

NUCLEAR WINTER AS THE GREATEST CLIMATE CRISIS FOR HUMANITY AND THE ROLE OF IRRIGATION SCIENTISTS

L'HIVER NUCLÉAIRE, LA PLUS GRANDE CRISE CLIMATIQUE POUR L'HUMANITÉ ET LE RÔLE DES SCIENTIFIQUES EN IRRIGATION

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ABSTRACT

Nuclear winter, caused after a large number of nuclear detonations and subsequent massive fires which inject huge amounts of soot into the stratosphere and blocking solar radiation is the greatest climate crisis humanity is facing. Although the probability of occurrence may be as small as once in thousand years, the expected death toll would be 100 times greater than that of natural disasters. To cope with the most severe famine ever recorded, nations in high-latitude regions need to stockpile food supplies. A recommended stockpile of wheat, soybeans, sugar, and cooking oil—sufficient to meet the energy and protein requirements for one year—costs approximately 460 USD per person in Japan. Implementing a rolling stock and consumption system significantly reduces costs and minimizes food waste. But even with a successful rolling stock and consumption strategy, a three-year stockpile may be the maximum financially sustainable, whereas a nuclear winter could last up to a decade. Even under a nuclear winter, crops may be cultivated in low-latitude and dry regions by shifting from tropical to temperate crops and by growing winter crops during summer. Such a rapid shift in crop cultivation requires bold international cooperation. If trade remains possible, a part of the population in temperate regions could be fed with food produced in tropical drylands. Irrigation may play a key role in alleviating the crisis, as precipitation is also predicted to be significantly reduced in tropical drylands under a nuclear winter. Fossil groundwater should be conserved for the crisis, and equipment for digging wells, pumping water, delivering it through pipelines, and irrigating with high water-use efficiency should also be stockpiled. Water harvesting and saving technologies should be further developed, even if they are not economically feasible during peacetime.

Keywords: nuclear detonations; natural disasters; tropical drylands; Water harvesting; winter crops; international cooperation.

RESUME

L'hiver nucléaire, provoqué par un grand nombre d'explosions nucléaires suivies d'incendies massifs qui injectent d'énormes quantités de suie dans la stratosphère et bloquent le rayonnement solaire, constitue la plus grave crise climatique à laquelle l'humanité est confrontée. Bien que la probabilité qu'il se produise soit aussi faible qu'une fois tous les mille ans, le nombre de victimes attendu serait 100 fois supérieur à celui des catastrophes naturelles. Pour faire face à la famine la plus grave jamais enregistrée, les pays situés dans les régions de hautes latitudes doivent constituer des réserves alimentaires. Les réserves recommandées de blé, de soja, de sucre et d'huile de cuisson — suffisantes pour couvrir les besoins énergétiques et protéiques pendant d'une année — coûtent environ 460 USD par personne au Japon. La mise en place d'un système de stockage et de consommation permet de réduire considérablement les coûts et de minimiser le gaspillage alimentaire.

Mais même avec une stratégie efficace de stockage et de consommation, une réserve couvrant trois ans représente peut-être la limite financièrement viable, alors qu'un hiver nucléaire pourrait durer jusqu'à une décennie. Même en cas d'hiver nucléaire, il est possible de cultiver des plantes dans les régions sèches de basses latitudes en passant des cultures tropicales aux cultures tempérées et en cultivant des cultures

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hivernales pendant l'été. Une telle transition rapide dans les pratiques agricoles nécessite une coopération internationale audacieuse. Si les échanges commerciaux restent possibles, une partie de la population des régions tempérées pourrait être nourrie grâce à des denrées produites dans les zones tropicales sèches. L'irrigation pourrait jouer un rôle clé dans l'atténuation de la crise, car on prévoit également une réduction significative des précipitations dans les zones tropicales sèches en cas d'hiver nucléaire. Les eaux souterraines fossiles doivent être préservées en prévision de la crise, et il convient également de constituer des stocks de matériel permettant de creuser des puits, de pomper l'eau, de l'acheminer par des canalisations et d'irriguer avec une grande efficacité hydrique. Les technologies de collecte et d'économie d'eau doivent être développées davantage, même si elles ne sont pas économiquement viables en temps de paix.

Mots-clés : Explosions nucléaires; Catastrophes naturelles; Zones tropicales sèches; Collecte de l'eau; Cultures hivernales; Coopération internationale.

