NUCLEAR FAMINE: ~~A~~ TWO BILLION PEOPLE AT RISK?

Global Impacts of Limited Nuclear War
on Agriculture, Food Supplies, and Human Nutrition

SECOND EDITION

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Introduction to the Second Edition

In April of 2012 we released the report *Nuclear Famine: A Billion People at Risk* which examined the climatic and agricultural consequences of a limited, regional nuclear war. The report looked specifically at the declines in US maize and Chinese rice production that would result from the predicted climate disruption and concluded that even a limited nuclear conflict would cause extensive famine, mainly in the developing world, and put more than one billion people at risk of starvation.

Since then new research by Lili Xia and Alan Robock has shown that the climate change caused by a limited nuclear war would affect Chinese maize production as severely as rice production and it would affect wheat production much more severely than rice output. Their new findings suggest that the original report may have seriously underestimated the consequences of a limited nuclear war. In addition to the one billion people in the developing world who would face possible starvation, 1.3 billion people in China would confront severe food insecurity. The prospect of a decade of widespread hunger and intense social and economic instability in the world's largest country has immense implications for the entire global community, as does the possibility that the huge declines in Chinese wheat production will be matched by similar declines in other wheat producing countries.

This updated version of *Nuclear Famine* attempts to address these new concerns and better define the full extent of the worldwide catastrophe that will result from even a limited, regional nuclear war.

Executive Summary

Over the last several years, a number of studies have shown that a limited, regional nuclear war between India and Pakistan would cause significant climate disruption worldwide. Two studies published in 2012 examined the impact on agricultural output that would result from this climate disruption.

In the US, corn production would decline by an average of 10% for an entire decade, with the most severe decline, about 20%, in year 5. There would be a similar decline in soybean production, with the most severe loss, again about 20%, in year 5.

A second study found a significant decline in Chinese middle season rice production. During the first 4 years, rice production would decline by an average of 21%; over the next 6 years the decline would average 10%.

A third study, completed in the fall of 2013, showed that there would be even larger declines in Chinese winter wheat production. Production would fall 50% in the first year, and, averaged over the entire decade after the war, it would be 31% below baseline.

The decline in available food would be exacerbated by increases in food prices which would make food inaccessible to hundreds of millions of the world's poorest. Even if agricultural markets continued to function normally, 215 million people would be added to the rolls of the malnourished over the course of a decade.

However, markets would not function normally. Significant, sustained agricultural shortfalls over an extended period would almost certainly lead to panic and hoarding on an international scale as food exporting nations suspended exports in order to assure adequate food supplies for their own populations. This turmoil in the agricultural markets would further reduce accessible food.

The 870 million people in the world who are chronically malnourished today have a baseline consumption of 1,750 calories or less per day. Even a 10% decline in their food consumption would put this entire group at risk. In addition, the anticipated suspension of exports from grain growing countries would threaten the food supplies of several hundred million additional people who have adequate nutrition today, but who live in countries that are highly dependent on food imports.

Finally, more than a billion people in China would also face severe food insecurity. The number of people threatened by nuclear-war induced famine would be well over two billion.

These studies demonstrate the need for additional research and underscore the urgent need to move with all possible speed to the negotiation of a global agreement to outlaw and eliminate nuclear weapons and the danger of nuclear war.

Background

In the 1980s, a number of scientific studies demonstrated that a large scale nuclear war between the United States and the Soviet Union would cause “Nuclear Winter”, a profound worldwide climate disruption with significant decreases in precipitation and average surface temperature.

A US National Academy of Sciences study on the medical consequences of nuclear war concluded that, in the aftermath of such a war, “the primary mechanisms for human fatalities would likely not be from blast effects, not from thermal radiation burns, and not from ionizing radiation, but, rather, from mass starvation.”[1] While the direct mortality attributed to a “large-scale nuclear war” was estimated at several hundred million people, the subsequent food and health crisis was expected to result in “the loss of one to four billion lives.”

In 2007, a study by Robock et al demonstrated that even a very “limited” regional nuclear war, involving only 100 Hiroshima-sized bombs, or less than 0.5% of the world’s nuclear arsenal, would also produce global climate disruption, although the impact on temperature and precipitation would be less profound.[2] At that time, there were no data on the effect that the predicted climate disruption would have on agricultural production. The historical experience following cooling events caused by volcanic eruptions, most notably the Tambora eruption in 1815, suggested that there might be a very significant impact on food production and human nutrition.

A 2007 report by the International Physicians for the Prevention of Nuclear War and its US affiliate, Physicians for Social Responsibility, suggested that up to one billion people might starve if a limited nuclear war led to even a 10% decline in their food consumption.[3]

This report is an initial attempt to quantify the impact of a limited nuclear war on agricultural production and the subsequent effects on global food prices and food supply, and on human nutrition.

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1 Harwell, M., and C. Harwell. 1986. Nuclear Famine: The Indirect Effects of Nuclear War. In, Solomon, F. and R. Marston (Eds.). *The Medical Implications of Nuclear War*. Washington, D.C.: National Academy Press. 117-135.

2 Robock, A., L. Oman, G. Stenchikov, O. Toon, C. Bardeen and R. Turco, 2007, Climatic consequences of regional nuclear conflicts. *Atm. Chem. Phys.,* 7: 2003-12.

3 Helfand, I. 2007. *An Assessment of the Extent of Projected Global Famine Resulting from Limited, Regional Nuclear War.* Paper presented to the Royal Society of Medicine, London, UK, October 2007.

Climate disruption from a “limited” regional nuclear war

A 2007 study by Toon et al[4] considered the consequences of a possible nuclear war between India and Pakistan and showed that such a conflict would loft up to 6.6 Tg (6.6 teragrams or 6.6 million metric tons) of black carbon aerosol particles into the upper troposphere. Robock et al then calculated the effect that this injection of soot would have on global climate assuming a war in South Asia occurring in mid May.

Their study used a state of the art general circulation climate model, ModelE from the NASA Goddard Institute for Space Studies, and employed a conservative figure of only 5 Tg of black carbon particles. They found that, “A global average surface cooling of -1.25°C persists for years, and after a decade the cooling is still -0.50°C. The temperature changes are largest over land. A cooling of several degrees occurs over large areas of North America and Eurasia, including most of the grain-growing regions.” In addition the study found significant declines in global precipitation with marked decreases in rainfall in the most important temperate grain growing regions of North America and Eurasia, and a large reduction in the Asian summer monsoon.[5]

Two additional studies, one by Stenke et al, and the other by Mills et al, each using a different climate model have also examined the impact on global climate of this limited nuclear war scenario and they have both found comparable effects.[6, 7]

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4 Toon, Owen B., Richard P. Turco, Alan Robock, Charles Bardeen, Luke Oman, and Georgiy L. Stenchikov, 2007: Atmospheric effects and societal consequences of regional scale nuclear conflicts and acts of individual nuclear terrorism. *Atm. Chem. Phys.,* 7, 1973-2002.

5 Robock, Alan, Luke Oman, Georgiy L. Stenchikov, Owen B. Toon, Charles Bardeen, and Richard P. Turco, 2007: Climatic consequences of regional nuclear conflicts. *Atm. Chem. Phys.,* 7, 2003-2012.

6 http://www.atmos-chem-phys-discuss.net/13/12089/2013/acpd-13-12089-2013.html

7 Mills, M., Toon, O. B., Taylor, J., Robock, A., “Multi-decadal global cooling and unprecedented ozone loss following a regional nuclear conflict,” publication pending.

