creates a vicious, self-reinforcing cycle of food system disruptions leading to refugee flows, and refugee flows disrupting food systems—crises beget crises.

The problem is compounded in the Sahel where local 'bigmen' (warlords) who wield more power in their communities than agents of the state.[42] Throughout 2017, various VNSA affiliates controlled critical chokepoints in the food supply chain in the Lake Chad Basin. Their disruption played a role in the resultant sky-rocketing food prices and famine and incipient famine conditions, which further exacerbated the social unrest upon which VNSA thrive.[43] VNSA rent seeking activity at the nexus of food systems and political unrest also directly bears on U.S. DoD concerns regarding "threat finance," the means and methods used by organizations—including money launderers, traffickers, VNSA, organized crime, etc.—to finance illicit operations and activities that pose a threat to U.S. national security and global financial security.[44]

[40] Rose, Matt. 2017. "Game of Tribes: Getting Counterterrorism Right." US Army War College War Room (blog). December 13, 2017. https://warroom.armywarcollege.edu/articles/game-tribes-counterterrorism-policy-development-tribal-analysis/.
[41] Whitehouse, Bruce. 2012. "What Went Wrong in Mali?" London Review of Books 34 (16): 17.
[42] Themnér, Anders. 2017. Warlord Democrats in Africa: Ex-Military Leaders and Electoral Politics. Zed Books Ltd; Reno, William. 1999. Warlord Politics and African States. Lynne Rienner Publishers. Themnér, Anders. 2017. Warlord Democrats in Africa: Ex-Military Leaders and Electoral Politics. Zed Books Ltd; Reno, William. 1999. Warlord Politics and African States. Lynne Rienner Publishers.
[43] United States Agency for International Development. 2018. "Lake Chad Basin." Complex Emergency Fact Sheet #6, Fiscal Year 2018. Washington, D.C.: USAID. https://reliefweb.int/report/nigeria/lake-chad-basin-complex-emergency-fact-sheet-6-fiscal-year-fy-2018
[44] American Security Project. n.d. "Threat Finance and Financial Intelligence." Asymmetric Operations (blog). Accessed April 3, 2018. https://www.americansecurityproject.org/asymmetric-operations/threat-finance-and-financial-intelligence/; Spiro, Jesse. 2017. "Threat Finance Has Become Big Business." Thomson Reuters (blog). June 28, 2017. https://blogs.thomsonreuters.com/answerson/threat-finance-fight-to-stop-it/.

Across the Sahel, as in much of Africa, mobile cell-phone banking is expanding at an exponential rate. VNSA rely on these same banking systems and technologies. To better monitor, assess and mitigate transnational activity, governments should utilize existing Anti -Money Laundering/ Know Your Customer (AML/KYC) regulatory frameworks and should consider working closely with the Financial Action Task Force (FATF)[45] to put in place more robust AML/ KYC standards for mobile payment systems such as M-Pesa, which is one of many, and has been identified by the U.S. State Department as an AML Risk in parts of Africa[46] M-Pesa was established in 2007 and today has more than 30 million users in 10 countries.[47] This system provides international money transfer capabilities opening the potential for illicit black markets and cross border flows, through schemes such "digital value smurfing" a term coined by the Asian Development Bank where "smurfs" or "runners" deposit or place small amounts of illicit money into financial institutions in ways that do not trigger financial transparency reporting requirements.[48] Digital smurfing adopts this process by way of stored value cards and mobile payment credits, which are then distributed. Likewise, there is also the potential to draw inferences and then track the diversification of VNSA funding sources by paying increasing attention to the commodities sector. For example, Kenyans consume more sugar than they produce every year. Somalia-produced sugar is therefore imported into Kenya every year, much of it not declared. According to Mohammed Maalim, County Commissioner in Garissa, Kenya, trade proceeds, especially from sugar imports, are going to militant group coffers.[49]

Driver

Weak Institutions, Endemic Corruption, Kleptocratic Regimes

Successful VNSA exploitation requires certain preexisting conditions—namely the presence of weak institutions, endemic corruption and kleptocratic regimes. These three factors, while analytically autonomous, interact to create endogenous political and economic processes that create perpetual traps of under-development.[50] LICs stuck in poverty traps constitute acute grievance environments, which serve as fertile recruiting grounds for VNSA. These countries also host fragmented armed forces, weak intelligence services and ruling elite coalitions held together by unofficial patronage networks instead of formal institutional arrangements. Again, Sahelian countries represent the perfect environment for VNSA to exploit, creating complex challenges for decision-makers operating at this defense-development nexus.