INTRODUCTION

Any scientists may not deny that man-made climate change is ongoing and the threats of its possible negative impacts on food production is undeniable. Even though great efforts and investments to early warning systems and hardware measures preventing disasters have been made, natural disasters is killing an average of 65,000 people worldwide per year (<https://www.undrr.org/developing-national-disaster-risk-reduction-strategies>), and the figure could rise owing to climate change. Efforts to minimize negative impacts of climate-change on disaster prevention and food production should be kept and even strengthened, we are facing yet larger risk which threatens humanity at far larger magnitude: nuclear winter.

Since the full-scale invasion to Ukraine, Russia has repeatedly and openly reminded the West that it is the strongest nuclear-armed superpower. On 5 February, the last treaty restricting nuclear arsenals expired, while China is rapidly developing ICBM silos. Washington plans to increase its nuclear weapons. Given these developments, the Doomsday Clock was advanced to 85 seconds to midnight, the closest it has ever been. On 2 March, French president announced that France is planning to increase nuclear warhead. In May, the review conference of the parties to the treaty on the non-proliferation of nuclear weapons (NPT) failed to adopt final document after Iran dispute.

It is predicted that a total nuclear war would kill 360 million people through direct blasts and rapid radioactive hazards. Moreover, massive fires ignited by nuclear explosions could generate strong ascending air currents, injecting vast amounts of soot into the stratosphere, where it can remain for years and block sunlight as shown in Figure 1.

The latest numerical simulations predict that a 70% reduction in solar radiation could cause a staggering 15°C drop in temperature across major croplands. Xia et al. (2022) warned that five billion people could starve to death due to crop failures caused by nuclear winter, even if grains for livestock are consumed by humans. Indeed, nuclear famine is the greatest climate crisis which humanity is facing. Although the probability of occurrence is small, the expected death toll is higher than that of any other disaster risks. Even if we assume that the probability of total nuclear war is only once in every thousand years, expected annual death toll would be five million, 92 times greater than that of natural disasters.

Funding to studies and investments on adaptive measures comparable to climate change should be made. The death toll estimate by Xia et al. (2022) is based on an assumption that no adaptive measures except for turning the feed to food. Actually, there may be adaptive measures. The purpose of this study is to present adaptive measures to nuclear famine and to discuss the role of irrigation scientists in the measures.

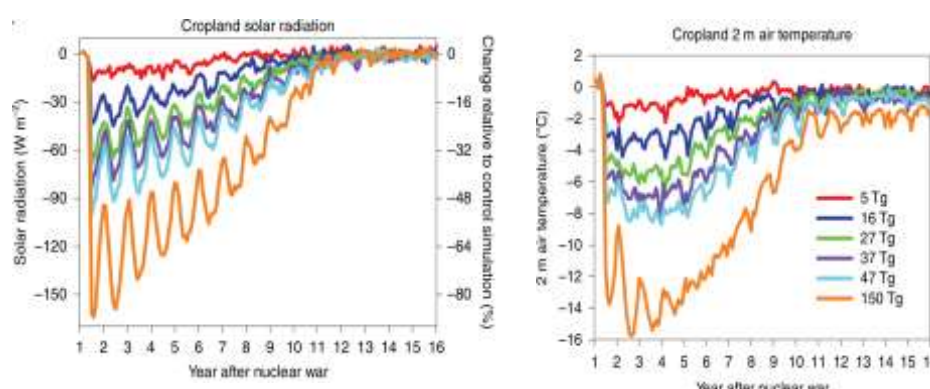


Figure 1. Predicted cropland-area-weighted-mean solar radiation and temperature after different scales of nuclear wars (Xia et al., 2022).

STOCKPILING

To cope with the most severe famine ever recorded, nations in high-latitude regions need to stockpile foods. Historically, stockpiling foods has been encouraged to cope with famines. More than thousand years ago, China, Korea, and Japan commonly had a legislated system of “justice storage” to cope with famines. Increased world trade and advances in agricultural practices including pesticide and irrigation has greatly reduced the necessity of large stockpiling. During cold war, nations stockpiled foods for months in their nuclear shelters, but as nuclear warheads reduced after the collapse of Soviet Union, public food reserves retreated: e.g. Europe dismantled intervention procurement under the Common Agricultural Policy. But now countries are aware have restarted stockpiling: e.g. Switzerland and Sweden are preparing enough foods for each of the country’s population for 12 months. Even if agricultural adaptive measures presented below are successfully implemented, it may take at least 12 months to adapt and shift resources. Also, the climate impacts of nuclear winter peaks after a few years after the explosions. First three years may be too challenging to rely on. Therefore, each should have stockpile for at least one year. Table 1 shows that a suggested stockpile of wheat, soybeans, sugar, and cooking oil—sufficient to meet the energy and protein requirements for one year—costs approximately 460 USD per person in Japan.

