Agriculture, Climate Change and Food Security in the 21st Century

Agriculture, Climate Change and Food Security in the 21st Century:

Our Daily Bread

By

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To the Librarians of Bangor, Maine

The True Guardians of the Galaxy

And

Leneida M. Crawford

My Guardian

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PREFACE

ANOTHER BOOK ON CLIMATE CHANGE? REALLY?

"There are people in the world so hungry, that God cannot appear to them except in the form of bread."
—Mahatma Gandhi.

If you are reading this sentence—thank you. It reflects a genuine desire to know more about food security and climate change, the threats, the challenges, and the solutions.

But why would anyone want to write another book about climate change?

One incentive is spiritual. Every Sunday, in my church and in Christian churches around the world, the Lord's Prayer is recited.

"*Our Father who art in Heaven,*
Hallowed be thy name,
Your Kingdom come, your will be done,
On Earth as it is in Heaven.
Give us this day, our daily bread
Forgive us our trespasses, as we forgive those who trespass against us.
And lead us not into temptation, but deliver us from evil."
—Matthew; 6:9-13.

The prayer honors God, and asks God, reverently, for a number of spiritual things, but demands one tangible in return: Bread. *"Give us this day our daily bread."* Not "please", not "could you"; but "give".

Seems pretty sassy on our part.

Why bread?

First, it is clear that "Bread" in this prayer means more than just flour and water. Bread is universal among all cultures and is known by many names:

Bob do Caco, Dorayaki, Focaccia, Hallulla, Kisra, Matzo, Naan, Pita, Rye, Zopf, among others. But bread, ultimately, means food; sustenance, a means to survival.

As to why? Simple: you cannot experience God if you are hungry. It is difficult to practice compassion, or charity, or ask forgiveness if you are without food. So in this prayer, we are asking for God to help us show empathy and to deliver us from evil and temptation; but we are asking-insisting on- food (bread) in return.

Another incentive to write this book is science. Based on the best science, we are, or will be soon, at a cross-road when it comes to bread.

That cross-road, hastened by human-induced climate change, is approaching quickly. When we reach it, our daily bread, so important to both our physical and spiritual needs, is going to be in short-supply. Food, its availability, its safety, its nutritional value, occupies a central role in our existence. Any disruption in the global food supply can, and will, disrupt civilization.

Because when food is absent, even for a few days, people can---*change*. We become less human. We become anxious, frantic, hopeless, and violent. Hunger exacerbates the worst of human tendencies—it doesn't deliver us from temptation; rather, it leads us to evil---from civil war to genocide (1).

These are, in part, the reasons and rationale—spiritually and scientifically—to try and communicate what is likely to become an existential crisis regarding food security, particularly from the climate change perspective.

Why write a book now?

Because we seem to have grown tired of academia, particularly in the United States; that current political and social dogma easily dismisses educated people as elitist or out of touch. That we are in an Orwellian "post-truth" or "alternative facts" world (2).

From a science perspective, a lack of reality engenders fear. Hair on Fire fear. When facts don't matter, or are "trumped" by ideology, then ignorance ensues. Ignorance is the antithesis of science. It steals time, energy and resources; it takes hard work, dedication and constant struggle

to negate it. It robs from future generations, it disrupts, it perverts. Finally, and most frightening, when it comes to agricultural science, and our ability to provide food for 7.5 billion people currently, (and 9-10 billion by mid-century) (3), it starves. It kills.

And fear can lead to foolish choices. As tempting as it is, some days, to curl up in a fetal position under your desk, it solves nothing. Reason, logic, hope and faith still provide the best ways forward.

So, in writing this book, I try to set aside panic and lay out facts. To provide a context, historical and scientific, of the importance of agriculture, the role of climate change in disrupting access to our daily bread, and perhaps, most importantly, how we can adapt and persevere.

Because there is light. A lot of it. Some in expected places like research and technology; but also new attitudes and novel thinking on how to grow food, and where to grow it, and how to consume it. That light shines beyond a farmer's field. It can reach into supermarkets, into palm plantations, into waste treatment plants. It extends to business practices and even to women's rights. Honest.

