Climate Change and National Security

How Can Public Policy Change the World?

THE ASPEN INSTITUTE
ENERGY & ENVIRONMENT
PROGRAM

THE UNIVERSITY OF CHICAGO
Harris Public Policy

Table of Contents

Forward

The effects of climate change are not limited to increase of temperature. It causes famine, drought, and agricultural change, that can result in socioeconomic, political and environmental disasters. For example, extreme drought and increase in temperature threaten agricultural sustainability, while frequent natural disasters can contribute to serious migration crises. In recent years, countries have realized the widespread impacts of climate change as national security issues.

The Inter-Policy School Summit is a student-run conference hosted by the University of Chicago Harris School of Public Policy that seeks to propose rigorous and tangible solutions to some of the most pressing global issues of our time. The 2019 Summit was held on March 1st – 3rd 2019. Policy students from fourteen universities in four countries gathered together to explore innovative strategies to address the issues of Climate Change and National Security, which will come to play an increasingly important role in the policy realm for decades to come.

At the Summit, participants were assigned into groups concentrating on particular climate change impacts: Agriculture, Coastal Development, Conflict, Energy, Health, Labor and Migration. Partnered with the Aspen Institute's Energy & Environmental Program, they discussed the challenges we are facing and worked to figure out ways to make contributions to our world. This white paper summarizes policy recommendations made by each group.

We would also like to show our gratitude to Greg Gershuny, Anna Giorgi, and Kate Henjum in Aspen Institute's Energy & Environmental Program for their great support and advice during the Summit as well as their comments on this paper. We are also immensely grateful to Sharon Burke, Senior Advisor to New America Foundation, Amir Jina, Assistant Professor at University of Chicago, Bob Rosner, Professor at University of Chicago, and Marilyn Shapley, Senior Policy Advisor at Mercy Corps for their insightful keynote speech and panel discussion. In addition, we acknowledge and thank our sponsors for their financial support.

The Executive Board of Inter-Policy School Summit 2019
The University of Chicago, Harris School of Public Policy

Editors: Takahiro Minami, Luis E Gonzales, Wanyu Sun
(The University of Chicago, Harris School of Public Policy)

Climate Change and Agriculture:
An Information Asymmetry Approach

KHARE Parth, VASU Bibind, VERNIEST Naelle, YADAV Smiti

---

1. Executive Summary

Based on the case study of India, this paper identifies and analyzes the vicious circle between agriculture and climate change, its origins, and its socioeconomic impacts. It proposes the implementation of information-based policies in India focusing on (1) the quality of information, (2) access to information and (3) information literacy. More generally, this study illustrates the crucial role of climate information for both agriculture and climate change actions.

2. Background

Agricultural practices are intrinsically linked to climate change. Despite farmers' ability to adapt to this phenomenon, the dramatic changes currently occurring will challenge the farmers to adapt even more their land use and production intensity. Hari, Khare and Subramanian (2018) evaluated that climate change could reduce farm incomes globally by 15 to 18%, and by 20 to 25% in unirrigated areas.

On the other hand, as explained by the OECD (2012), agriculture itself is responsible for 10 to 12% of the total global anthropogenic emissions of greenhouse gases (GHGs). Farm management practices directly affect these GHGs and mitigation actions are thus needed. The OECD highlights the fact that many win-win situations such as fertilizer management and animal breeding are not adopted.

There seems to be a vicious cycle between climate change and agriculture: climate change negatively impacts agricultural yields and farming techniques themselves exacerbate climate change patterns by trying to increase yields. Most farmers, for survival purposes, tend to plan their farming activities based on a short-term perspective and not a medium or long-term perspective. This specific issue should be tackled to break the vicious cycle, thus limiting the impact of climate change on agriculture and vice-versa.

Given the importance of agriculture in the economy of developing countries and their potential impact on climate change, this paper focuses on the Indian case of crop yields. In 2018, 37.2% of working Indian men and 55.4% of working Indian women were employed in the agricultural sector (World Bank, 2019). As a consequence, 58% of Indians rely on agriculture for their livelihood (IBEF, 2018). Agriculture accounts for 15.47% of the Indian GDP (World Bank, 2019). Farming practices in India will thus need to adapt drastically to climate change to sustain economic prosperity.

3. Literature Review

Countless studies have assessed conducive climatic conditions for optimizing crop yields. Amongst them an increasing body of recent research has dedicated itself to studying the impact of changing weather and extreme events on crop productivity. Deschênes and Greenstone (2012), assess the economic impact of changing weather on US agricultural land by estimating the effect of random year-to-year variation in temperature and precipitation on agricultural profits. Dell, Jones and Olken (2012) use historical fluctuations in temperature within countries to identify its effects on aggregate economic outcomes and catalogue wide-ranging effects, reducing agricultural output, industrial output, and political stability. Dell, Jones & Oalken (2014) compile an exhaustive summary of ongoing studies harnessing exogenous variation over time within a given spatial unit. These studies credibly identify (1) the breadth of channels linking weather and the economy, (2) heterogeneous treatment effects across different types of locations, and (3) nonlinear effects of weather variables. The paper also proposes a new and adaptive modeling framework for assessing the crucial insights from the number of ground stations incremented to the Global Human Climatology Network (GHCN). Deschênes, and Greenstone (2007 and 2011) explore the relationship between daily temperatures and annual mortality rates and daily temperatures and annual residential energy consumption. Chand (2012) and Gulati (2009), among others have analyzed the temporal and spatial performance of agriculture. Real agricultural growth since 1960 has averaged about 2.8 percent in India. A recent study on Indian agriculture by Hari, Khare & Subramanian (2018) prepared for the Indian Economic Survey, uses much higher density of data (than GHCN/University of Delaware), covering a larger geographical area. They estimate reductions in farm incomes by 15-18%, and by as much as 20-25% in unirrigated areas. An rich analysis of the impact of climate change on agriculture to labor productivity is summarized in the International Monetary Fund's (IMF) report 'Effects of weather shocks on economic activity: How can low income countries cope' (2017). The IMF forecasts the climate and its impact under Representative Concentration Pathways (RCPs) projection scenarios for next 100 years. RCPs are scenarios that describe alternative trajectories for carbon dioxide emissions and the resulting atmospheric concentration from 2000 to 2100.

The impact of weather on agricultural yields is a slow-moving process. Hence, most of the literature is focused on (1) identifying better models and improved functional form specifications (to address non-linearities), (2) assessing disparate geographies over longer periods of time and (3) optimizing raw data density and exploiting advanced spatially interpolated/gridded models to study agro-climatic zones at a higher resolution distinctively.