The impact on agricultural production

Two studies conducted in 2012 examined how these climate alterations would affect agricultural output.

Ozdogan et al[8] examined the impact on corn and soybean production in the US Corn Belt where more than 70% of US grain is produced. Localized climate data were generated for four separate sites in the Corn Belt, one each in Indiana, Illinois, Iowa, and Missouri (Figure 1). The study used a comprehensive terrestrial ecosystem model, the Agro-Integrated Biosphere Simulator (Agro-IBIS), to calculate the change in predicted yield for corn and soybeans at each of these sites for the 10 years following a limited nuclear war in South Asia. The calculated change in crop yield was based on the decline in precip-itation, solar radiation, growing season length, and average monthly temperature predicted in Robock's study.

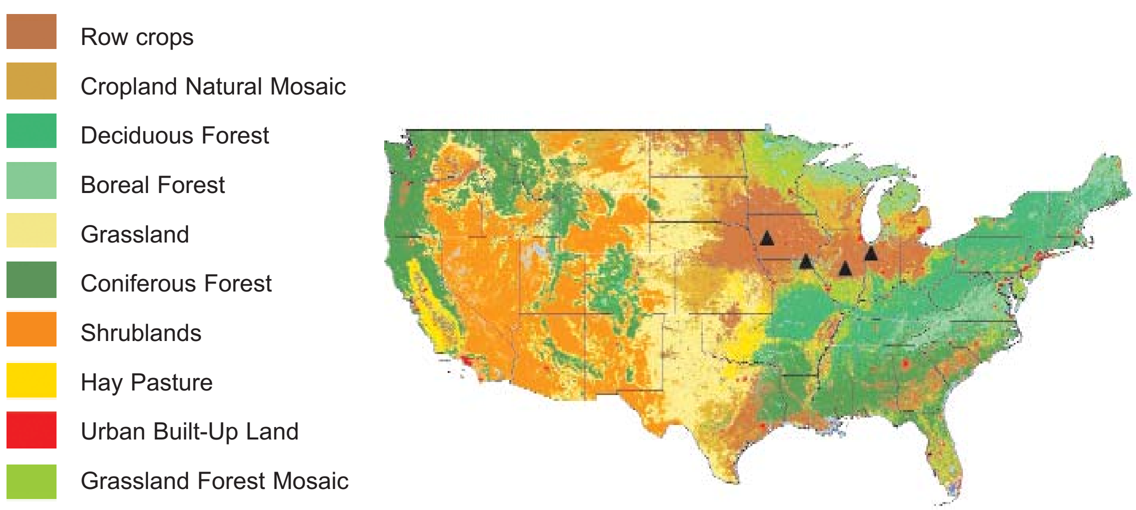


Figure 1. Localized climate data were generated for four sites in the US Corn Belt. From left to right, Iowa, Missouri, Illinois, and Indiana. [Figure 1 from Ozdogan et al.[8]]

8 Ozdogan, Mutlu, Alan Robock, and Christopher Kucharik, 2012: Impacts of Nuclear Conflict in South Asia on Crop Production in the Midwestern United States.

The calculations in this initial study are probably conservative, as the study did not consider two other environmental factors which would be expected to produce a further significant decline in yield. It did not factor in the increase in UV light secondary to ozone depletion, and, perhaps more importantly, it did not consider daily temperature extremes which may lead to complete crop failure. The observed weather following the Tambora eruption suggests that these daily extremes may be the largest determinant of total crop losses. The average global deviation in temperature in 1816 was only -0.7°C, but there was significant shortening of the growing season.

In the northeastern United States and eastern Canada, which were particularly hard hit, temperatures were actually above average during the early part of the year, and even during the summer months there were a number of periods with average or above average temperatures. But four severe cold waves, June 6-11, July 9-11, and August 21 and August 30, brought killing frosts as far south as the Mid Atlantic States, and in New England and Quebec there was even significant snow fall in June.[9] These periods of frost

TEMPERATURE EXTREMES MAY LEAD TO COMPLETE CROP FAILURE

A farmer in Timor-Leste packs up bundles of rice destroyed by climate extremes.

UN PHOTO / MARTINE PERRET

9 Stommel H, Stommel E. 1979. The year without a summer. *Scientific American*. 240:176-186

caused extensive damage to crops. A similar pattern in Northern Europe caused crop losses in the range of 75%[10] and the last multi-country famine in European history.

In addition, the study did not consider several other factors which might limit food production. Modern agriculture is very dependent on gasoline to power tractors and irrigation pumps and to transport produce to market, and on other petroleum products used in the manufacture of fertilizer and pesticides. A major conflict in South Asia would be very likely to affect petroleum supplies and prices which would have an additional negative impact on agricultural output. Further, given the intense demand for petroleum products, some of the grain produced might be diverted to ethanol production to try to offset the shortfall in petroleum.

Despite this conservative bias, the study showed very significant declines in both corn and soybean production. Averaged over 10 years, corn production would decline by 10% at all four sites (Figure 2). But there would be a great deal of variation from year to year, and losses would be

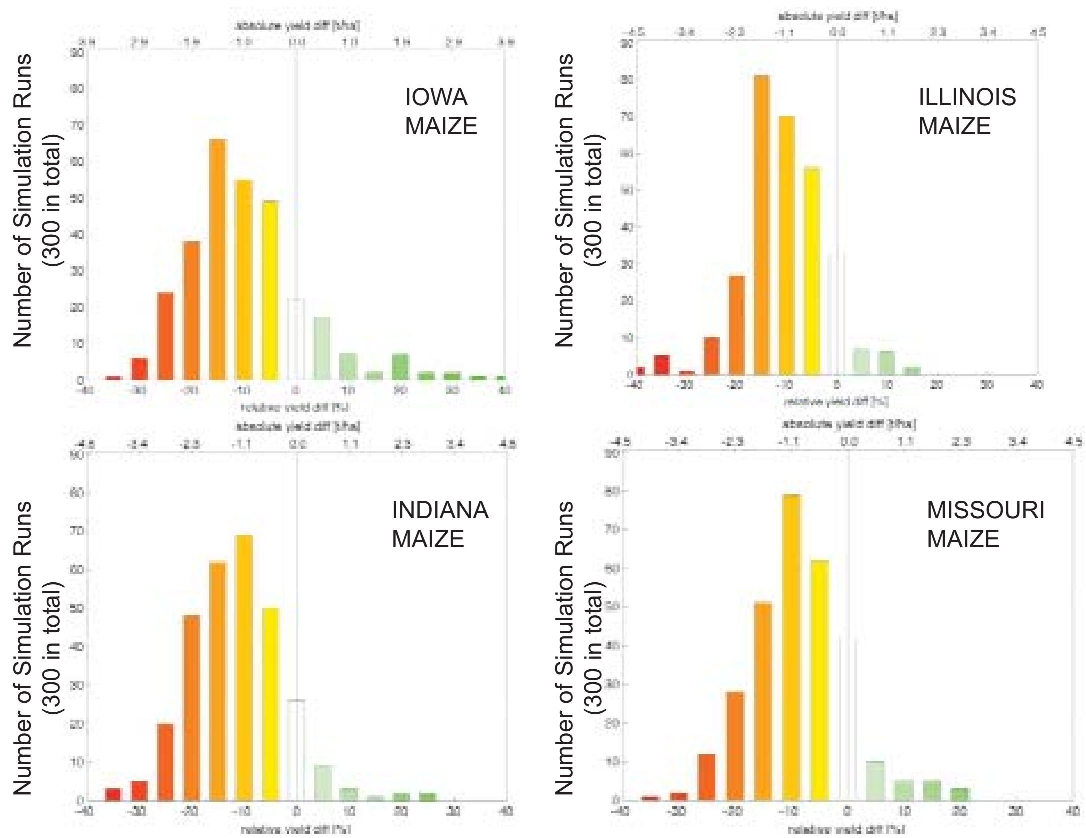


Figure 2. Declines in US corn (maize) production. To generate an estimate of the probable change in crop yield, computer simulations were run to obtain 300 different baseline crop yield levels using random selection of actual annual climate data over the past 30 years. The x axis shows the percent change in crop yield from the estimated baseline; the y axis shows the number of simulations that yielded a change of that size. [Figure 7 from Ozdogan et al.[8]]