The bottom line is this: how we have obtained food in the past, will not work for the future. We must change the fundamentals of agricultural science. This book offers the reasons why and hopefully, some ideas on how to do so. If you disagree with what is written here, by all means, please, ask questions, offer advice. Take the initiative. Check out sources. Ask more questions. Questions are to science as breath is to air. Facts really do matter. Ignorance isn't bliss.

Finally, while I hope that this book appeals to your reason, I also hope it can inspire. Yes, "man does not live by bread alone"—true. But remember that bread (food) is necessary to live at all. And our daily—and future—bread is never certain. *The science of how we obtain our bread, without destroying the environment that provides it, is fundamental to whether civilization endures.*

And that is **not** an alternative fact.

PART I.

SETTING THE TABLE

CHAPTER ONE

BREAKFAST OF CHAMPIONS

"What nicer thing can you do for somebody than make them breakfast?"
—Anthony Bourdain

Eating defines humanity. Rich or poor, black or white, urban dweller or hard---scrabble farmer---you have to eat. Eating is humanity's common core.

While we have to eat, we like to eat. We like the smells, the sounds, the social interaction from preparing the food, to serving it, to consuming it. Food is fundamental. It is a sharing event, it has its own rules, its own rituals. From Thanksgiving, to Christmas, from Birthdays to Anniversaries, we celebrate our country, our religion, our culture, our accomplishments, our family, and ourselves, through food.

And while we attach our own set of values to these events, in terms of health and well-being, no food is more important than the first meal, when we break our fast.

Somewhere in the distance—far and wee?—there is a chirping noise; soft, incessant. My eyelids drag open. I am seeped in exhaustion, for a few moments, I have no idea where I am. Slight feeling of panic, then I remember the 20 hour series of flights, of bad food and cramped seats, that got me to this gun-metal grey hotel room somewhere in downtown Beijing.

The chirp—chirp—chirp continues. I reach out and pick up the receiver. A metallic voice tells me the time. 7 am. I swing my legs over the side of the bed and clutch my head in my hands. There is a 12 hour time difference between Beijing and Washington D.C.

I spend a long time in the shower trying to clear the cobwebs—a few sharp thoughts race across my mind. Is the flash drive where I left it? What should I wear? Will I be understood? Who's going to be here?

I am in Beijing giving a talk on rice, a cereal crop I have worked on for the past 25 years. Many consider it the world's most important crop—with good reason---more than two billion people depend on rice as their primary food source. Before I left the states, there were headlines proclaiming famine across Africa and parts of Asia. I know that if we are to address famine, rice must be part of the solution. Now I have the envious task of explaining to scientists and policy makers at an international conference how climate change is going to make that solution more difficult.

I ride the elevator 40 stories to the restaurant at the top. A number of colleagues are sitting quietly at linen covered tables, sipping tea or coffee staring at their laptops. A bright orange sun is edging over the horizon, silhouetting black construction cranes.

Waiters are rapidly shuffling between the kitchen and three long tables positioned against a panoramic window. Each table is soon overloaded with white trays centered in squares of ice, or steaming caldrons lit by small, dancing flames.

Coffee and tea; pink, purple, and yellow juices are staggered on a smaller circular table. I grab a cup of coffee, am reassured by its warmth, and explore the breakfast buffet.

For reasons which I have yet to understand, conferences on hunger are always chock-a-block with food. I stare at the cornucopia of calories with a mixture of curiosity and hunger.

There are dumplings, zongzi, small cakes, shrimp, noodles in pig fat, steamed rice, many different fish, miso soup, pickles, salads, short ribs, kimchi, and seasoned kelp. I take a few small rice cakes, (I do work on rice), but my stomach is turning cartwheels at the site and smells of what would be traditional breakfasts for Chinese, Koreans and Japanese.

I wander over to the western side of the buffet. Now there are familiar foods and my hunger stirs: eggs, cereals, porridge, fruits, rolls, bacon. But here too, I encounter a few oddities that reflect my Australian and

European friends: baked beans and catsup, sliced cold cuts, and vegemite, (a spread made from brewer's yeast). I settle for hot cereal, toast, butter and, of course, more coffee.