4. Socioeconomic, Political, And Environmental Impacts of Climate Change in Agriculture and Their Relation to Human Security

Studies suggest that increasing temperatures are likely to have a negative effect on the global yields of crops like wheat, rice, maize and soybean. These crops make for about two thirds of the human calorie intake (Chuang Zhao, et. al., 2017). This can be termed as a first level impact of climate change on agriculture, which can lead to a host of second level socioeconomic, environmental, and political impacts. In this paper, we will discuss these impacts, which have a particular influence on the human security element in the case of India.

a) Socioeconomic Impacts

The case of India provides a clear example of how climate change has contributed to the deaths of over 60,000 farmers in the past three decades. A study by the University of California, Berkeley found extreme sensitivity of the Indian agricultural industry to spikes in temperatures. An increase of 1℃ on an average day during the growing season was associated with 67 more suicides. On the contrary, temperature increases outside the growing season had no significant impact on suicide rates. Furthermore, a rainfall rise of 1 cm found a drop in the average suicide rate of 7% (Tamma A. Carleton, 2017).

Declines in crop yield also result in food security issues, which can cause internal disturbances. The 'onion wars' in India in 2013 were the result of soaring onion prices, which provoked a political outcry (The Telegraph, 2013). Furthermore, a significant drop in cultivators and a rise in agricultural laborers has been witnessed in India between 2001 to 2011 (Gupta, N., 2016). Although this can be attributed to a number of factors, such as increase in industrial or service employment, or mechanization of labor, the decline in farm income is a contributing factor.

b) Political Impacts

The melting of glaciers, flash floods, and rising temperatures in the deserts or plains are bound to have an impact on our military's operational deployment, organizational structures, or strategies. In addition, a change in the kind of crop grown in certain areas affects the nutritional support provided to defense forces deployed in those areas. For instance, the arid desert of Ladakh, north-west India is sparsely populated and cultivation is a difficult task. The soil of Ladakh is not fertile and absorbs little water. Glacier meltwater is the primary source of water in the region, which receives less than two inches of rain and three to four inches of snow per year, as the Himalayan mountains prevent the entry of the monsoon into the region (Chewang N., Tashi P. 2014). Most farmers in the area grow crops like wheat, barley, and potatoes and earn their livelihoods by selling them to the Indian army.

However, in the past few years, the changing climate has led to shorter winters, receding glaciers, and an increasing number of pests in upper villages, which are all growing warmer. Farmers in Ladakh widely acknowledge the recession of glaciers, and, in some villages, water stress has become tangible, particularly during the crucial spring sowing season (Gagne, 2016). The changes in pasture lands and farming has forced several farmers to either migrate to other places or change their jobs. This poses a serious threat to the Indian army deployed in the Ladakh region, which is an important conflict zone between India, Pakistan, and China (NERC, 2017). Changes in yields of important crops which constitute a major part of their nutritional intake would necessitate the need for substitution. This would subsequently increase the government's expenditure on maintaining the caloric intake of the soldiers, through transport of food or creation of infrastructure for continued food provision to the Indian army.

The Indus river, shared by the neighboring country of Pakistan, has also become a contentious issue over the years, owing to a drop in yields in the river basin in Pakistan. The river is the subject of the Indus Waters Treaty between India and Pakistan since 1960 (Indus Waters Treaty, 1960). The Treaty, brokered by the World Bank, delimited the rights of use of the water from the Indus river system. The river is an important part of the history of both countries and provides key water resources for Pakistan's economy – especially the *breadbasket* of Punjab province, which accounts for most of the nation's agricultural production, and Sindh. The river

meandering in Pakistan resulted in the formation of an oxbow lake in the 1990s, due to the effects of climate change and soil erosion. The image was captured by NASA's Landsat 5 and is presented below in *Figure 1*.

Figure 1: Formation of an oxbow lake in the Indus river in Pakistan captured by NASA's Landsat 5

Furthermore, the river is prone to moderate to severe flooding (BBC, 2011). As a result, a decline in the crop yields has been observed, which is evidenced by the World Bank's report on land use through the years.

The IWT has ever since become a hotbed for bargaining between the two countries. India, having an upper hand over the river and its tributaries can exploit this position, thereby escalating the water tensions and agricultural crisis in Pakistan.

Climate change impacts in other areas have led to migration and internal security issues as well. For instance, in the states of Andhra Pradesh and Chattisgarh, the problem of naxalism ensued after several farmers were rendered poor and starved due to agricultural crises and failures in crop yields. The farmers in these areas mainly depend on subsistence agriculture, and rainfall shocks have been directly linked to violence (Ghatak, M., Eynde, O.V., 2017). Naxalism was termed as one of the largest internal threats in India, with poverty and inequality being a serious concern of the farmers. One of the most important demands of the farmers was a sound agricultural infrastructure to cope with climate shocks in these areas (Ghatak, M., Eynde, O.V., 2017).

c) Environmental Impacts

Climate change, farming, and the environment are interconnected - climate change affects the farming practices, which leads to an increased use of practices that are harmful to the environment. This is particularly visible in developing economies, where a major part of the population depends on agriculture for their livelihoods.

The Indian agricultural practices have led to several environmental issues, primarily: degradation of land, deforestation, pest problems, disposal of industrial and agricultural waste, and air pollution. Subsistence farming employs nearly half of the population and vagaries of weather push the farmers into the increased use of pesticides, changing the crop type, or other activities that result in environmental harm. For instance, the Indian State of Punjab has more than 80% of its land under cultivation, which has turned into a rice-wheat monoculture and suffers from a severe paddy stubble burning problem. The pollution effects are visible in as far as New Delhi, where stubble burning contributed to 32% of its pollution levels in October 2018 (ET, 2018). The increased particulate matter (or PM2.5) can lead to a host of respiratory problems when inhaled.

5. Policy Recommendations

Climate change has imposed a multitude of impacts on the farmers. The success of agriculture and thereby livelihood security for a marginal farmer depends on their decision-making skills. An accurate decision of when to sow or what type and quantity of fertilizer to apply is affected by climate variables and will affect the climate in return. Climate change has generated a lot of risks which ultimately translate to costs and greatly affect livelihood sustainability. Hence, there is a great need for proper planning and real information analysis.