Table 1. An example of the stockpile and its cost satisfying 2,200 kcal/day and 60 g of protein for 12 months for one person for one year.

	wheat	soybean	sugar	oil	total	
storage(kg)	140	30	25	10	205 kg	
density(kg/L)	0.7	0.83	1.04	0.9		
storage(L)	200	36	24	11	271 L	
energy density (kcal/kg)	3600	4170	3840	8000		
energy density (kcal/L)	2520	3461	3984	7200		
protein density (g/kg)	90	353	0	0		per day
total energy (kcal)	504000	125100	96000	80000	805100	2206 kcal/d
total protein (g)	12600	10590	0	0	23190	64 g/d
price (USD/kg)	1.25	7.50	1.50	2.50		
cost(USD)	175	225	37.5	25	462.5	

Implementing a rolling stock and consumption system significantly reduces costs and minimizes food waste. The demand for grains used in animal feed and biofuel production should be met by utilizing expired grains. Note that required volume is less than 1 m³ for three years and even the initial costs would be affordable even for developing countries. World commodity price may soar if every country starts to gear up. For coming years until target stockpile is met, demand for grains may increase.

ADAPTIVE AGRICULTURE

Even with a successful rolling stock and consumption strategy, a three-year stockpile may be the maximum financially sustainable, whereas a nuclear winter could last up to a decade. Even under a nuclear winter, crops may be cultivated in low-latitude and dry regions by shifting from tropical to temperate crops and by growing winter crops during summer. Summer crops such as rice, maize, sweet potato, and soybean may not be grown almost anywhere during the worst years, but winter crops such as wheat, barley, potato, and chickpea could still be grown in tropical areas and low-altitude temperate regions in summer. Countries with wide territory in north-south direction may be able to accomplish such a shift within its own land, making the shift more feasible during wartime. Figure 2 shows monthly average temperature in norm for two locations within two countries. When a 15 °C drop occurs, climate of regions such as Kagoshima or Bander Abbas will be like those of Asahikawa or Tabriz in norm, respectively.

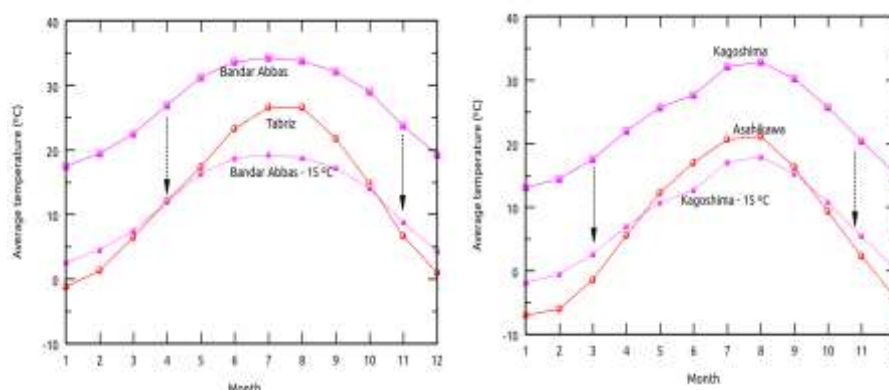


Figure 2. Monthly average temperature in norm for two locations in Japan (left) and Iran (right)

In other words, agriculture practiced in those high latitude area may be implemented in low latitude area at least in terms of temperature. Figure 3 compares digestible energy and protein per area per growing season for major winter crop in Japan under well-watered condition. As is well known, potato produces the highest energy per area. Interestingly, fababean and chickpea, commonly known as protein-rich foods, can produce less than half of others. Wilson et al. (2023) presented optimum combination of cropping under nuclear winter in New Zealand.

Not mathematically optimized, yet an example of suggested allocation of cropping area for Japan satisfying energy and protein requirement is presented in Figure 4, assuming that the same land productivities as norm can be attained. Grains and legumes were not included since betting on those fruiting crops with non-uniform harvest indices as a function of biomass may be too risky under unknown climatic patterns and new regions. Multiplying total population in Japan yields a required cropping area of 5.56 Mha, 24 % larger than current arable land.

Note that about half of the arable area may be too cold to cultivate under a nuclear winter even five years after a total nuclear war. Therefore, if most of the population are survived blasts and subsequent radioactive hazard, massive and rapid reclamation is required to turn forests covering two-third of Japan into cultivation.

Anyway, huge number of woods will have to be cut for heating, electric power and sugar production from cellulose if paper industry and supply chain survived. Seeds for those crops should also be stockpiled. Most countries may have too narrow to implement such an internal shift. International cooperation is required to realize trans-border shift. Even under halved solar radiation, tropical and subtropical areas, drylands in particular, may have solar radiation enough to grow winter crops grown in temperate regions.