Breakfast, as we have been told many times, "Is the most important meal of the day.". Whether in Beijing or around the globe, the amount of food you eat should balance the amount of energy you use.

Growing up it was clear to me that a day's work dictated a day's breakfast. My Uncle Bill, an apple farmer in Ohio, and probably the skinniest human being I ever knew, would wake at 5 a.m., consume half a dozen eggs, sausages swimming in gravy, oatmeal, several slices of toast coated liberally with butter and jam, and a slab of apple pie before leaving his frame house.

That breakfast, needless to say, would raise hackles among modern nutritionists, but seemed suitable that summer for moving and climbing heavy wooden ladders, picking and filling bushel baskets, and lugging them over to tractor pulled carts. Uncle Bill, who was in constant motion around the farm in response to a never ending list of chores, never gained weight. Even into his fifties, his wife, my Aunt Emily, would tease, "If Bill stuck out his tongue and turned sideways, he would look like a zipper."

If the goal of breakfast is to set the fuel supply to the energy needed, modern workers often take away the wrong lesson from the previous generation. Working at an office does not require a breakfast of several thousand calories; sitting at a desk, pecking at a keyboard, attending meetings, fixing jammed printers (playing freecell) does not consume anywhere near the number of calories it takes to operate a farm, even a small one.

Yet, what we eat, how we eat, when we eat, is often learned directly from our parents, who in turn, learned it from their parents, and so on.

But as family dynamics change, so does our knowledge of food. And for many kids that means, TV, internet, blogs, tweets, etc. Media outlets make use of opportunities to tempt the appetite, especially during mealtimes. Growing up, Saturday mornings were ripe with loud, multi-colored lures regarding sugar-coated cereals.

Few ads promote the culinary joys of balanced and nutritious meals, (I have never seen a broccoli commercial), but the immediate pleasure of food that is high in fat, sugar, and cholesterol. Ironically being enjoyed on screen as part of a happy, fun family activity (no fat kids or obese parents please).

The end result is that the first meal of the day is often a parody of what it's supposed to be. Not an opportunity to process the needed day's energy, but an excuse to engage in heavy doses of pancakes and syrup, doughnuts, croissants, biscuits, hash browns, muffins, muffin tops, cinnamon buns and so on---and to wash it down, not with simple coffee, but with cappuccino, espresso, latte, caramel, and whipped cream.

Or to skip it all together. Over 30 million of us, about 10% of the U.S. population, mostly men aged 18 to 34, have no breakfast, citing work or lack of appetite (1). For kids, teenagers aged 13 to 17 had the highest incidence of going to school hungry, with 14 percent missing breakfast.

Yet, between the extremes of too much and none at all there is a "goldilocks" breakfast, one of protein and healthy grains (think eggs and whole wheat toast; oatmeal) that can provide the needed energy to improve your daily tasks. Such a breakfast can be multi-faceted; protein can come from fish, cheese, meats, beans, etc., and is not restricted solely to Western style scrambled eggs and toast. But whatever the source, breakfast results in enhanced performance, whether picking apples in an Ohio orchard, taking a standard aptitude test in school, or fixing that stubborn printer. (Not sure about Freecell).

Not surprisingly, such performance improvements are linked to better health benefits. Eating breakfast sets your thermostat, your metabolic rate (2). After a night's sleep, food revives your brain, wakes—and warms up—your body to begin working. It improves your endurance, enhances eye to hand coordination, helps you concentrate in school (3). It can help regulate blood sugar levels to keep your mood elevated and better able to cope with difficult tasks (4). Skipping breakfast on the other hand, can cause the opposite reaction; your body reacts to a lack of food by shutting down, conserving energy and making you sluggish.

Finally, and most importantly, it keeps hunger at bay. Breakfast is the day's first "hunger game," and winning it requires eating a nutritious, balanced meal that can keep you from feeling empty, a means to avoid snacks and fast food later in the day.