Need for timed and accurate weather information is crucial for agriculture, particularly in a drastically changing climate. This study proposes strategies for information standardization and access focusing on two perspectives 1) global weather data repositories to exhaustively represent ground stations 2) interpretable and timed weather forecast made available to farmers. This will require *collecting and harmonizing* climate and meteorological data, soil data, and water table data by the various agencies. Furthermore, the establishment of a framework and architecture for *analyzing* the data and making information *accessible* to the farmer is necessary. This will allow farmers to make informed decisions based on both short-term and long-term considerations and to adapt to climate change. This policy thus involves the promotion of symmetry of information both at the farming level and at the institutional level.

a) Why Information Matters

i. The role of information in farming: fighting against the effects of climate change

For a farmer, it is important to make the right decisions in order to sustain their activity. Farmers today are increasingly cognizant of the changes in the climate and are concerned about its impact. They thus need to integrate climate change as a factor in their decision-making process when they plan their farming activities. In order to factor the various variables affected by climate change, there is a need for a real-time information system on climate and meteorological factors.

It is important for the government to integrate the climate change variables in the local planning and redefine climate change adaptation strategies. Implementing the best low carbon-intensive technologies and enhancing access to these technologies requires participatory planning. Any project should be able to garner the trust of the community which is crucial for the policy implementation process. How to bring this synergy will depend on building consensus and ownership in the community. However, bringing the voice of farmers in the local planning will not be efficient if they are not able to access and interpret data on climate change and agriculture.

It is also important to note that the farmer collectives or clusters do not cohabit in a vacuum and require further nurturing and promotion to reach sustainability. This will require formulating policies to sustain the institutions of farmers by the formation of a regulatory or a monitoring and evaluation body.

ii. Information as a nudge: a powerful tool

Behavioral economics and lab experiments have proven that information in public policy has a strong power on individual choices. According to Kahneman and Tversky (1974), people have biased expectations of future outcomes. They identified three judgment heuristics (representativeness, availability and anchoring) which explain this bias, and which can justify a policy intervention, notably providing information. In our case, farmers would be able to better predict their short-term and long-term yields if they had access to harmonized and reliable information and if they were able to interpret them correctly. Providing information about short-term and long-term tradeoffs and beneficial practices given the weather patterns may influence farmers' practices towards more environmental-friendly methods.

However, as explained by a longstanding notion of social psychology that people have a desire to behave consistently, beliefs are sometimes hard to change. This point was supported, by Falk et al. (2017). Hence, additional data can help farmers adjust their perceptive probabilities of yields; but, it may not be very efficient if they have strong beliefs that are not based on scientific facts.

The actual content, as well as the way information is presented, will greatly influence the impact of the policy on farmers. As shown by Datta et al. (2015), the classic brochure approach is not the most efficient to accurately change people's expectations about future outcomes. They thus use repetition and instant feedback and prove the accuracy of such a method. The policy will need to develop an efficient way to provide information as well as the appropriate tools to interpret it. Furthermore, as pointed out by Allcott (2011), people care about their performance compared to their relatives and neighbors. Sending information to farmers about the impact of their activity on their future yields as compared to surrounding farmers could have a great effect on farming activities.

Even though studies in behavioral economics have not focused a lot on agriculture itself, human behavior can be better predicted thanks to this field of studies. The OECD (2012) has thus advised to use nudging as an approach to guide policies in agriculture. People's choice would thus be influenced - but not restricted – towards decisions that they would have taken if they had not been subject to limitations such as misperceived probabilities, irrationality, or asymmetry of information.

b) Policy Proposal

We identified three pillars as key elements to work on to provide proper incentives for farmers to plan their activities based on both short-term and medium or long-term analyses of their environment.

i. Quality of the information

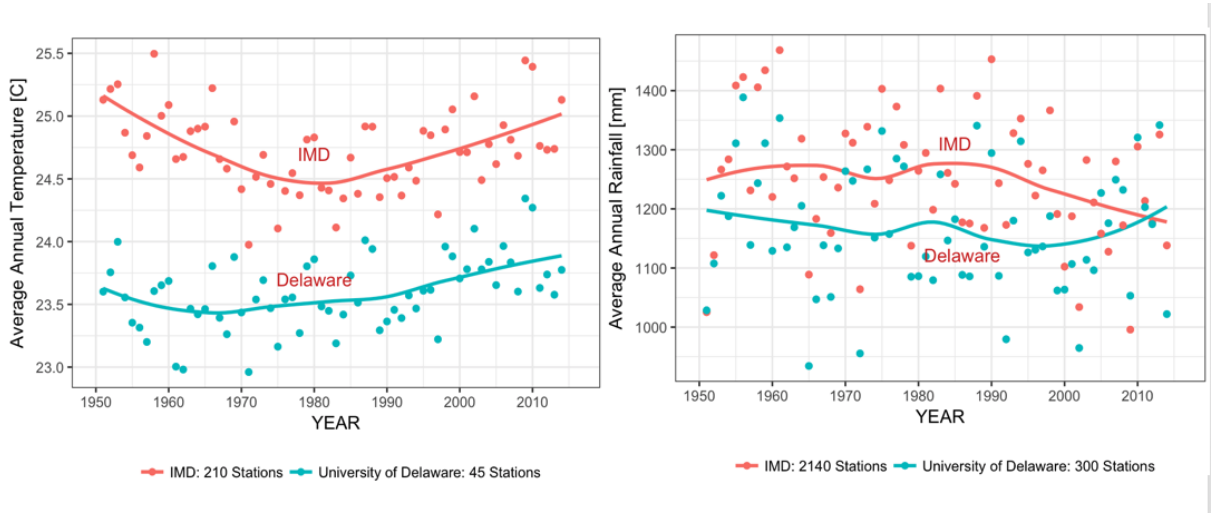
To guide farmers in the right direction and improve their farming practices, it is

fundamental to collect reliable data and to publish harmonized information at the regional, national, and international level. We encourage cooperation among the various institutions in charge of data collection. Hari, Khare, and Subramanian (2018) studied the case of meteorological ground stations in India and highlighted a serious issue of information quality. A global data repository on precipitation and temperature used for conducting agricultural analyses is maintained by the Global Human Climate Network (GHCN) and National Oceanic and Atmospheric Administration (NOAA) at NASA. Another major global research repository is University of Delaware (which sources the data from GHCN). These weather data repositories are prepared in the form of a grid, where rainfall and temperature data from ground stations are collected and spatially interpolated. This gridding process is a relatively better measure for capturing localized weather trends than stations which might only provide information on where the station is based. It can be understood that the precision of gridding would improve with density of spatially spread ground stations. Unfortunately, the global repositories do not get complete information on ground stations across countries, affecting their estimates. This can further lead to inaccurate predictions. Given the diversity of climate patterns in India which accounts for 16 climate zones (or Köppen classification), the quality of the data used in environmental studies is not as good as it could be. The weather variations across regions are not precise enough, as illustrated in Graph 1. Furthermore, because of this reduced sample, the evaluation of the average annual temperature is 1 degree Celsius lower than it should be in the Delaware data.