[45] "About - Financial Action Task Force (FATF)." n.d. Financial Action Task Force. Accessed April 5, 2018. http://www.fatf-gafi.org/about/.
[46] Masinde, Joshua. 2017. "US State Dept Thinks Africa's Leading Mobile Money Platform Is Vulnerable to Money Laundering." Quartz (blog). March 6, 2017. https://qz.com/924977/us-state-dept-thinks-africas-leading-mobile-money-platform-is-vulnerable-to-money-laundering/.
[47] Monks, Kieron. 2017. "M-Pesa: Kenya's Mobile Success Story Turns 10." CNN, February 24, 2017. https://www.cnn.com/2017/02/21/africa/mpesa-10th-anniversary/index.html.
[48] Bureau of International Narcotics and Law Enforcement Affairs. 2008. "Mobile Payments--A Growing Threat." International Narcotics Control Strategy Report. Washington, D.C.: United States Department of State. http://www.state.gov/j/inl/rls/nrcrpt/2008/vol2/html/101346.htm.
[49] Caulderwood, Kathleen. 2014. "Al-Shabab's Finances: The Militant Group Gets Funding From Local Businesses, Sources Abroad." International Business Times, September 4, 2014. http://www.ibtimes.com/al-shababs-finances-militant-group-gets-funding-local-businesses-sources-abroad-1678894.
[50] Collier, Paul, and Nicholas Sambanis. 2005. Understanding Civil War: Africa. Vol. 1. World Bank Publications; Walter, Barbara F. 2015. "Why Bad Governance Leads to Repeat Civil War." Journal of Conflict Resolution 59 (7): 1242–72. https://doi.org/10.1177/0022002714528006

Scenario 4

Implications of Gray Zone Activity and Inter-State Conflict

The U.S. remains the effective underwriter of the international rule-based order. This global hegemony is now facing unfamiliar and evolving threats in the form of indirect gray zone and hybrid challenges from revisionist states around the globe.[51] Gray zone tactics refer to adversaries "employing instruments of power—often asymmetric and ambiguous in character—that are not direct use of acknowledged regular military forces".[52] In gray zone conflicts, which defy traditional views of war and peace, food systems constitute a perfect non-military instrument of power that can be utilized for destabilizing purposes.[53]

Revisionist states seek to alter the strategic environment incrementally and harness the gains of altered strategic terrain without escalating to conflicts short of traditional coercion or war. They utilize a nuanced form of warfare, seeking limited political victories, as opposed to conspicuous military triumphs that are likely to precipitate retaliation.[54] Gray zone tactics are unconventional, including cyberattacks, political sabotage, economic coercion, fake news and the use of proxy forces. Gradual changes over time have a cumulative impact and strategic implications. Gray zone actors rely on asymmetric, ambiguous and non-military instruments of power to generate long term, less attributable strategic outcomes.[55] For them, food systems provide an attractive set of targets to acquire.

Simultaneously, in an era where the international system is in increasing flux, and traditional balance of power arrangements are changing, the U.S. National Security Strategy also takes the potential for regional and great power competition and conflicts seriously.[56] South and East Asia are replete with emerging powers seeking resource advantages, both nuclear and non-nuclear, that stand to alter the existing balance of power in the region. International relations scholars consistently warn of the higher propensity for inter-state conflict in moments when the equilibrium conditions of balance of power change in the international system.[57] With integrated markets and overlapping complexities in the food system means, any regional interstate conflict in South or East Asia stands to directly impact the global food system with catastrophic consequences.