Because people who skip breakfast, thinking that this will help them lose weight, find that the opposite is true; the desire for food upon waking up, is, in reality, a biological imperative (5). Our body recognizes that the day has begun, we need to do work, and we need the proper fuel to do it. That fuel, that energy, cannot be ignored, and is best exemplified by what the body needs—grains, proteins, fiber—not fats and sugars.

But what if you don't have access to food? What if that need, that imperative, can't be met?

With food so abundant, is that really likely to happen? Given the availability, the profusion, of food---in super sized piles stacked in day-glow colors---is skipping breakfast, really an option that any child has to experience? Isn't it more likely that there are too many options; and that the greatest danger to our health comes from eating the wrong kind of food?

Yes, and No.

Today, the farmers of the world are producing more food than has ever been experienced in the history of human kind.

Today, one in seven people are going to bed hungry. The World Health Organization (WHO) lists hunger as the world's greatest threat to public health (6). But hunger is a "third-world" problem, right?

Guess again. In the United States in 2009, 50 million of us didn't know where our next meal was coming from. Sixteen million children under the age of 18 were food insecure (7).

And, side by side, Yin and Yang, a billion and a half people are obese, including about 100 million of us in the United States (8).

This paradox is difficult to understand. How can there be too much, and too little food? Why are over 2 billion people either under nourished or malnourished?

These are not trivial academic questions. They are the moral imperatives underlying our spiritual insistence on our daily bread. According to the WHO, undernutrition contributes to the death of 3.1 million children under five every year. If you do the math, about 8500 children each day (9).

Imagine if those 8500 children died as part of a terrorist plot. Imagine the outrage.

But sadly, as offensive at that number is, few people seem to notice or care.

My Beijing talk was a success. At least there were good questions and complements afterwards. A clear consensus that we need to be doing something about rice, climate change and food security….

….and, general acknowledgment that no additional resources, especially research money, would be forthcoming.

CHAPTER TWO

HUNGER IS NO GAME

"Hunger of choice is a painful luxury; hunger of necessity is terrifying torture."
—Mike Mullin

It's easy enough to toss around numbers. 8,500 children die of malnutrition every day. Hey, it's a number, a statistic, a stat.

Unless hunger is something you've experienced. Then it has meaning.

Growing up, we were "working poor.". My father was in the military, so we never starved, but money was always in short supply, and often so was food.

It was cyclical. When my father was paid on the first of the month, we ate well. But by the end of the month, we were visiting the day-old bakery and buying stale Wonder bread. I remember many meatless meals. Eggs and toast, potatoes and cabbage, soup and bread. Bacon, when we had it, was fought over as fiercely as gold among misers.

It seems odd, and more than distressing, to talk to military families today and see the same cycle repeating itself.

It seems even sadder, that in the United States, with a Mickey D's on every corner, one in six children go to bed hungry every night (1). It seems equally bizarre to see the number of families that wait in line at the local food pantry. Not because they're lazy, not because they're on welfare; many are working full time jobs and still cannot afford food for their children (2). And before you cry, "But Food Stamps!" that provides—as of 2016—$4.00 a day in assistance (3). If you think that's enough to live on—go for it.

What is it like to go hungry? What is hunger beyond the stats?

I remember my stomach hurting. Imagine a fist of broken glass in the center of your gut. Your thoughts turn to food; it becomes the center of your universe. TV commercials advertising food suddenly get your immediate and complete attention. Even as you eat, you stare at other people's plates, asking if they are going to finish that. You are always hungry, always wanting more. Food takes on a lot of significance, a lot of value.

Asking for volunteers to scientifically evaluate extreme hunger isn't likely to pass many ethics panel's in today's academia, but at the end of World War II, Dr Ancel Keys, one of the pioneers of diet and health (and inventor of the "K-ration") conducted a year-long study on hunger at the University of Minnesota (4).

There was obvious concern that war-induced starvation would pose a huge challenge for relief agencies at war's end. If America could lead efforts to reduce the suffering of war refugees and camp survivors, it could, potentially, also acquire political advantages in a post-war period.