10 Post, J. 1983. Climatic change and subsistence crises. *Journal of Interdisciplinary History*. 14:153-160.

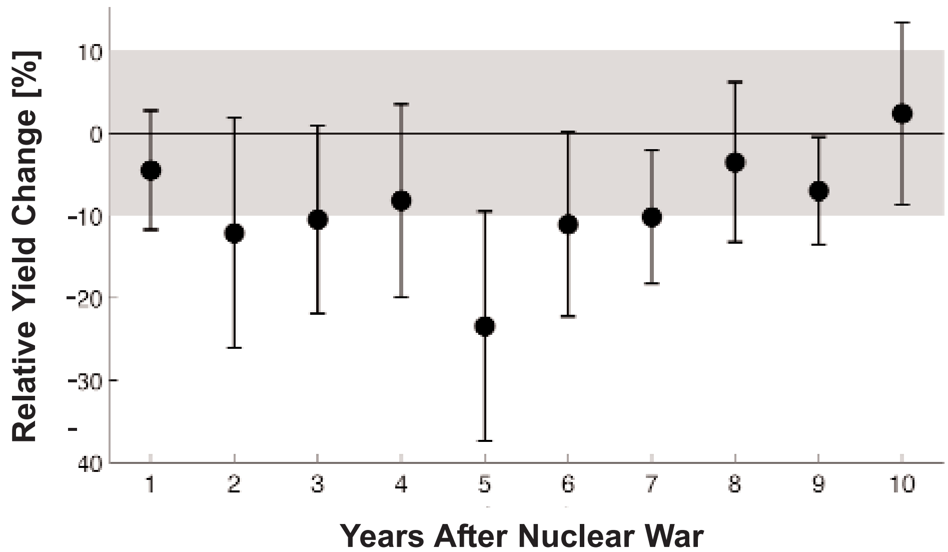


Figure 3. Reduction of maize production over time, with whiskers showing one standard deviation for each year after the nuclear war. The gray area shows ±1 standard deviation from the control runs, illustrating the effect of interannual weather variations. [Figure courtesy of M. Ozdogan.]

most severe in year 5, averaging more than 20% (Figure 3). For soybeans there would be a similar decline averaged over 10 years (Figure 4 on pg 9). Here, too, the losses would be most severe in year 5, again averaging more than 20%.

In a separate study, Xia and Robock[11] examined the decline in Chinese middle season rice production in response to this 5 Tg event. This study used a different model, the Decision Support System for Agrotechnology Transfer model 4.02 (DSSAT). It is a dynamic biophysical crop model and simulates plant growth on a per hectare basis, maintaining balances for water, carbon and nitrogen. The required inputs include the plant environment (weather and soil), cultivar genotypes and agricultural management practices. The outputs from this model are potential yields, which are usually higher than actual yields. Perturbed climate data in 24 provinces in China were generated using predictions of climate change from Robock et al. and observations in China from 198 weather stations from 1978 to 2008 (China Meteorological Data Sharing Service System). The simulated change in middle season rice yield in China was due to the predicted decline in average monthly precipitation, solar radiation and temperature.

This study also did not consider the effect of UV light increases or daily temperature extremes, or the possible decline in available fertilizer, pesticide and gasoline. Again, despite this conservative bias, the study showed a significant decline in Chinese middle season rice production. Averaged over 10 years, the decline would be about 15% (Figure 5 on pg 10). During the first 4 years, rice production would decline by an average of 21%; over the next 6 years the decline would average 10% (Figure 6 on pg 10).

The impact on rice production was found to vary widely by province (Figure 7 on pg 11). In some areas in the South and East of China, production would actually rise. For example, in Hainan rice

11 Xia, Lili, and Alan Robock, 2012: Impacts of Nuclear Conflict in South Asia on Rice Production in Mainland China. *Climatic Change*.

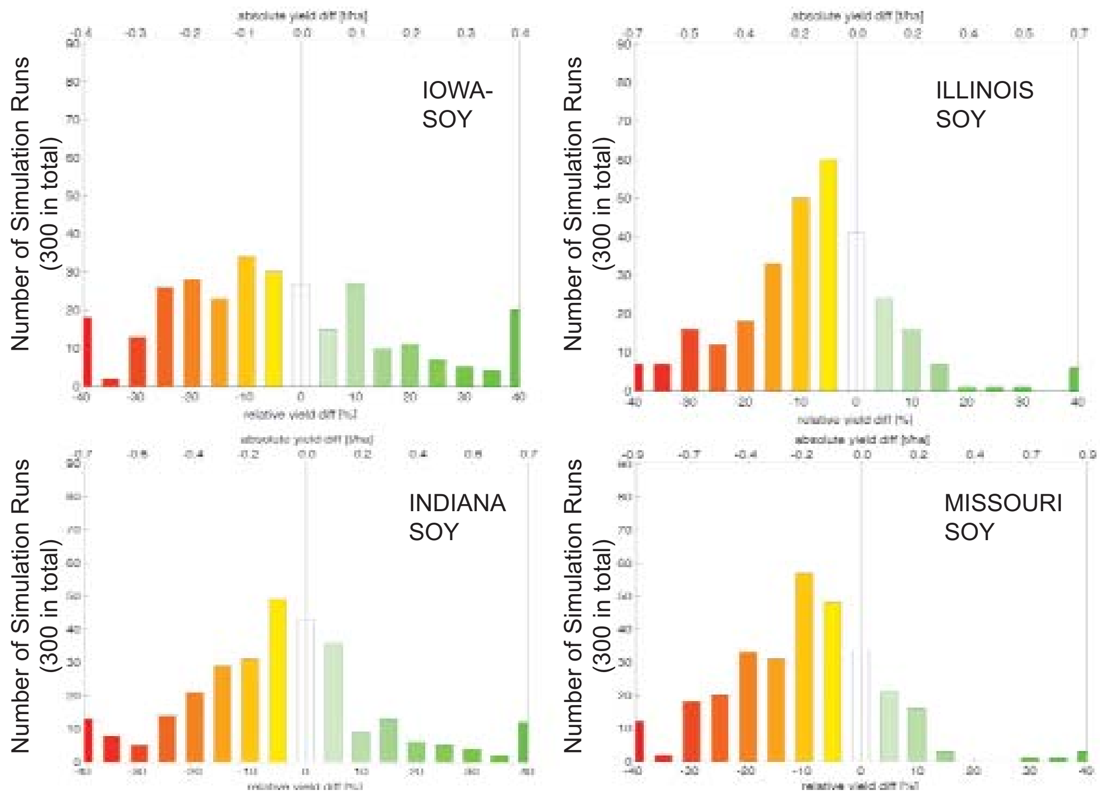


Figure 4. Declines in US soy production. The graphs were generated using the same methodology as in Figure 2 on pg 7. [Figure 8 from Ozdogan et al.[7]]

yield would increase by 5 to 15% per year. In other areas to the North and West the decline would be much more severe than the national average. In Heilongjian province, home to 36 million people, there would be a complete failure of the rice crop in year 1 following the war. Rice production would remain 60 to 70% below baseline for most of the rest of the following decade (Figure 8 on pg 11).