[51] Mazarr, Michael J. 2015. "Mastering the Gray Zone: Understanding a Changing Era of Conflict." US Army War College Carlisle; Freier, Nathan, Charles Burnett, William Cain, Christopher Compton, Sean Hankard, Robert Hume, Gary Kramich, et al. 2016. "Outplayed: Regaining Strategic Initiative in the Gray Zone." Monograph. Washington, D.C.: Army Capabilities Integration Center in Coordination with Joint Staff J-39/Strategic Multi-Layer Assessment Branch. https://ssi.armywarcollege.edu/pubs/display.cfm?pubID=1325.
[52] International Security Advisory Board. 2017. "Report on Gray Zone Conflict." Final Report. Washington, D.C.: United States Department of State. http://www.state.gov/t/avc/isab/266650.htm.
[53] Statement of General Joseph L. Votel, U.S. Army Commander United States Special Operations Command. 2015. Washington, D.C. http://docs.house.gov/meetings/AS/AS26/20150318/103157/HMTG-114-AS26-Wstate-VotelUSAJ-20150318.pdf.
[54] Matisek, Jahara W. 2017. "Shades of Gray Deterrence: Issues of Fighting in the Gray Zone." Journal of Strategic Security 10 (3): 2.
[55] Mazarr, Michael J., Strategic Studies Institute, and U. S. Army War College. 2015. Mastering the Gray Zone: Understanding a Changing Era of Conflict. LULU Press.
[56] "National Security Strategy of the United States of America." 2017. Washington, D.C.: The White House. https://www.whitehouse.gov/wp-content/uploads/2017/12/NSS-Final-12-18-2017-0905.pdf.
[57] Allison, Graham. 2017. Destined for War: Can America and China Escape Thucydides's Trap? Houghton Mifflin Harcourt.

Driver

Connectivity, Interdependencies, Supply Chain integration

Consolidation has become a defining characteristic of the evolution of the global food system. One needs look no further than the recent concentration of cereal production in a few key breadbasket regions or the monopolization of agrichemicals, seeds and agricultural goods to witness consolidation within the food system.[58]

In practice, consolidation is a double-edged sword, and is especially dangerous if the inherent security implications are not recognized. Capturing any individual concentrated node within the global food system can have severe, widespread and lasting ramifications. Further, while market-driven supply chains controlled by competing corporate entities function with a relative degree of efficiency in peacetime, there is no certainty that this system will function seamlessly under moments of international and regional crisis. Nor is it certain that market efficiency and profit motive will prevail if the supply chains are covertly captured by rogue states or rogue state proxies. The catastrophic potential remains precariously unknown and understudied.

Additionally, efficiency gains of supply chain consolidation have inadvertently created a series of fragile chokepoints in the global food system. A recent study published by Chatham House finds that the majority of the world's staple crops pass through only 14 global chokepoints.[59] This handful of globally important specialized ports, logistics nodes, and corridors, which are vulnerable to both natural and man-made hazards, represent a critical blind spot of both the defense and development communities.

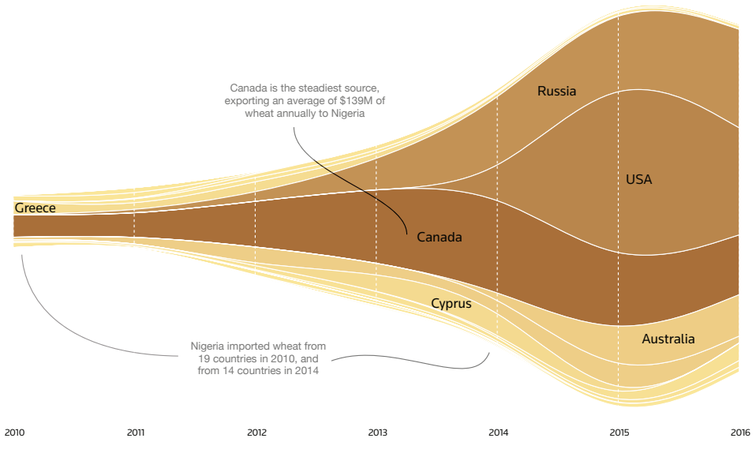
Contemporary history provides ready explanations of how political instability affects major chokepoints in the global trade network. At the height of the Iran-Iraq war, both countries engaged in disrupting oil shipments from each other. Though initially a regional affair, military engagements between Iran and Iraq quickly extended to attacking purchaser vessels which disrupted shipping in the Persian Gulf—the jugular of the global economy. The spillover effect of regional instability instantly increased insurance premiums, generated oil price volatility, and global economic uncertainty. Similarly, the critical choke-points in the food system represent attractive targets for capture and control by gray zone actors.

FIGURE 8

Wheat Imports to Nigeria, 2017

In recent years Nigeria has increased its volume of imported wheat while maintaining abalanced mix of import countries and regions. Some partners like Russia and Canada have a longer history with Nigeria, while others come and go.

Source: UN Comtrade



[58] Kato, Takayuki, and Soichi Inai. 2016. "Agrochemical Consolidation Creating 3-Pronged Market." Nikkei Asian Review, September 15, 2016. https://asia.nikkei.com/Business/Deals/Agrochemical-consolidation-creating-3-pronged-market.