The study volunteers were all college-aged conscientious objectors who wanted to help the war effort. Keys's study consisted of three parts. First, a baseline, or control, was established over a three month period and the volunteers were given normal diets and exercise. This was followed by six months of reduced caloric intake, simulating a diet that was common to war victims: weak soup, turnips, potatoes, little meat, etc. Finally, three months of re-feeding with gradual increases in calories was provided in order to examine recovery. The physiology and mental state of the volunteers was recorded daily. So, a slow induction of hunger. Then semi-starvation over six-months.

The volunteers became weak. Their movements became slower. They were more sensitive to cold. Their skin dried and peeled, hair came out in clumps. Their sex drive vanished. They developed edema.

Psychologically, the men became depressed and apathetic. They had a hard time concentrating on tasks and became frustrated. They turned inward, showing less empathy for the group. Individuals became scapegoats for other's frustration. Six (of the 32 volunteers) were eventually diagnosed with character neurosis, two bordering on psychosis.

Food became their obsession. When they spoke it was about food. When they read it was about food. They collected recipes, studied cookbooks, drew up menus. Meals stretched into hours.

After six months of this, rehabilitation began. The volunteers were divided up into four groups and given an additional 400, 800, 1,200 or 1,600 calories a day, plus vitamin and protein supplements. All of the men recovered, but Keys determined that the speed at which they recovered was directly related to the caloric intake, not vitamins or supplements.

Finally, at the end of the experiment all of the volunteers were given free access to food. All of them binged (up to 11,500 calories a day!) and still felt hungry. But all gained their weight back. Many remarked that actual wartime service would have been easier. Perhaps it is not surprising that war and hunger have devastating effects on the human condition.

But what if you weren't a volunteer? What if, after going without for so long, no one stepped in to tell you the study was over and provide you with all the food you needed?

Symptoms of starvation progress at different rates depending on how quickly you are removed from food (5). The initial symptoms are digestive. Stomach pains and ravenous feelings are common. If no food follows, digestive and waste-related issues from painful constipation to diarrhea can develop. Faintness, weakness, dizziness follow. Thirst increases.

Still, the body keeps working to preserve its most vital systems, heart and brain. To do this your body eats itself (Catabolysis). Fat cells in the face and around the eyes are consumed, giving starvation victims a sunken, "big-eyed" stare. Other fat stores are used up, although extremities like feet and hands may retain water, causing edemas. Body temperature and blood levels start to drop. You develop anemia. If you are a woman, your menstrual cycle stops. You begin to shiver from the cold, consuming more energy at a faster rate.

With fat cells gone, your body starts digesting your muscles. You become apathetic, not caring, and insensitive to what is going on around you. You cannot move—even to go to the bathroom.

As you weaken, your disintegrating body is open to any opportunistic infection, any wandering bacteria, pathogen, virus, or insect that finds your weakened state a place to proliferate. For example, fungi, or molds, can grow under the esophagus, making swallowing painful. But waiting in the wings are dysentery, cholera, TB, typhoid, AIDS… (6). There is a long, long list of potential invaders.

As you regress to fatality, heart and brain function start to cease. You become even more apathetic. Mental symptoms become extreme. You have vivid hallucinations; you suffer from confusion, vertigo, nightmares. You may lapse into a coma.

Eventually, the body's resources become so depleted that the last system, the heart, can no longer function and the victim extinguishes from cardiac arrest.

Surprisingly, figures on actual starvation are uncertain, in part because as body functions diminish, it becomes vulnerable to a number of mortality factors (6). Yet, even today, around 1 billion people are food insecure.

Why?

Why, in 2017, is there still so much hunger in the world? Could it have anything to do with agriculture?

CHAPTER THREE

A BRIEF HISTORY OF AGRICULTURE, CIVILIZATION AND FAMINE

"*Famine was the mark of a maturing agricultural society, the badge of civilization*."
—Richard Manning

"*From the sweat of thy face shalt thou eat bread, till thou return unto the ground.*"
—Genesis 3:19.