In their 2013 study, Xia, Robock and their colleagues looked at the impact of the climate change following limited nuclear war on rice, maize and, wheat production in China.[12] For this study they used the 2007 climate change projections by Robock et al. that were used in the earlier studies of US maize and Chinese rice production, and also the subsequent climate projections of Stenke et al. and Mills et al. There were some variations in the crop outputs found using the different climate models, but they all showed significant declines in crop size. For maize the average decline was about 16% over a full decade. For middle season rice the projected decline was somewhat larger than in their earlier estimates: 20% for the first 5 years and 17% over the course of 10 years. The most disturbing new projection related to the Chinese winter wheat crop which normally is just a little bit smaller than middle season rice production. The effect on winter wheat was much more severe, averaging about 39% for the first 5 years and 31% for a full decade. In the first year, the projected decline in winter wheat was more than 50%.

12 Xia, L., Robock, A., Mills, M., Stenke, A., Helfand, I., "Global famine after a regional nuclear war" submitted to *Earth's Future* October 2013.

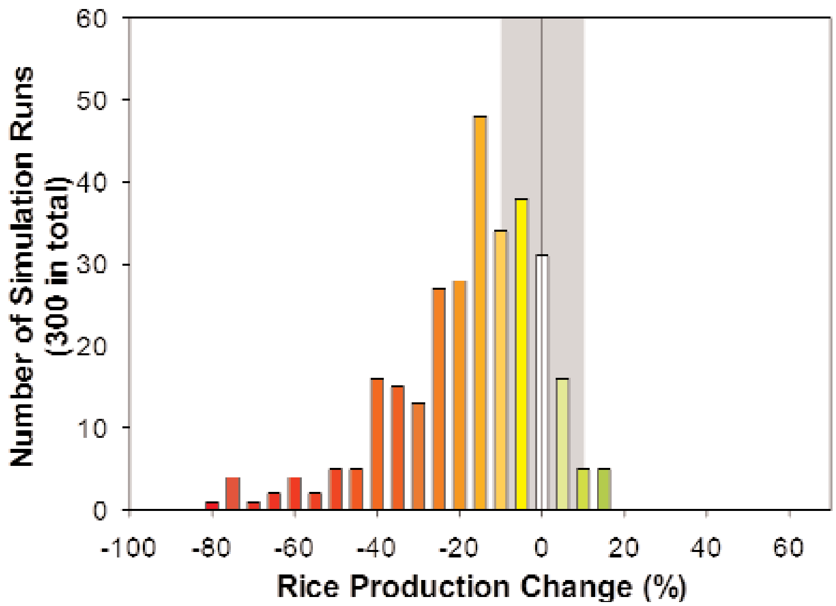


Figure 5. Distribution of rice production change (%): The gray area shows ±1 standard deviation from the control runs, illustrating the effect of interannual weather variations. [Figure 2(b) from Xia and Robock.11]

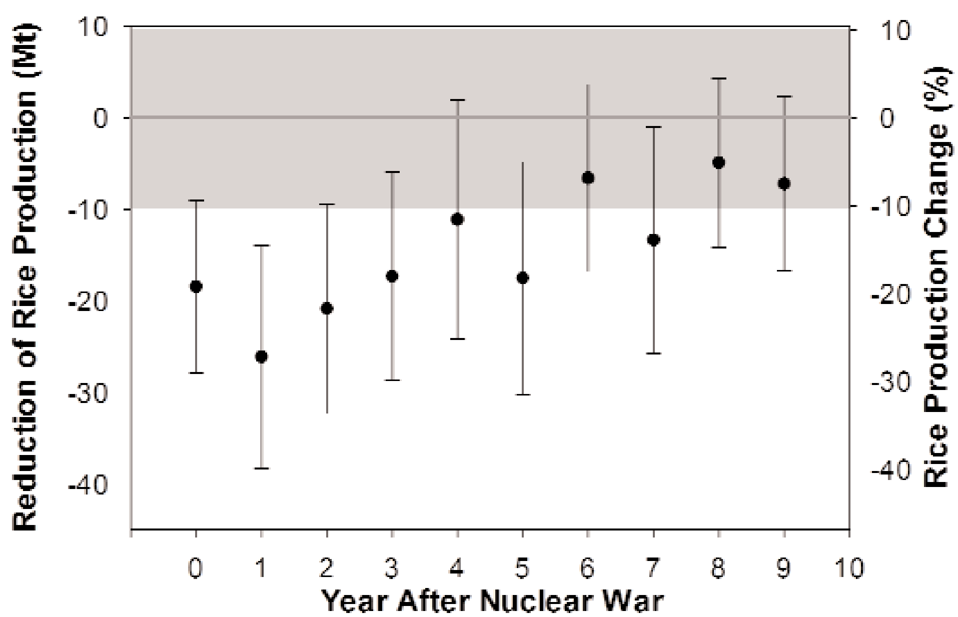


Figure 6. Reduction of rice production with whiskers showing one standard deviation for each year after the nuclear war. The gray area shows ±1 standard deviation from the control runs, illustrating the effect of interannual weather variations. [Figure 2(a) from Xia and Robock.[11]]

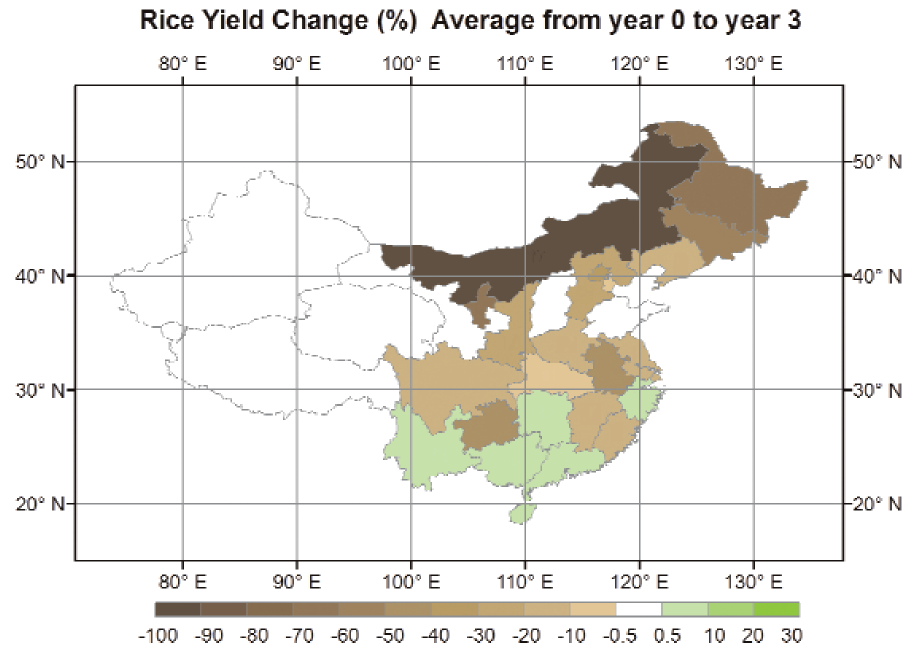


Figure 7. Map of rice yield reduction (%) for the first 4 years after regional nuclear conflict. Brown indicates negative change, and green indicates positive change. White regions are provinces for which we did not conduct model simulations. [Redrawn from Figure 5 of Xia and Robock.[11]]