The quality of the data has tremendous impacts on the planning of farming practices. These quasi-contradicting data sets can confuse the farmers' expectations about future outcomes. In the worst-case scenario, the Delaware graphs could even nudge them in the wrong direction.

Hence, we advise to reinforce and ensure the quality of data thanks to the cooperation of meteorological institutions at various levels – local, national, and international. The harmonization of publications on climate change and weather patterns will only increase the quality of the data sets used.

Graph 1: average annual temperature and rainfalls in India according to the IMD and the Delaware indexes



Source: Climate Change & Indian Agriculture, Hari, Khare & Subramanian, 2018

ii. Access to information

The next challenge is to ensure access to the information gathered to all farmers. This requires either to develop the Information and Communication Technologies (ICT) in rural areas or to find alternative ways to (reliably) provide information. Indeed, the teledensity in India was 56% in 2018 (Rathee, 2018). Similarly, even though the number of internet users has increased in rural areas, only 23% of this population has access to the internet and 66% of the population in urban areas does (calculated based on numbers in Bhattacharya, 2018). Furthermore, only half of the Indian rural inhabitants use the internet as an online communication tool, and 35% of them use it for online services (Bhattacharya, 2018). There are thus many barriers to the communication of data on climate change and meteorological conditions to the farmers.

Hence, we recommend the policy to integrate various channels to communicate data to the farmers in a way which preserves the integrity of the information. This requires using and developing ICT while also incorporating less traditional channels such as networks of farmer cooperatives or international aid programs (see the stakeholder section below). The ICT potential of rural India can be leveraged by opening up kiosks disbursing real-time climate information to the farmers. They could become a center for facilitating good agricultural practices and information sharing to the farmers.

iii. Information Literacy

Finally, once the information is reliable and accessible, it is important to ensure that it can be correctly interpreted and used by the farmers. The farmers' skills shall be strengthened with training and capacity building exercises, information analysis, and farm equipment. The cooperatives and farming collectives appear as the most relevant institutions to partner with in order to reach as many farmers as possible.

According to the OECD (2012), advisory systems and trainings have a crucial role in shaping people's attitudes and motivations. Vocational trainings could sustainably impact their farming practices and their methods to analyze their environment. Social norms and capital can potentially influence the farmers' practices as well, hence the importance of collective programs. This will be also be another way for farmers to learn about their neighbors' farming practices and to compare their performance to others.

c) Key Stakeholders in Agriculture and Climate Change Actions That Need to Be Mobilized to Implement Policy

Various stakeholders are at play and must be involved during the policy implementation process. Some of them are key to make sure that the policy is approved by a majority. We believe that the networks in place can be used to improve the quality, accessibility, and the comprehensibility of the information. Hence, this policy will need to heavily mobilize the stakeholders.

i. Farmers

The policy is directed at the farmers and should consider their needs to be efficient. The various networks available are key to collect appropriate information about their current farming practices and about their daily difficulties, to spread reliable information about meteorological conditions, and to provide them with the means to interpret this information.

Agricultural cooperatives, run either by its members or the government, currently cover 97% of Indian villages (Kaur, 2015). For example, the Indian Farmers Fertiliser Cooperative (IFFCO), a multi-state cooperative engaged in the business of manufacturing and marketing fertilizers, may be interested in our policy. Given its market power, it is very important to convince its members of the utility of such a new information scheme.

Farmer unions can also bring together farmers around the information asymmetry issue and gather political support for our policy proposal. Some of the biggest farmer unions in India are Bhartiya Kisan Sangh (BKS) and Kisan Sabha. BKS has 20 million members and uses peaceful demonstrations and direct interaction with the government to achieve its goals. Their claims should be taken into account and integrated in the policy program in order to get their support.

Finally, it is important to consider the gender dimension of the Indian agricultural sector. A FAO report showed that women are often the main producers of the world's staple crops. This is especially the case in developing countries and regions likely to be adversely affected by climate change. Ownership of land is a symptom of power in India. The women have been reduced to agricultural laborers by patriarchy and laws, which are lopsided towards men. Models which facilitate ownership of land for women can be a powerful alternative for mitigating and adapting to climate change risks. In the rural areas where some women only own marginal land holdings, formation of joint liability groups or collectives of women and promoting lease land farming by women who are members of self-help groups has been an effective innovation. This model has been institutionalized by the Government of Kerala, India through its state poverty eradication arm called *Kudumbashree*. Their interventions to support women agricultural farmers is an interesting case study. Apart from mobilizing women belonging to poorer families, *Kudumbashree* provides technical support and guidance, engages local self-government institutions in promoting women-owned agriculture, and converges with technical support agencies. Particular attention should thus

be paid to the integration of women in the policy drafting and implementation process. They will provide key insights to develop environmentally friendly practices through information access.

ii. National institutions

Governmental institutions must be mobilized to coordinate and harmonize information. They will be needed to spread the information or to mandate other institutions to provide all farmers with an access to the meteorological data.

At the federal level, the Ministry and research institutes must be mobilized. Local planning agencies can help gathering and spreading information at the regional level. Meteorological stations and their international counterparts must also be involved.

We identified the Krishi Vigyan Kendra (KVK) as a key potential actor. This network was created by the State Agricultural Universities, the Indian Council of Agricultural Research, and Agricultural Research Institutes of the State Governments. It provides trainings for farmers with on-the-field demonstrations, financially supports them to purchase new technologies, and provides agro-clinical services – such as analysis of soil to efficiently use agricultural products.

iii. International aid

A lot of Non-Governmental Organizations and International Organizations currently provide help to Indian farmers. They could back up the policy implementation thanks to their network or to their financial tools.

Among them, the International Federation of Organic Agriculture Movement (IFOAM), also called "organics international", has an organic regulation toolkit for developing countries to guide users towards the best tools and templates given their local environment. Information could become part of this toolkit in India: reliable and complete information could help farmers plan in a more sustainable way to limit their long-term negative impact on climate change (and thus on their future yields).