[59] Bailey, Rob, and Laura Wellesley. 2017. Chokepoints and Vulnerabilities in Global Food Trade. Chatham House.

CONCLUSIONS AND RECOMMENDATIONS

Toward Food System Resilience

The global strategic environment, replete with formidable challenges to the United States and its allies, is rapidly changing with the rise of gray zone actors, revisionist powers directly challenging the rule-based order, and a proliferation of VNSA in low-income countries.

The latest National Security Strategy indicates that the United States takes the emerging threats seriously, is doubling down on its commitments, and is dedicated to maintaining both its hard and soft power capabilities abroad and will continue to be the largest net contributor of humanitarian aid in the world.

This study highlights the strategic implications of food system vulnerabilities and risks, and introduces a holistic, scalable risk assessment framework to capture the impact of food system risks and potential failures. This framework captures and suggests ways to model the probabilistic relationships between acute shocks, chronic stressors, supply chain risks and country-specific institutional variables. A logical next step of such a framework is the development of a broad Food System Risk Index comprised of multiple sub-indices. This index, which can also be conceptualized as a multi-layered data-aggregation platform, will be able to monitor and assess food system risks in real time and inform decision makers operating at the defense-development nexus.

With the use of qualitative scenarios, this study illustrates how food system risks have direct security implications for the U.S. homeland and its close allies in a changing global security environment of gray zone actors, global revisionist powers and countries vying for regional hegemony. The scenarios also illustrate how food system risk in MICs and LICs has direct security and development implications.

This study also describes an ongoing paradigm shift within the U.S. Government—moving from explicitly outcome-oriented analysis (food security) to processes that enable the near real-time monitoring and assessment of food system risk (food systems). This conceptual and operational shift creates room for innovation and collaboration across the public (defense, development and humanitarian) and private sectors.

The study also highlights how food system risk indices define a new risk space and consequently create a new market for parametric insurance and re-insurance. Though the emergent paradigm opens up an array of opportunities, it is also fraught with challenges. The recommendations briefly highlight some of the key challenges.

RECOMMENDATIONS

Supporting the Defense-Development Nexus

Interagency Cooperation

Greater interagency cooperation among defense, intelligence and development agencies on food system and security-related indicators for surveillance is needed. Improved conflict and food system threshold analysis will likewise advance policy formulation and operational planning.

In order to ensure maximum utility, agencies should coordinate and collaborate on a standard set of conflict drivers and food system related threshold indicators. Subsequent cross-sector collaboration and data sharing will optimize analysis and better inform policy makers and operational planners.

Developing a New Framework for Food System Stability

To properly assess the national security implications of global food system vulnerabilities, defense, intelligence, and development agencies should continue to establish shared concepts of food systems as a foundation for a holistic risk assessment framework that takes into account the complexity, very rapid and evolving dynamics and interdependencies of global food systems (to include analytical assessment qualitative scenarios such as Multiple Breadbasket Failures, Multi-State Food Crisis, VNSA, Gray Zone and Inter-State Conflicts, and their subsequent drivers).

In order to ensure maximum utility, agencies should coordinate and collaborate on a standard set of conflict drivers and food system related threshold indicators. Subsequent cross-sector collaboration and data sharing will optimize analysis and better inform policy makers and operational planners.

Developing a Food System Risk Index

Building upon existing frames of analysis that have traditionally focused on monitoring outcomes (crop yield forecast, food security, food insecurity/famine, crisis conditions) to frames suitable for national security interests that are designed to flag present, near future and more distant future instabilities. By monitoring processes that constitute and shape food systems well beyond crop yield, and economic indicators related to trade, defense, intelligence, and development agencies should also facilitate the development of a Food System Risk Index – a multi-use data aggregation platform --capable of capturing, monitoring, and assessing systemic risk in real time and in a more proactive way.

A collaborative food risk monitoring system should be developed to serve as a data aggregation and analytical platform-- relevant across sectors-- to share information and advance innovations at the defense-development nexus (i.e. food system risk correlation to country risk).

Public Private Partnerships should also be developed to support this risk monitoring system to enhance and optimize food value chains to help ensure private sector adaptability and resiliency.

Working groups should be established in cooperation with, and the participation of, the private sector to develop guidelines and preemptively address potential regulatory and privacy concerns in this space.