If we look at the number of people currently suffering from malnutrition and/or starvation it's tempting to invoke some omnipotent being to punish us for letting so many individuals, particularly children, starve. To blame such horrific deaths on social, political or religious differences---well, it's easy enough to accept such a proposition. Blaming nature or God for the death of children is, sadly, a time-honored tradition.

But the truth is that agriculture, *of and by itself*, is inextricably linked to starvation and famine. To understand why, you need to understand the history of agriculture's inception and spread.

Culturally, the onset of agriculture did not start with a single decision, but a number of biogeographic quirks that favored increased food supplies for local populations.

In the Middle East, specifically the "fertile crescent" that stretches from Southern Turkey to the red sea and Persian Gulf, there are several species of cereal grasses. Some of these grasses have a genetic mutation that keeps their seed from shattering. Because of the semi-arid climate associated with the region, these seeds were relatively large and packed with enough carbohydrates so that they could grow to maturity during a short rainy season.

But such seed also made an easily available, starchy snack for any hunter-gatherers who might be looking for a new calorie source. Our first "daily bread.". One can imagine them returning to a site of wild cereals on a seasonal basis to reap a pre-made harvest, and over time, spreading the seed of these plants over a larger area.

That transition, from gathering to sowing, was first seen along human settlements in the Euphrates River with its larger and plumper grains of barley as well as einkorn and emmer (ancestral wheat lines). But the area between the Euphrates and Tigris rivers was not the only location. Based on anthropological evidence, human subsistence began changing in a number of locations between 11-12,000 years ago, at the end of the last ice age: wheat in the Middle East, maize in central Mexico, rice to East Asia and the Ganges plain of India, potatoes in the Andes. In turn, each center of domestication sprouted its own major civilization, Mesopotamian, Aztec, Asian, Western and Incan.

Civilization—human culture—is rooted in the domestication of plants. Why? Because it is the surplus of food generated by agriculture that leads to societal stratification. After all, if everyone has to be gathering food, we couldn't have merchants, accountants, lawyers, priests, doctors, plumbers, etc. Law, culture, history, prose, music, art, religion—all the hallmarks of civilization—would not be possible without a smaller subset of farmers able to generate sufficient food for everyone. Civilization is, and will always be, dependent on agriculture.

But why did it take so long for agriculture to become wide-spread? Wouldn't agriculture have freed us from the nasty, brutish, all too short, lives of the hunter-gatherers? The advantages of being stationary and farming the land seem so obvious compared to the drudgery of trekking up and down the countryside looking for food.

Right?

Sounds reasonable. But it ignores what farmers actually do. Up before the sun, working until it sets, day after day after day, is hard work. Yes, we romanticize such work, but farming---particularly pre-mechanization farming, is monotonous, back breaking, and exhausting. Moreover, it does not bring any immediate reward—it takes many months to see the actual caloric "fruits" of your labors. A better question then, as asked by Colin Tudge of the London School of Economics is:

> "*Not to explain why some people were slow to adopt agriculture, but why anybody took it up at all…*"(1)

But wouldn't farming have led to better food security? Wouldn't early farmers have been healthier?

In fact, just the opposite was true. While hunter-gatherers were certainly not immune from changes in food availability, a migrating lifestyle allowed them to access additional food sources. In contrast, the social stratification inherent in agricultural adoption led to a society of haves (priests, rulers) and have nots (farm laborers). Yes, the availability of grain as a cheap and easily accessible source of carbohydrate made it relatively available to the poor; but lack of access to a varied and complex diet led to the bulk of the population suffering from malnutrition and poor health.

This is clear from archeological evidence. The degree of bone and tooth decay, of disease associated with over-crowding and a sedentary life style, of bearing more children in such an environment and, of course, the back-breaking (sometimes literally) work that led to shorter life-spans and shorter people (2). Researcher Mark Cohen provides a list of health issues experienced by early farmers but absent among hunter-gatherers (3). The list includes malnutrition, osteomyletis, periostitis, intestinal parasites, syphilis, leprosy, tuberculosis, rickets, anemia, among others. Few people recognize that it is only in the last few decades that humans, on average, are now as tall as their hunter-gatherer ancestors.