The Food and Agriculture Organization (FAO) of the United Nations has been strengthening adaptive and productive capacities in agriculture. In India, it specifically provided technical assistance, got directly involved in the implementation of various projects like the Farmers Water Schools (FWS), assisted natural resources management, and developed programs for building skills. These initiatives would all be reinforced by our policy proposal. Their experience in trainings and their infrastructures would also be of a great help to provide access to the information and data literacy.

iv. Institutions providing access to technologies and artificial intelligence

To increase the access to information, the institutions in charge of information and communication technologies should be involved in the policy program. They will be key actors in sending the information and in developing access to the data.

The Indian government has developed several programs meant to increase the use of digital tools in the rural areas. The *Digital India* program aims at creating points of delivery of various electronic services to villages. It empowers people through access to technology with its infrastructure and service platform. *Startup India* is boosting start-ups with funds, hand-holding

services and incubation and is often used in the agricultural sector. *E-Choupal* has been a model for disseminating agricultural information to the rural poor in India by facilitating access to agricultural and market information. Finally, the various Custom Hiring Centers which have developed to rent new technologies to farmers could be of a great use to provide them with an access to technologies and thus to the necessary information for their farming plan.

6. Feasibility and Challenges To Overcome – Resource Allocation, Practical Evaluation Mechanism

a) Funding and Means of Implementation

Funding will be required to increase access to information in the agricultural sector. Coordinating with various state and federal stakeholders is key to update the various stakeholders about climate change patterns. Providing access to the data, either through ICT or through existing farmer networks, will require funds which can be sourced through union, government, and state government funds. There would also be a need to organize farmers and facilitate and empower them to use the information about the climate change parameters in the decision-making process. This will require mobilizing the farmers, training and capacity building exercises, and imparting technical knowledge for climate change resilient agriculture techniques. This calls for increased awareness about climate change effects on agriculture at various levels of governance. The budgetary allocation of the country in agriculture shall be cognizant of the increased information requirements to mitigate the climate change. Public-private partnerships in agriculture and corporate social responsibility funds can be pooled in to develop pilot models which can be scaled up by the government at a later stage. We further identified international actors which could bring additional support to ease the policy implementation.

i. Indian Government programs

The government of India could get funds and implement the policy either by implementing a program dedicated to the policy itself or by mobilizing its already-existing programs. *Digital India* could thus fund technological access to information. *Startup India* could financially support startups getting involved in the policy implementation. These programs however are not specifically dedicated to agriculture and other tools will be needed to effectively implement the policy.

The Indian government machinery has extensive programs to support agriculture. Climate change risks to agriculture will have to be tackled in a holistic way. This will require policy changes in minimum support prices, interest free loans, technical knowledge transfer for climate resilient cropping, capacity building of government machinery, encouragement to farmer collectives, efficient market linkages, and substantive investment in research and development support. To name a few, some of the agriculture interventions by the government are Mahila Kisan Sashakthikaran Paryojana (Women farming project), Interest Subvention Schemes, Priority Lending policies, Krishi Vigyan Kendras, Input subsidy schemes for fertilizers, National Agricultural Policy, and the state and central government departments on Agriculture. While there are many government programs in these areas, there is a need for new outlook and philosophy in dealing with the risks of climate change and making suitable modifications in the existing policies.

ii. International organizations and Public Financial Institutions

As mentioned above, some NGOs and international organizations are involved in India in the agricultural sector. Mobilizing them is easier if they are already well implemented and if the policy corresponds to their specific actions. They could either get directly involved in the policy implementation and by providing the necessary human and technological resources or help this project financially. Bilateral organizations like the World Bank (WB) and the Asian Development Bank (ADB) have financed agricultural projects and infrastructure projects. The possibility of engaging with the WB and the ADB can be explored to build a holistic model for accessing international funds.

As an example of such a framework, the Emergency Event Database (Em-Dat) was initially created with the support of the World Health Organization (WHO) and of the Belgian government. The Em-Dat's objective is to provide sound information for vulnerability assessment and preparedness to extreme events.

Public financial institutions and especially investment banks invest in development projects around the world. Agriculture is an important target for these institutions, which increasingly adopt a sustainable-development approach to their projects. Hence, our information scheme may attract them since it limits the impact of climate change on the farmers and vice versa.

b) Evaluation mechanisms

Monitoring and evaluation shall be crucial for the success of the interventions which address information asymmetry. It is recommended that the state governments build a task force at the state level to monitor the progress of the policy implementation. The agriculture departments shall create a team which works on a mission mode and directly reports to the Secretary of Agriculture which would be ideal to bring convergence between different divisions. It is recommended that a baseline data be prepared before the implementation of policy and a mid-term review at the end of each year be constituted by a technical team.

Another policy recommendation for evaluation shall be to create a community of volunteers or farmer producer organization who shall provide the last mile delivery to the various programs which aim to enhance access to climate change data. The current agriculture extension officers and farmer cooperatives can play an important role in monitoring the program. Capacity building trainings and an organization for monitoring and evaluation mechanism seems to be crucial for the success of the policy.

c) Farmer Literacy and ICT Challenges

The success of the policies to enhance information access to the farmer and facilitate better decision making in agricultural practices will call for reliance of reach of information and communication technology in the remote areas of the country. The information technology revolution has caught up in many developing countries. Cell phones have become ubiquitous and it is important to rely on mobile-based technologies to address the information asymmetry issues.

A policy model which has been successfully implemented by ITC Limited is called E-Choupal and can be a case in point. The E-Choupal follows a kiosk model which is connected to

internet and set up in the rural areas, which become a knowledge hub for farmers in the locality. The kiosk will have computers and shall be run by one of the farmers in the locality. Through this model the farmers can get real time information about supply and demand sides which is helpful in planning, establishing market connections, and reviewing prices.

The policy recommendations for facilitating information access will be providing services in the local languages which will be crucial in increasing acceptance and adoption of the policy by the farmers themselves. The last mile delivery of the policy can be supported by the village level organizations and by developing a pool of volunteers who will work with the farmers to take the information technology to the farm level. This calls for training and capacity development exercises and regular monitoring and review.

7. Conclusion

The importance of information to mitigate the effects of climate change cannot be over-emphasized. The paper has looked at the various aspects pertaining to the lack of quality macro data on climate change variables that influences agriculture. It provides a number of recommendations which can be implemented by the government to improve farm level incomes. Information is an asset and there is a great need for engaging with information in the context of climate change. What is required is a coordinated action and the development of ICT-based tools and infrastructure to reach the unreached, where climate variables get communicated to the farmers and they are able to synthesize the information in their decision-making process.