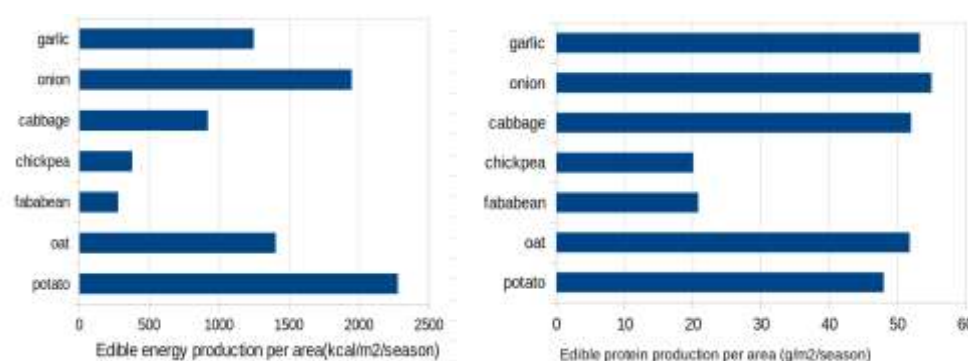


Figure 3. Comparison of edible energy (left) and protein (right) production per area per season in Japan under well-watered conditions.

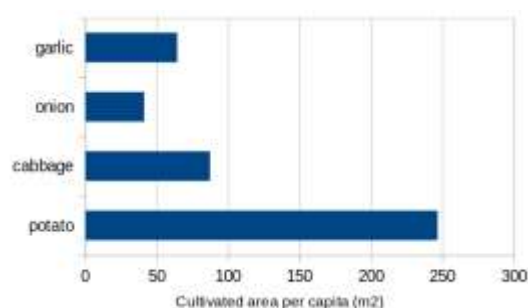


Figure 4. Comparison of edible energy (left) and protein (right) production per area per season in Japan under well-watered conditions.

Foods produced in the southern countries, most of which are the members of treaty of prohibiting nuclear weapons and neutral for the conflict, therefore pure victims, may feed the world and save humanity, if ceasefire is made and supply-chains are restored in a few years. Such a rapid shift in crop cultivation requires bold international cooperation to transfer seeds, machines and knowledge to southern country s. Northern countries should make partnership pacts enacted in emergencies with southern countries before it happens.

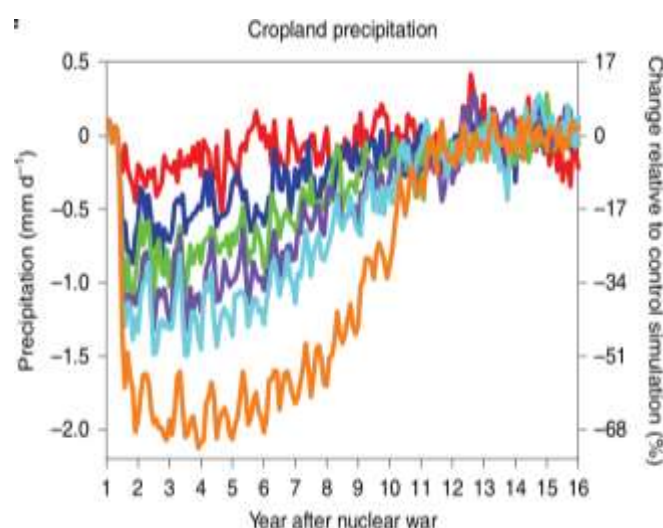


Figure 5. Predicted change in cropland-area-weighted-mean precipitation than norm (Xia et al., 2022).

However, reduced solar radiation and lowered temperature inevitably cause a plummet in precipitation. Figure 5 shows predicted change in precipitation. Tropical and subtropical drylands, suffering from severe water stress even now, will face further droughts.

CONCLUSIONS

Irrigation may play a key role in alleviating the crisis. Fossil groundwater should be conserved in order to cope with the crisis, and equipment for digging wells, pumping water, delivering it through pipelines, and irrigating with high water-use efficiency should also be stockpiled. Reverse osmosis units should also be stockpiled. Water harvesting and saving technologies should be further developed, even if they are not economically feasible during peacetime.

A modified food production model, which assumes that each farmer optimizes crop selection based on predicted temperature and solar radiation, is required to accurately predict the effects of mitigation measures. Experiments to evaluate yield under low solar radiation and different seasonal temperature patterns to provide parameter values in the modified model may also be required.

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