So how exactly did agriculture become embraced by all humans on a global scale? Did hunter-gatherers coming into contact with agricultural peoples become so taken with their technology that they immediately stopped, stared and said, "Wow, this is so cool.".

Or, as Richard Manning states:

> *"A bunch of guys who spent their time running around the woods, hunting and fishing and trading meat for sex, one day saw someone hoeing weeds and said to themselves, 'What a fine idea! Let's go do that instead.'"*(4).

Part of the answer to the spread of agriculture isn't its "whiz-bang" technological appeal, but the ability of agriculture to generate high population densities for a specific location (e.g. development of cities). In such locations, diseases (e.g. cholera) could become established but of particular importance may have been the domestication of livestock. The

closeness of the livestock to human populations under crowded conditions allowed pathogens to "jump" from animals to humans and infectious diseases such as smallpox, influenza, measles, tuberculosis and malaria developed (5).

The development of disease in early farming societies unquestionably extracted its toll. But those who survived were inoculated, carrying some degree of resistance. *Resistance that hunter-gatherers did not have*. As a consequence, when agricultural societies came into contact with "uncivilized" peoples, disease was a great leveler.

To gain some idea of how effective a leveler, follow the onset of smallpox in the conquest of the New World by Europeans. Jared Diamond, in his seminal work, "Guns, Germs and Steel" (6) points out that far more Native Americans were killed by Eurasian germs than on the battlefield. In describing the conquest of the Aztec Empire by Cortes, Diamond points out that smallpox (from an infected Cuban slave) had reached Mexico just ahead of the Spanish conquistadors. The resulting epidemic killed about half of the Aztecs; indeed, by the early 17th century, Mexico's initial population of about 20 million natives had diminished to less than 2 million.

The idea then that agriculture was just too "good to pass up", and spread rapidly throughout the world as a result of superior technology is a lie. Rather, it is the ability of agriculture; particularly European agriculture, to spread through germ warfare that is fundamental to its wide adoption. The wars that were actually fought on battlefields in the new world, from Cortez to Custer were, as Richard Manning puts it, "Mopping up operations." (4).

Today of course, all lands, all cultures (with a microscopic few) are agriculturally based. Yet, the connection between agriculture and famine still seems antithetical. How does adoption of one lead to the occurrence of the other?

Remember that agriculture provides a means to develop large populations concentrated on small areas of land. However, that land must continue to supply the necessary nutrients (e.g. nitrogen) and resources (water) that ensure the stability of food production over time. It is no surprise that river valleys, prone to periodic flooding (and hence new nutrient deposition),

were the locations for the earliest agricultural civilizations (e.g. Egypt, Mesopotamia).

But, over time, the ability of the land to provide sufficient food for a given population is dependent on external forces. One of the most important is environmental; i.e. shifts in climate (7).

For this reason, cultures rise and fall. They are prone to these external forces and such forces topple empires. They do so in a fundamental way: by limiting food production and inflicting wide spread starvation and famine within a concentrated population. Remember---*concentrated populations only exist because of the ability of agriculture to provide the necessary food*. Consequently, when such food is not available, famine occurs and civilizations fail.

History is overripe with examples of how agriculture leads to famine and how famine, in turn, leads to collapse. Famine was associated with the Fall of Rome, with the disappearance of the Mayan and Anastazi empires, with the Byzantine Empire, with the forced migration of the Toltecs, with the French Revolution, with the Irish Potato Famine, with cannibalism following the Russian Revolution in the 1920s, with the horrors of China's great leap forward in the late 1950s and early 1960s (8).

How devastating were these famines? Well to provide perspective, during the 20th century there were two global wars, World War I and World War II that resulted in an estimated ~75 million individuals who were killed (9). There are thousands of books, articles, posts, etc. that discuss what happened, when it occurred, who was affected, the root causes, the social, the political, the geographical consequences—all in great detail.