References

Allcott H.(2011). Social Norms and Energy Conservation. *Journal of Public Economics*. Vol 95. Issues 9-10. pp. 1082-1095

Bhattacharya A. (2018). In India, the internet is a place for cityfolk and men. *Quartz India*. Website visited on March 4, 2019.

Burke, Marshall, Solomon M. Hsiang, and Edward Miguel (2015), "Global non-linear effect of temperature on economic production." Nature 527.7577, pp. 235-239.

Chand, Ramesh, Raka Saxena, and Simmi Rana (2015), "Estimates and analysis of farm income in India, 1983-84 to 2011-12." Economic and Political Weekly 50.22. pp. 139-145.

Chand, Ramesh, and Shinoj Parappurathu (2012), "Temporal and spatial variations in agricultural growth and its determinants." Economic and Political Weekly 47.26. pp. 55-64.

Chewang, N., Tashi, P (2014). Snow Water Harvesting in the Cold Desert in Ladakh: An Introduction to Artificial Glacier. *Mountain Hazards and Disaster Risk Reduction*. Nibanupudi, H.K., Shaw, R. Springer Japan. pp. 199–210.

Datta, S. et al. (2015). Risking it all for love? Resetting beliefs about HIV risk among low-income South African teen. *Journal of Economic Behaviour and Organization.* Vol 118. Pp 184-198

Dell, Melissa, Benjamin F. Jones, and Benjamin A. Olken. (2014), "What do we learn from the weather? The new climate–economy literature." Journal of Economic Literature 52.3 pp. 740-798.

Dell, Melissa, Benjamin F. Jones, and Benjamin A. Olken (2012), "Temperature shocks and economic growth: Evidence from the last half century." American Economic Journal: Macroeconomics 4.3 pp. 66-95.

Dell, Melissa, Benjamin F. Jones, and Benjamin A. Olken (2009), "Temperature and income: reconciling new cross-sectional and panel estimates." No. w14680. National Bureau of Economic Research.

Dell, Melissa, Benjamin F. Jones, and Benjamin A. Olken (2008). Climate," Climate change and economic growth: evidence from the last half century." No. w14132. National Bureau of Economic Research.

Deschênes, Olivier, and Michael Greenstone (2012), "The economic impacts of climate change: evidence from agricultural output and random fluctuations in weather: reply." The American Economic Review 102.7. pp 3761-3773.

Falk A., Zimmermann F. (2017). Information Processing and Commitment, *The Economic Journal, vol.* 128, pp.1983-2002.

Gagne, Karine (2016). Cultivating Ice over Time: On the Idea of Timeless Knowledge and Places in the Himalayas. University of Toronto Press. *Anthropologica*. Volume 58. Number 2. pp. 193-210.

Ghatak, M., Eynde, O.V. (2017). Economic Determinants of the Maoist Conflict in India. *Economic and Political Weekly*. Vol. LII. No. 39. pp. 69 - 76.

Climate, Climate Change and Agriculture, Economic Survey of India (2017-18), Government of India.

Greenstone, Michael and Brohé, Arnaud (2007), "The economic impacts of climate change: evidence from agricultural output and random fluctuations in weather." The American Economic Review 97.1. pp. 354-385.

Gupta, N. (2016). Decline of Cultivators and Growth of Agricultural Labourers in India from 2001 to 2011. *International Journal of Rural Management.* Vol 12. Issue 2. pp. 179 -198.

Hari, Khare and Subramanian (2018). Climate change and Indian agriculture. *VoxDev*. Website visited on March 5, 2019.

IBEF (2018). Agriculture in India: Information About Indian Agriculture & Its Importance. *Indian Brand Equity Foundation*. Website visited on March 10, 2019.

Kahneman D., Tversky A. (1974). Judgment under Uncertainty: Heuristics and Biases, *Science*. New Series. Vol. 185. No. 4157. pp. 1124-1131

Kaur R. (2015). Co-operatives societies and rural India. *MyIndia*. Website visited on March 4, 2019.

Nelson, Dean (2013). Indian capital Delhi gripped by 'onion war'. *The Telegraph.*

NERC (2017). Increasing Resilience to Environmental Hazards in Border Conflict Zones (Ladakh, India). *UCL Institute for Risk and Disaster Reduction*. NERC Reference: NE/P016138/1. Website visited on March 10, 2019.

OECD (2012). *Farmer Behaviour, Agricultural Management and Climate Change.* OECD Publishing.

Press Trust of India (2018). Stubble burning from Punjab, Haryana contributed to 32% of pollution in Delhi on Saturday: SAFAR. *The Economic Times*.

Rathee K. (2018). At 56%, rural density and broadland target lag way behind urban India. *Business standard*. Website visited on March 4, 2019.

WorldBank (2019). *Database on agriculture*. Website visited on March 10, 2019.

World Bank Group (1960). *Indus Waters Treaty.* Website visited on March 11, 2019.

Effects of Climate Change on Inland Migration and Policy Solutions

Ammara Ansari, Marcelo Mautone

1. Effects of Climate Change on Inland Migration

After Hurricane Harvey in Texas, Melanie Elliott decided to leave: "Harvey was it for us… Too much water, we can't deal with this anymore. We are going to San Diego."[1]They were pushed out of their own homes because they had witnessed major chaos in their communities, but at a more fundamental, they had witnessed the heart-wrenching results of climate change.

While climate change is scientifically proven, it is difficult to determine its exact effects on human beings and their surrounding environment at any particular point in time. However, there are certain trends that are clear to us; for instance, in the case of coastal cities across the United States, rising sea levels, an increase in natural disaster occurrences, and fluctuations in temperature may push people to move inland. According to some estimates, "the movements may happen more gradually, but they will likely occur on a grander scale. Researchers estimate as many as 13.1 million people will be displaced by sea level rise in the coming decades."[2] On a very human level, these imminent realities for populations on coastal cities due to climate change will destroy people's homes and infrastructure, put an end to businesses, and devastate foreign trade and the American economy. Hurricane Maria cost Puerto Rico over $43 billion in damages to the economy, and this figure takes into account any federal aid that the island received.[3] Imagine what a hurricane would do to cities like Los Angeles, New York, or Washington, D.C..