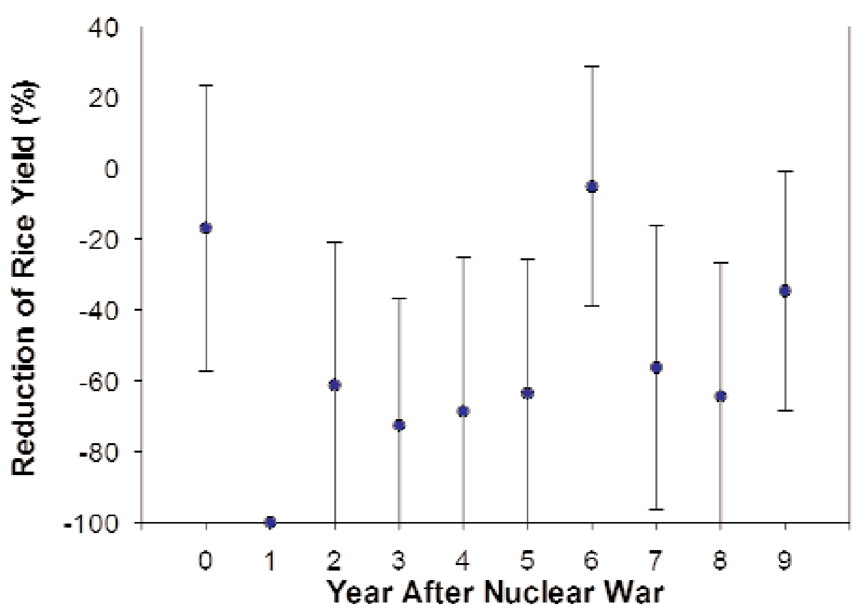


Figure 8. Reduction of rice yield over time in Heilongjiang Province, with whiskers showing one standard deviation for each year after the nuclear war. [Redrawn from Figure 6 of Xia and Robock.[11]]

UN PHOTO / STUART PRICE

The impact on human nutrition and health

The world is particularly vulnerable at this time to a major decline in food production. In June 2013, the UN Food and Agriculture Organization estimated that grain stocks were 509 million metric tons, 21% of the annual consumption of 2,339 million metric tons.[13] Expressed as days of consumption, this reserve would last for 77 days. The US Department of Agriculture estimates were somewhat lower at 432 million metric tons of grain stocks, a mere 19% of their estimated annual consumption, of 2,289 million metric tons.[14] Expressed as days of consumption, this reserve would last for only 68 days.

Furthermore, the UN Food and Agriculture Organization estimated in 2012 that there are 870 million people in the world who already suffer from malnutrition.[15]

Given this precarious situation, even small further declines in food production could have major consequences.

The large and protracted declines in agricultural output predicted by Ozdogan and Xia are unprecedented in modern times, and the full extent of their impact on human nutrition are difficult to predict.

Normally a decline in agricultural production affects food consumption by raising the cost of food; the decline in "accessible" food, the amount of food that people can afford to buy, is much greater than the decline in "available" food, the actual agricultural output. The impact of rising food prices is, of course, felt disproportionately by people who are already malnourished precisely because they cannot, at baseline prices, afford to buy enough food.

A 2011 study by Webb et al[16], drawing on the data generated by Ozdogan, attempted to estimate the effect that the shortfall in agricultural output following a limited nuclear war would have on the price of food, and therefore on its accessibility. Using a global economy-wide model, the Global Trade Analysis Project (GTAP), the study examined the effects on food prices, and the numbers of people who are malnourished. In order to simulate the shock's effect on cereal and soybean prices, the study assumed that all crops produced globally suffer yield declines to the same extent that Ozdogan predicts for maize and soybeans in the US corn belt.

The study found that the rise in food prices associated with the average yearly decline in food production would cause an additional 40 million

13 www.fao.org/worldfoodsituation/wfs-home/csdb/en/

14 www.usda.gov/oce/commodity/wasde/latest.pdf

15 www.fao.org/publications/sofi/en/

16 ippnw.org/pdf/projected-impacts-webb.pdf

Somalia Suffers from Worst Drought in Century

A woman holding her malnourished baby queues for food at the Badbado camp for Internally Displaced Persons. Famine has been declared in two regions of southern Somalia. In 2011, UN Secretary General Ban Ki-moon indicated that 3.7 million people across the country—that's nearly half of the Somali population—were in crisis and in urgent need of assistance.

UN PHOTO / STUART PRICE

people to become malnourished, and that the largest annual decline in food production in year 5 would cause 67 million to enter the ranks of the malnourished. The cumulative effect over 10 years would cause a total of 215 million people to become malnourished.

The study concluded that a one year 20% decline in crop yield would cause crop prices to rise 19.7%. But this rise would be very unevenly distributed across the globe. In East Asia the rise would be 21.4% and in South Asia 31.6%. The relationship between crop yield and food prices is not linear: a further decline in yield would lead to a much larger increase in prices. While the current crop studies do not predict a decline of 40%, should that occur, it would cause global crop prices to rise an average of 98.7%. Again the price rise would be very uneven. In South Asia as a whole prices would rise 140.6%, and in India 159.6%.

It is hard to calculate with certainty the effect of these price rises on caloric intake, but the study argues that, "There is a broad consensus in the literature that this parameter [the percentage change in caloric intake given a one percent increase in the price of food] is approximately -0.5." So a one year decline in crop yield of 20% worldwide would lead to a 19.7% rise in prices and a 10% decline in caloric intake. The much larger increases in food prices in some areas that are predicted in the study would therefore be expected to have a profound effect on the number of calories that people are able to consume.

A number of factors suggest that the accessible food for those who are already malnourished would decline even more dramatically than these numbers suggest. The GTAP model looks only at market behavior and assumes that markets behave "normally." In fact, experience suggests that, in the aftermath of nuclear war, markets would not behave normally. As the authors explain, "Markets react.. with commodity speculation, hoarding (withholding of products from the market), or by seeking to capture market share through private non-open market deals (a loss of transaction transparency), each of which contributed to higher price volatility and market uncertainty" in recent years. For example, in March 2008, global wheat prices leaped 25% in a single day; in the following month the price of rice rose 50% in just two weeks.[17] These transient jumps in price were prompted by events far less significant than a nuclear war.

At the time of the great Bengal famine of 1943,

17 Webb, P. 2010. Medium to Long-Run Implications of High Food Prices for Global Nutrition. *Journal of Nutrition.* 140 (1): 140S-47S.

during which three million people died, food production was only 5% less than it had been on average over the preceding five years, and it was actually 13% higher than it had been in 1941 when there was not a famine. But in 1943, after the Japanese occupation of Burma, which had historically exported grain to Bengal, the decline in food production was coupled with panic hoarding, and the price of rice increased nearly five fold, making food unaffordable to large numbers of people.[18] These two factors, hoarding and the severe increase in rice prices, caused an effective inaccessibility of food far more severe than the actual shortfall in production.