Yet, during the 20th century, about the same number of individuals---75 million---died of famine. There are certainly records of these famines, from Russia to China to India; and a number of scholarly books, but you would be hard pressed to find anything like the detailed historical record that accompanies WWI and WWII. Death by starvation in huge numbers has no historical resonance. It is only recently, in the last few decades, that the threat of massive famine has not hovered over humanity (10).

But is it fair to lay the blame for such famines on agriculture? Isn't famine the result of bad government, or civil war, or totalitarian regimes? Don't we still produce more food than we consume?

There is no argument that government, though maliciousness, mismanagement or malfeasance can greatly aggravate food shortages. They have done so repeatedly, from the response of the English Parliament to the Irish potato famine, to Stalin's land redistribution schemes, to Mao Zedong's "Great Leap Forward", to Assad's handling of the current drought in Syria, bad government can claim credit for exacerbating famine (11).

But bad governments can claim responsibility for famines since the inception of civilization. Why? Because historically, agriculture *created* government and leaders. The societies that are the hallmark of agricultural expertise relied on government for the infrastructure and political stability necessary to maintain agricultural production. If these leaders, being human, fail to provide the means to maintain productivity, then famine can and will occur.

While bad government, whether dictatorships or parliaments, can aggravate famine, it is nature that is the ultimate cause---from the introduction of a fungus, *Phytophthera infestans* to potato fields in Ireland, to the severe drought in Russia in 2010 that sent wheat prices soaring, (and contributed to the current political unrest in the Middle East). The vulnerability of agriculture; especially industrial agriculture; i.e. large, concentrated areas of mono-specific crops, to biological and natural pressures is immense. Yes, having a dictator or political villain makes government a convenient scapegoat, and exacerbates the conditions that result in famine; but famine and harvest failure have been hand in glove companions since agriculture's onset (12). You cannot assume that all government will be good.

Wait! Isn't the fact that many people are obese and others starving mean that there is plenty of food? All we need to do is redistribute it. Wouldn't this solve any potential famines?

Of all the arguments related to disproving the links between agriculture and famine, this one is, perhaps, the most deceptive.

Granted, it does appeal to our better selves. That is, we care for each other, and we would never let someone else starve while we had plenty, right? While mothers use the image of starving kids to get their own children to eat their vegetables, there is legitimate and shared compassion that children are indeed starving.

Such is the appeal of children that we can, and often do, respond. Few growing up in the 1980s can forget the images of skeletal Ethiopian children, the coming together across the globe to raise awareness and money; “Band-Aid”, “Live-Aid”, “We Are the World”, were all part of the effort to alleviate starvation in Africa and elsewhere.

However, such efforts, while admirable, do not provide a permanent solution for the issue of hunger, malnutrition and famine. Why?

Because it is not possible, nor is it likely, that food or other resources will be equitably shared between developed and developing countries on a permanent basis. To think that such redistribution will ever occur is unrealistic, even utopian.

Think of food as money. While charities can, and do, transfer monies to countries undergoing famine or wide-spread malnutrition, they do not transfer sufficient funds to lift an entire country out of poverty. Yet, such a transfer, given the obvious and well-documented connection between poverty and hunger, is what would be necessary to alleviate food insecurity on a permanent basis. Or put in starker terms: people who are wealthy will not voluntarily transfer the bulk of their wealth (or food) to another country.

They will of course, justify not doing so. Such justification runs a human emotional gamut from race to politics, to religion, to “freedom”. But imagine if you will, the United States rising up as one and saying, “Oh yes, we know we are obese, we have too much food and it is hurting us. So here Sudan (or whatever country is currently experiencing a food crisis) is all the food you need. Enjoy.”.

Not going to happen. And to keep insisting that famine is just a matter of food redistribution is to ignore a fundamental aspect of capitalism. Money is not equitably distributed, nor are the things that money can buy, like food. Famines occur, not because food is unavailable, but because the cost of that food is beyond the reach of a large segment of the population. And the cost of that food in turn, is going to depend on the ability of agriculture to provide it. A lot of it. All the time. *No matter the environmental circumstances.*

In making such an argument, it is reasonable to pause and ask: if agriculture invariably leads to famine; why are so many people (over 7.5