With great damage due to extreme weather patterns, people will have to move to areas that have less risk of hurricanes or their homes being flooded - in other words, to inland areas within the United States. To this end, it's important to shift our thinking of the effects of climate change on coastal cities to a more expansive view that includes the perspectives of inland areas. In fact, according to Mathew Hauer: "We typically think about sea level rise as a coastal issue, but if people are forced to move because their houses become inundated, the migration could affect many landlocked communities as well."[4] There is admittedly very little information in the present about

---

[1] Jeff Goodell, Welcome to the Age of Climate Migration, *Rolling Stone*, Feb 25, 2018, https://www.rollingstone.com/politics/politics-news/welcome-to-the-age-of-climate-migration-202221/.

[2] Brooks Hays, Sea level rise to trigger human migration, reshape inland cities, *UPI*, APRIL 17, 2017, https://www.upi.com/Sea-level-rise-to-trigger-human-migration-reshape-inland-cities/9471492453676/.

[3] Associated Press, Puerto Rico lost $43 billion after Hurricane Maria, according to govt. Report, *NBC*, Dec 4, 2018, https://www.nbcnews.com/news/latino/puerto-rico-lost-43-billion-after-hurricane-maria-according-govt-n943441.

[4] Mathew E. Hauer. Migration induced by sea-level rise could reshape the US population landscape. *Nature Climate Change*, 2017; DOI: 10.1038/nclimate3271.

how inland migration will impact the economies and the overall constitution of these inland communities, and whether or not there are even enough resources to support migration (whether the migration happens over a long period of time or whether it takes the shape of mass migration due to a sudden disaster). Hauer's work has determined that cities like Atlanta and Phoenix will be the first ones to face the challenges of inland migration, as they are near coastal areas.[5]

Of course, the real question is how Americans will adapt to the incoming crisis. Yet, adaptability in the context of climate change migration is synonymous with wealth: "Income levels also play a role. The new study estimates that coastal residents with an annual incomes of more than $100,000 might be better able to invest in protective measures against sea-level rise and, as a result, less likely to migrate."[6] This means that those who are more affluent (which often means they are Caucasian) are more likely to be able to afford the very resources they need to protect themselves. By extension, they are going to be more resistant to leaving their coastal city for inland cities because of climate change. Those at the lower end of the economic spectrum may be forced to move.

2. Policy Solutions

While it is certainly difficult to reverse the effects of climate change, Americans do have the power to at least adapt to extreme changes in weather. Specifically, we have to make sure that we equip both inland communities for inland migration and coastal cities for strong defenses against natural disasters and rising sea levels.

a) Invest in Research

As aforementioned, there are very few resources dedicated to understanding the effects of inland migration on inland cities. In performing further research, we would be able to develop the tools necessary to ensure that these communities have the social services, infrastructure, and space necessary to adopt families from coastal cities when necessary.

Moreover, research should also involve gaining an understanding of how extensive the cultural tensions would be as a result of inland migration. How are inland communities going to receive the migrant communities, and what can we do to ensure that we can ease any upcoming tensions?

b) Funding FEMA/Emergency Preparedness:

In the case of Puerto Rico, thousands of people still did not have basic necessities after the hurricane. It is important that the federal government invest in communities in the event that people can no longer sustain their livelihoods due to a disaster in their coastal city. Emergency Preparedness is going to be critical as the frequency of disasters increases and intensifies, affecting more people. Perhaps FEMA should also fund migration. The federal government should also invest in infrastructure to protect communities so that there is less need for FEMA resources.

---

[5] Marlene Cimons, If you think traffic is bad now, wait for the inland migration, *Think Progress*, April 24, 2017, https://thinkprogress.org/sea-level-migration-inland-d5f9e995c8bd/.

[6] *Ibid.*

Rethinking National Security: The Effects of Climate Change on Conflict and Geopolitics

Laura Benrey Rodriguez, Cathy Chen, Dan Misch, Sagatom Saha

1. Introduction

Global warming will come with great human and economic cost: hundreds of millions are expected to fall into poverty, 20 percent of all land will become desert, and $20 trillion global GDP lost.[7] Droughts and extreme weather events will become more frequent while food and water will become scarcer. These changes will exacerbate international security risks that arise when resources become rarer, large displaced populations migrate, and the global balance of power shifts.

For this reason, it comes as no surprise that the U.S. Department of Defense characterized climate change as a "threat-multiplier" in its Quadrennial Defense Review.[8] More recently, the Trump administration's Fourth National Climate Assessment determined that "climate change, variability, and extreme events, in conjunction with other factors, can exacerbate conflict."[9]

That climate change provokes conflict has been widely acknowledged. This paper aims to comprehensively catalog the myriad of ways that climate change could intensify existing conflicts and possibly create new ones while providing potential solutions that civil society, national governments, and international organizations can adopt to mitigate conflict amid increasing global warming.

After providing a literature review of the relationship between climate change and conflict, this paper provides three ways that climate change will drive conflict: increasing resource scarcity, impairing state capacity, and motivating geopolitical competition. Having systematically outlined the ways that climate change will inform the future of conflict, the paper offers options to "de-link" climate change from conflict. Specifically, this paper suggests that civil society, national governments, and development organizations should partner to improve the resilience of climate and conflict vulnerable states. Further, international organizations like the United Nations should work toward revamping international rules and norms governing global commons that climate change will shift. National governments should work together on innovation efforts that would alleviate resource scarcities before they arise to prevent conflicts. Finally, the paper acknowledges potential challenges associated with these solutions and offers some remedies from existing literature on foreign aid and international institutions.

---

[7] The Economist, 'The latest report on global warming makes grim reading," October 11, 2018 https://www.economist.com/science-and-technology/2018/10/11/the-latest-report-on-global-warming-makes-grim-reading.

[8] U.S. Department of Defense, "2014 Quadrennial Defense Review," http://archive.defense.gov/pubs/2014_quadrennial_defense_review.pdf, p 8.

[9] U.S. Global Change Research Program, "Fourth National Climate Assessment: Climate Effects on U.S. International Interests," 2018, https://nca2018.globalchange.gov/chapter/16/.