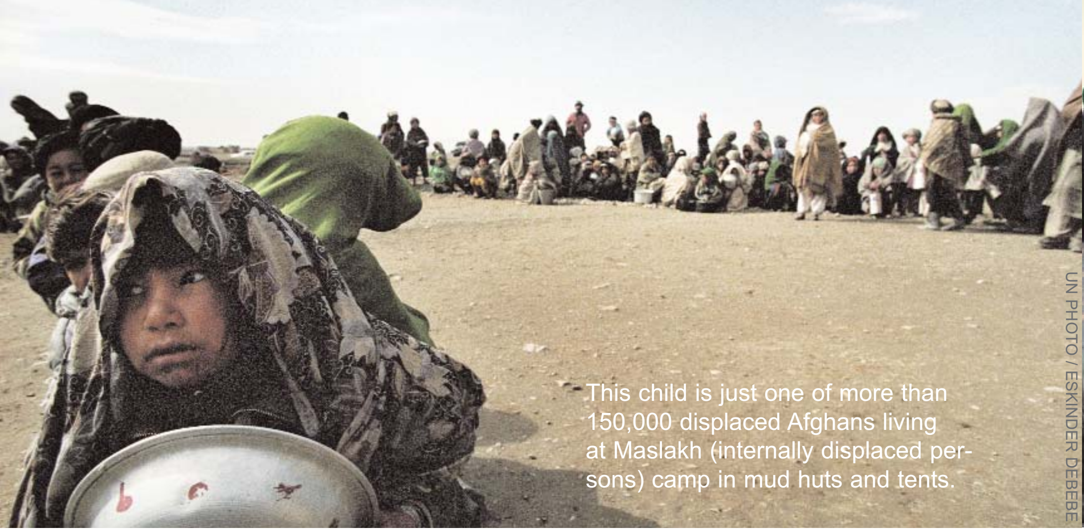
We would have to expect panic on a far greater scale following a nuclear war, even if it were a "limited" regional war, especially as it became clear that there would be significant, sustained agricultural shortfalls over an extended period.

It is probable that there would be hoarding on an international scale as food exporting nations suspended exports in order to assure adequate food supplies for their own populations. In the last decade there have been a number of examples of nations banning grain exports. In September 2002, Canada, faced with a sharp decline in wheat production because of drought conditions, suspended wheat exports for a year. The next year the European Union took similar action, as did Russia. And in August 2004, Vietnam indicated it would not export rice until the following spring.[19] India banned rice exports in November 2007 which, followed by export rice restrictions in Vietnam, Egypt, and China in January 2008, contributed to historic increases in world rice prices. In 2010, Russia, responding to the severe drought conditions that year, again suspended grain exports.[20]

In the event of a regional nuclear war, the grain exporting states would be faced with major crop losses and the prospect of bad harvests for the next several years. It is probable that they would take similar action, and refuse to export whatever grain surplus they might have, retaining it instead as a domestic reserve. It is also probable that there would be widespread speculation on agricultural markets.

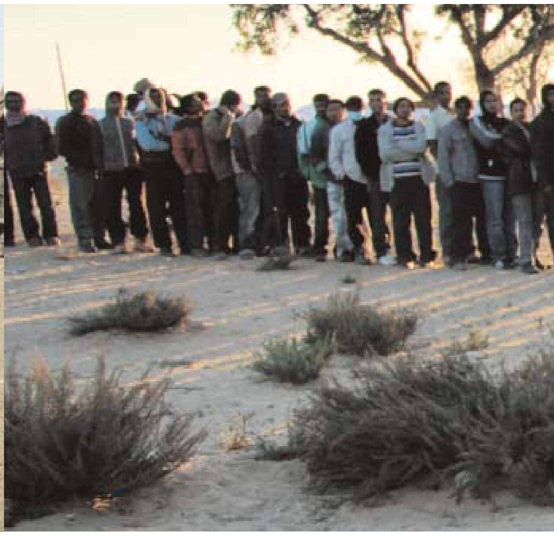
Given these potential disturbances in normal market conditions, it is possible that the increases in food prices could be much larger than predicted by the Global Trade Analysis Project (GTAP) model used in the Webb et al study.

Even if we do not take into account the way that rising food prices exacerbate the effects of a fall in food production, the declines in available



This child is just one of more than 150,000 displaced Afghans living at Maslakh (internally displaced persons) camp in mud huts and tents.

UN PHOTO / ESKINDER DEBEBE



18 Sen, A. *Poverty and famines*. Oxford: Oxford University Press. 1981.

19 Brown, LR. *Outgrowing the Earth.* New York: WW Norton & Co. 2004.

20 Khrennikov, I. Medvedev orders review of Russian grain export ban at harvest end. 2010. www.businessweek.com/news/2010-10-04/medvedev-orders-review-of-russia-grain-export-ban-at-harvest-end.html

food predicted by Ozdogan and Xia would be devastating.

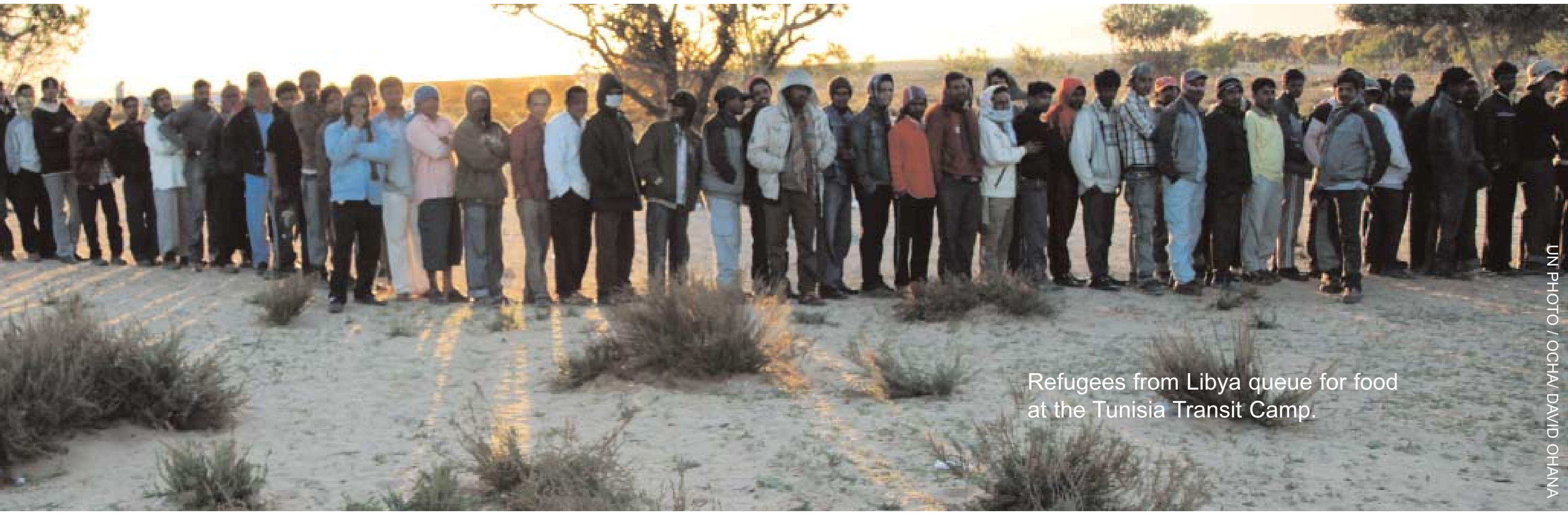
For the 870 million people who are currently malnourished, the majority of their caloric intake is derived from grain. For example, in Bangladesh the figure is about 78%. We cannot know with certainty that a 10-20% decline in grain production would translate directly into a 10-20% decline in grain consumption for all 870 million. Some of the malnourished are subsistence farmers who live in areas where grain production might not decline. But we do know that the chronically malnourished cannot survive a significant, sustained further decline in their caloric intake. With a baseline consumption of 1,750 calories per day, even a 10% decline would lead to an additional deficit of 175 calories per day. While many of the malnourished might survive the first year, it is realistic to fear that they would not survive if these conditions persisted for a decade.