Maximizing Usable Big Data

To effectively harness the exponential growth of time-sensitive and decision-relevant data, defense, intelligence and development agencies should continue to actively facilitate the use of modern tools and capabilities to collect and analyze disparate real time/near real time data sets relevant to food systems and their application to institutional goals and missions. A particular priority will be new artificial intelligence and machine learning techniques to aggregate and analyze big data to estimate global food stocks of strategic importance to the United States to help facilitate the stability of the global food system.

Given the exponential and accelerating growth of multi-use data aggregation tools and applications, defense, intelligence and development agencies should facilitate the creation and collection of verifiable multi-use data sets in both non-crisis and crisis environments to build indicator and information monitoring capabilities at the sub-national, country, and regional levels able to help identify and predict the impact of future systemic food system risks.

Public Private Partnerships

Defense, intelligence, and development agencies should establish public-private sharing platforms to systematically organize open data and available proprietary data, to better inform the analysis of food system vulnerabilities.

Public Private Partnerships should also be developed by defense, intelligence, and development agencies to support the goals of the 2018 National Defense Authorization Act (Section 1075) and provide a venue for government and private sector food experts and specialized manufacturers to collaborate with leading technologists, development/humanitarian, security practitioners and logisticians to define and systemize monitoring efforts, and to develop methods to effectively leverage information technology, data management, risk detection and surveillance.

Farmer Inspects Crops Thomson Reuters

APPENDIX I

A Missed Opportunity: Fall Armyworm Invasion in Africa

The spread of a caterpillar pest of corn and other crops, the Fall Armyworm (FAW) crisis spreading across Sub-Saharan Africa illustrates a systemic failure in existing monitoring efforts to detect and respond to a perfect "trojan horse." Fall Armyworm, *Spodoptera frugiperda*, is a moth species native to the Americas, which is currently estimated to be destroying millions of hectares of fields across Sub-Saharan Africa. It was first detected in Central and Western Africa in early 2016, and has since spread across the continent.[60] In 2017, experts estimated that it could cost 12 African countries upwards of $6 billion dollars a year in lost crops alone.[61] In addition to its direct economic consequences, FAW has consequential defense and development implications. Precipitous declines of crop yields in countries plagued by weak institutions and chronically vulnerable food systems can result in food system failures, social unrest, internally displaced people, political instability and conflict. Secondary effects, such as the massive importation and deregulation of pesticides may result in both acute and longer term consequences that may be at least as severe.

Intrinsic characteristics of FAW combined with analytical rigidities and conceptual silos in existing monitoring methods help explain how and why FAW escaped the attention of the international community, until it had already become an emergency. As an insect, FAW fell outside the purview of existing disease, disease insect vector, and other epidemiological modeling and monitoring efforts. While its cumulative effects are undoubtedly devastating, it does not spread rapidly enough to be acknowledged by the disaster relief community as a sudden onset shock. Furthermore, FAW is native to the Americas so some experts reflect ruefully today that this was an accident waiting to happen. As an invasive species now established on the African continent, it has a leg up against African agronomists, who have not been formally trained to detect or combat this specific pest. Long term breeding programs are not established for types adapted to Africa. The range of crops affected is not well defined. Lastly, existing country risk indices failed since FAW does not fit within any existing monitoring parameters.

Regional or country specific FSRIs will include monitoring behavioral patterns, individual and market sentiment and shifts in demand, among many other indicators. Close observation (automated or manual) of these unconventional reconnaissance features of food system stability could have detected aberrations and prompted investigation and/or intervention of FAW before it deteriorated into a regional crisis.

[60] Plant Production and Protection Division. 2017. "Sustainable Management of the Fall Armyworm in Africa." Rome, Italy: Food and Agriculture Organization of the United Nations.
[61] Maclean, Ruth. 2017. "Invasion of Maize-Eating Caterpillars Worsens Hunger Crisis in Africa." The Guardian, October 25, 2017. http://www.theguardian.com/global-development/2017/oct/25/invasion-of-maize-eating-caterpillars-worsens-hunger-crisis-in-africa-fall-armyworm.

WISCONSIN
UNIVERSITY OF WISCONSIN–MADISON

THOMSON REUTERS®

Northwestern University

EOFSAC
EARTH OBSERVATIONS FOR FOOD SECURITY AND AGRICULTURE CONSORTIUM
Down to Earth Decisions for Food Security and Agriculture

NASA

USC University of Southern California

U.S. ARMY WAR COLLEGE
Carlisle Barracks, PA

NASA does not endorse or sponsor any commercial product, service, or activity; any mention of a product, service, or activity does not constitute NASA endorsement.