Even if minimal, life-sustaining, levels of calories could be provided for all of the malnourished, the decline in quality of nutrition would cause significant health effects. As Webb et al point out in their study:

"As food prices rise people spend relatively more on staples and less on 'quality' foods (which tend to be micronutrient rich, including meat, eggs, vegetables, etc.)...

"The specific impacts of reduced diet quality as well as quantity include a rise in wasting among children under 5, maternal undernutrition (low body mass index) which can also cause irreversible damage to the fetus and a rise in rates of low birth weights, and outbreaks of micronutrient deficiency diseases that may be killers in their own right.

"Based on such experiences, one can assume that any large food price increases attendant on a nuclear shock would result in similar shifts in household consumption globally (not only in South Asia) away from nutrient-rich, higher cost foods towards core staples (with a view to buffering at least a minimum energy intake). There are insufficient data to allow for the more complex modeling required to estimate resulting nutrition outcomes in terms of increased micronutrient deficiencies, maternal nutritional compromise or low birth weight. However, it is clear that the human impacts would be huge—with impaired growth and development of children, increased morbidity (due to failing immune functions caused by malnutrition), and a rise in excess mortality."[21]



Refugees from Libya queue for food at the Tunisia Transit Camp.

UN PHOTO / OCHA/ DAVID OHANA

21 Webb et al, op. cit. 2011. www.ippnw.org/pdf/projected-impacts-webb.pdf

The agricultural disruption caused by a limited nuclear war would also pose a threat to the several hundred million people who enjoy adequate nutrition at this time, but who live in countries that are dependent on food imports. The nations of North Africa, home to more than 150 million people, import more than 45% of their food.[22] Malaysia, South Korea, Japan and Taiwan, as well as a number of countries in the Middle East, import 50% or more of their grain.[23] The anticipated suspension of exports from grain growing countries might cause severe effects on nutrition in all of these countries. The wealthier among them might initially be able to obtain grain by bidding up the price on international markets, but as the extent and duration of the crop losses became clear, exporting countries would probably tighten their bans on exports threatening the food supplies of all these importing countries.

The more recent study of Chinese maize and wheat production by Xia and Robock suggests other impacts that need to be considered. Prior to the release of their work, it had been assumed that China, like most of the industrial world, would be spared the worst effects of the global famine. But these new data raise real questions about China's ability to feed its own people.

At baseline, China is in a better position to withstand the effects of decreased food production than the poorer nations of the world. Caloric intake has risen significantly with the dramatic economic expansion of the last 3 decades and the average Chinese now consumes about 3000 calories per day.[24] The diet has also become more diversified with some decline in the proportion of calories obtained from grains and a rise in the amount obtained from fruits, vegetables and meat products, although cereals still account for more than 40% of caloric intake.[25] In addition, expressed as days of food consumption, China has significantly larger reserves of grain than the world as a whole. In the summer of 2013, wheat reserves totaled nearly 167 days of consumption, and rice reserves were 119 days of consumption.[26]

Despite this relatively strong position, China would be hard pressed to deal with the very large reduction in wheat production projected in the new study. While rice (144 million tons per year) is the most important grain in China in terms of direct human consumption, wheat (125 million tons) is a close second and accounts for more than 1/3 of grain consumption,[27] and China's wheat consumption amounts to 19% of world production.[28] As a 2012 Australian government study noted, "Security of supply for these two cereals is of uttermost importance in China and therefore food security in China often refers to "grain security". Not surprisingly, China pays much attention to ensuring a high-level of self-sufficiency in these two crops."[29]

A 31% shortfall in wheat production, coupled with the previously predicted 15% decline in rice production, would end that state of self-sufficiency. Even the large reserves that China maintains would be exhausted within 2 years. At that point China would be forced to attempt to make massive purchases on world grain markets driving prices up even more. If, as expected, international hoarding made grain unavailable, China would have to dramatically curtail rice and wheat consumption.

The 15% decline in Chinese maize production predicted in the new study by Xia and Robock would further affect food security. Maize is actually China's largest grain crop, at 177 million tons in 2010.[30] The vast majority is used, not for direct

22 www.ers.usda.gov/publications/gfa16/GFA16CountryTablesNAfrca.xls.

23 www.iucn.org/themes/wani/eatlas/html/gm19.html.

24 http://faostat.fao.org/CountryProfiles/Country_Profile/Direct.aspx?lang=en&area=351

25 Pinstrop-Anderson, P and Cheng, F, Case Studies in Food Policy for Developing Countries. Ithaca, New York. Cornell University Press. 2009. Viewed at http://goo.gl/oAGfoS

26 http://www.fas.usda.gov/psdonline/psdreport.aspx?hidReportRetrievalName=BVS&hidReportRetrievalID=867&hidReportRetrievalTemplateID=13

27 http://www.daff.gov.au/__data/assets/pdf_file/0006/2259123/food-consumption-trends-in-china-v2.pdf

28 http://www.fas.usda.gov/psdonline/psdreport.aspx?hidReportRetrievalName=BVS&hidReportRetrievalID=867&hidReportRetrievalTemplateID=13

29 http://www.daff.gov.au/__data/assets/pdf_file/0006/2259123/food-consumption-trends-in-china-v2.pdf

30 Ibid.



human consumption, but for animal feed. The decline in maize production would primarily affect the 20% of caloric intake currently provided by meat and poultry.

Taken together, the declines in rice, maize, and wheat would lead to a decline of more than 10% in average caloric intake in China. However, this is the average effect, and given the great economic inequality seen in China today the impact on the billion plus people in China who remain poor would probably be much greater. It is difficult to estimate how many of these people might actually starve. It is clear that this dramatic decrease in food supply would cause profound economic and social instability in the largest country in the world, home to the world's second largest and most dynamic economy, and a large nuclear arsenal of its own.

The data on Chinese grain production also raise questions about possible implications for production in other parts of the globe. Most of the world's wheat is grown in countries at latitudes similar to China's. Will there be similar impacts on wheat production in North America, Russia, the European Union? Will the decline in maize production demonstrated now for both China and the US also occur in other countries? There is an urgent need to determine the impact that climate disruption after limited nuclear war will have on these critical food crops.

Combined with the 870 million people who are currently malnourished, and the populations of the food importing countries, the 1.3 billion Chinese who are also at risk place the number of people potentially threatened by famine at well over two billion.

Two other issues need to be considered as well. First, there is a very high likelihood that famine on this scale would lead to major epidemics of infectious diseases. The prolonged cooling and resultant famine in 536-545 AD was accompanied by a major outbreak of plague which developed over the next half century into a global pandemic.[31] The famine of 1816 triggered an epidemic of typhus in Ireland that spread to much of Europe[32] and the famine conditions in India that year led to an outbreak of cholera that has been implicated in the first global cholera pandemic.[33]

The well studied Great Bengal Famine of 1943 was associated with major local epidemics of cholera, malaria, smallpox, and dysentery.[34]

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31 Keys, D. *Catastrophe.* London: Century. 1999.

32 Stommel, H. *Volcano weather: The story of 1816, the year without a winter.* Newport, Rhode Island: Seven Seas Press. 1983.

33 Stommel, H, Stommel, E. op. cit.

34 Sen. op. cit.

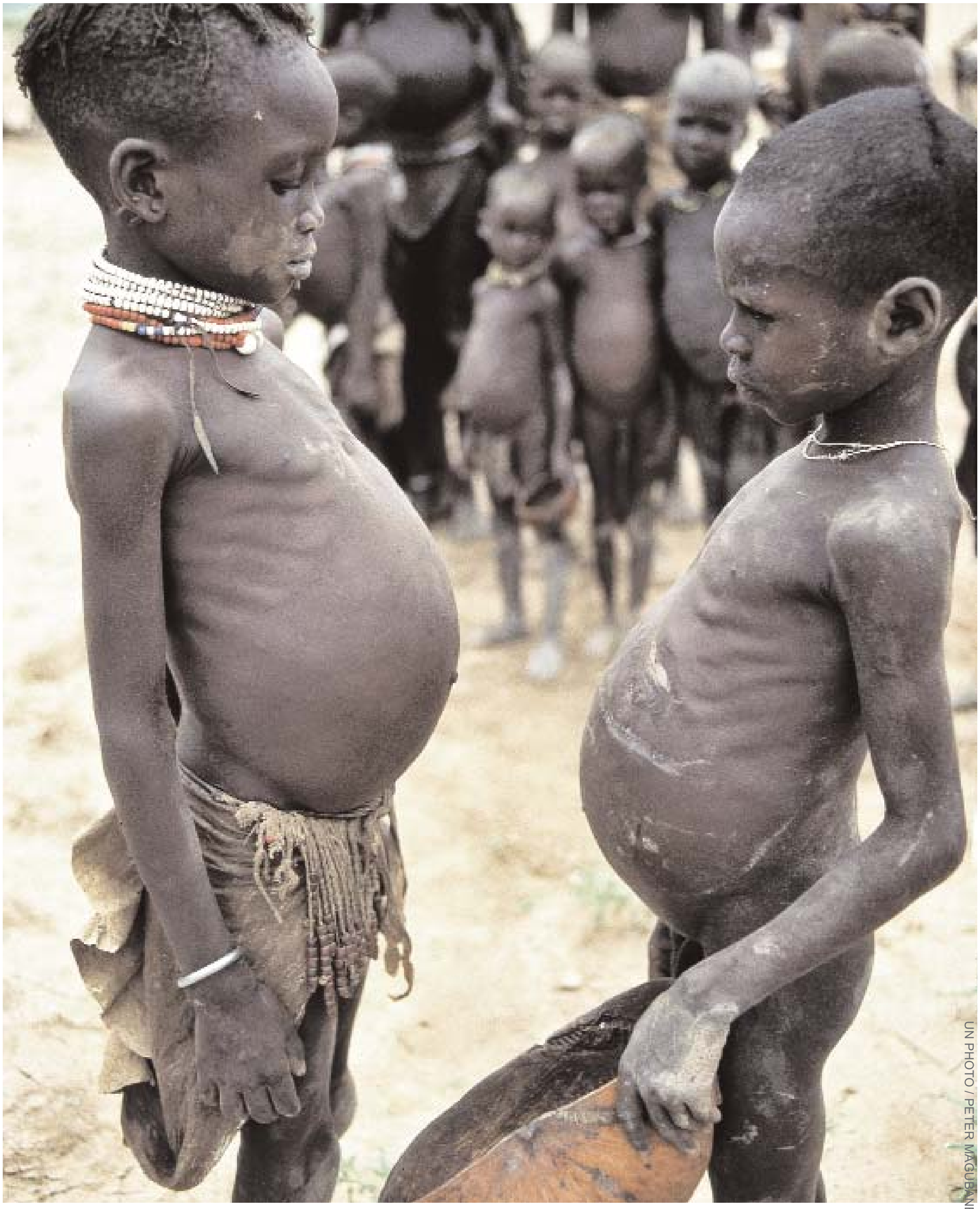
Despite the advances in medical technology of the last half century, a global famine on the scale anticipated would provide the ideal breeding ground for epidemics involving any or all of these illnesses. In particular, the vast megacities of the developing world, crowded, and often lacking adequate sanitation in the best of times, would almost certainly see major outbreaks of infectious diseases; and illnesses, like plague, which have not been prevalent in recent years might again become major health threats.

Finally, we need to consider the immense potential for war and civil conflict that would be created by famine on this scale. Within nations where famine is widespread, there would almost certainly be food riots, and competition for limited food resources might well exacerbate ethnic and regional animosities. Among nations, armed conflict would be a very real possibility as states dependent on imports attempted to maintain access to food supplies.

It is impossible to estimate the additional global death toll from disease and further warfare that this "limited regional" nuclear war might cause, but, given the worldwide scope of the climate effects, the dead from these causes might well number in the hundreds of millions.

A husband watches over his severely malnourished wife as she lies in agony at a camp for drought victims in Makalle, northern Ethiopia.

UN PHOTO / JOHN ISAAC



UN PHOTO / PETER MAGUBANE

According to the World Food Programme, the number of under-nourished people worldwide is just under 1 billion - equivalent to the population of North America and Europe combined.

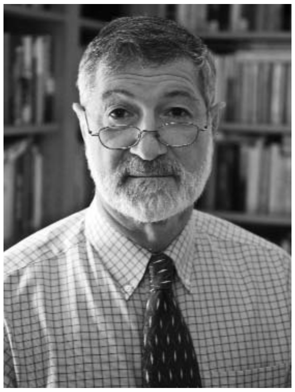
Conclusions and recommendations

The newly generated data on the decline in agricultural production that would follow a limited, regional nuclear war in South Asia raise the concern that a global famine could result, threatening more than two billion people. Epidemic disease and further conflict spawned by such a famine would put additional hundreds of millions at risk. These findings support the following recommendations:

1) There is an urgent need for further study to confirm the declines in corn, rice and wheat predicted by Ozdogan, Xia and their colleagues and to examine the effect on key crops in other important food producing countries.

2) There is a need to explore in more detail the subsequent effects that these shortfalls would have on human nutrition including both the extent of the decline in caloric intake that would result from these crop losses and the extent of micronutrient deficiencies that would, in turn, result from this decline in caloric intake.

3) The need for further study notwithstanding, the preliminary data in these studies raises a giant red flag about the threat to humanity posed not only by the nuclear arms race in South Asia but also by the larger and more dangerous nuclear arsenals possessed by the other nuclear weapons states. These studies demonstrate the need for additional research and underscore the urgent need to move with all possible speed to the negotiation of a global agreement to outlaw and eliminate nuclear weapons and the danger of nuclear war.



About the author

Ira Helfand, a physician from Northampton, Massachusetts, has been writing and speaking about the medical consequences of nuclear war on behalf of IPPNW and its US affiliate, Physicians for Social Responsibility, since the 1980s. For the past five years, he has been working with climate scientists Alan Robock, O. B. Toon, and others to help document the health and environmental disaster that would ensue from a range of possible nuclear wars.

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International Physicians for the Prevention of Nuclear War (IPPNW) is a federation of national medical organizations in 62 countries, representing doctors, medical students, other health workers, and concerned citizens who share the common goal of creating a more peaceful and secure world freed from the threat of nuclear annihilation. IPPNW received the 1985 Nobel Peace Prize.

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