2. Literature Review

The fact that climate change causes conflict is well-established. In fact, one analysis demonstrates an 11 percent increase in the risk of intergroup conflict per one standard deviation change in traditional climate indicators like temperature, rainfall loss, drought, and storms.[10] Another predicts a 54 percent increase in armed conflict incidence and 393,000 more battle deaths in Sub-Saharan Africa as temperature increases drive civil wars.[11] Further, the World Bank predicts more than 140 million internal climate migrants by 2050.[12] There is also a wealth of research linking conflict to environmental indicators like rainfall and temperature that climate change will affect. For example, resource scarcity has been well-established as an indicator of violent conflict.[13] Environmental economics researchers point to rainwater "shocks" as a more important driver of conflict than grievances among warring parties in a study of 41 African countries.[14] Existing research demonstrates that large populations and dense populations are at higher risk of conflict given their increased dependency on natural resources.[15] Attempts have been made to give a broad overview of how the global shift toward clean energy technologies will affect global geopolitics.[16] For example, the International Renewable Energy Agency recently released a report describing how the global energy transformation will alter the distribution of power, relations between states, the risk of conflict, and the social, economic and environmental drivers of geopolitical instability.[17] The report depicts a rebalancing of winners and losers from the global energy transformation: those countries less affected by climate change that will benefit from increased clean energy and those countries hit hardest by climate change that also export fossil fuels.

These efforts help paint a picture of how climate change will affect the future of conflict. This paper provides a framework for policymakers to understand climate impacts on existing violence like civil war and insurgency, new violence over valuable resources, and geopolitics in global commons like cyberspace and the Arctic. This paper intends to provide its readers with a template to consider the effect climate change has in these areas.

3. Impacts of Climate Change on Conflict: Local and National Violence, Intrastate and Interstate Conflict, and Geopolitical Competition

---

[10] Marshall Burke et al., "Climate and Conflict," *Annual Review of Economics*, 2015, http://emiguel.econ.berkeley.edu/research/climate-and-conflict.
[11] Marshall Burke, "Warming Increases the Risk of Civil War in Africa", *Proceedings of the National Academy of Sciences,* Vol. 106(4(), 2009, https://doi.org/10.1073/pnas.0907998106.
[12] Kanta Kumari Rigaud et al., "Groundswell: Preparing for International Climate Migration," The World Bank, March 19, 2018, https://www.worldbank.org/en/news/infographic/2018/03/19/groundswell---preparing-for-internal-climate-migration.
[13] Adam Evans, "Resource Scarcity, Climate Change, and the Risk of Violent Conflict," World Development Bank Report Background Paper, 2011, http://documents.worldbank.org/curated/en/351651468337157443/Resource-scarcity-climate-change-and-the-risk-of-violent-conflict.
[14] Edward Miguel et al., "Economic Shocks and Conflict: An Instrumental Variable Approach," *Journal of Political Economy*, Vol. 112(2), 2004, http://emiguel.econ.berkeley.edu/research/economic-shocks-and-civil-conflict-an-instrumental-variables-approach.
[15] Colin Kahl, *States, Scarcity and Civil Strife in the Developing World*, Princeton: Princeton University Press, 2006.
[16] Daniel Scholten et al., *The Geopolitics of Renewables*, 2018, Springer, https://www.springer.com/us/book/9783319678542.
[17] International Renewable Energy Agency, "A New World: The Geopolitics of the Energy Transition," 2019, https://www.irena.org/publications/2019/Jan/A-New-World-The-Geopolitics-of-the-Energy-Transformation.

The drivers of climate change on conflict can be categorized into three areas: resource scarcity, state instability, and shifting balances of global power. Across local, national, regional, and global arenas, each driver will impact conflicts, new and old. Some regions are more susceptible. For example, regions where flood irrigation is common, like Sub-Saharan Africa, will be especially vulnerable to resource scarcity. Decision-makers should expect climate change to worsen state capacity in regions where it is already tenuous like the Middle East and North Africa. For countries with considerable external influence like Russia and China, geopolitical competition will come into play. How these drivers could manifest are discussed below.

A. Resource scarcity as a driver of local and national violence

Climate change causes conflict by making natural resources such as food, water, land, forests, and fisheries scarcer. Resource scarcity is made worse by migration, commodity spikes, population growth, and unequal distribution. The demand for new resources like lithium and cobalt to support a clean energy transition also has the potential to create and drive new conflict.

Climate change can affect conflict by directly disturbing on a micro-economic level. For example, if farmers can no longer farm the same crops because they become uneconomic where they live because of drought or changing temperature, it will directly reduce their incomes. There is evidence that links lower income caused by price shocks on natural resources to an increase in conflict by reducing the opportunity cost of committing violence.[18]

One only need look at the Syrian Civil War to understand how the disruption of food systems, conflict over water resources, and migration to urban centers in search of greater economic opportunity can lead to devastating human tragedy. Since 1998, the Eastern Mediterranean has endured its worst drought in the past 900 years.[19] Climate change did not compel Assad to brutally crack down on the Syrian people, but the drought drove rural farmers to the country's urban centers like Damascus and Aleppo, priming the populace for concentrated, large-scale political unrest. From 2002 to 2010, Syria's total urban population increased from 8.9 million to 13.8 million, a 50 percent increase.[20]

Much of the migration crisis in the Middle East can be attributed to decreasing rainfall and pervasive drought in the region. Extreme drought contributes to agricultural failures, economic dislocations, and population displacement globally.[21] In Somalia, for example, alternating droughts and floods led to migrations and prolonged instability upon which local warlords can capitalize.

Droughts that cause local resource scarcity also exert pressure on the global economy. In 2010 and 2011, droughts in Russia, Ukraine, and the United States corresponded to a global reduction in wheat production which contributed to a spike in prices for the foodstuff.[22] In Russia

---

[18] Oeindrila Dube and Juan F. Vargas. "Commodity Price Shocks and Civil Conflict: Evidence from Colombia." *Review of Economic Studies*. Vol. 80(4), October 2013, https://doi.org/10.1093/restud/rdt009,

[19] Ellen Gray, "NASA Finds Drought in Eastern Mediterranean Worst of Past 900 Years," National Aeronautics and Space Administration, March 1,2016, https://www.nasa.gov/feature/goddard/2016/nasa-finds-drought-in-eastern-mediterranean-worst-of-past-900-years.

[20] Colin P. Kelley et al., "Climate Change in the Fertile Crescent and Implications of the Recent Syrian Drought," *Proceedings of the National Academy of Sciences,* Vol. 112(11), https://doi.org/10.1073/pnas.1421533112.

[21] Peter Gleick, "Water, Drought, Climate Change, and Conflict in Syria," *Weather, Climate, and Society*, July 1, 2014 https://journals.ametsoc.org/doi/abs/10.1175/WCAS-D-13-00059.1.

[22] U.S. Global Change Research Program, "Fourth National Climate Assessment: Climate Effects on U.S. International Interests."

alone, 20 percent of the wheat harvest was destroyed, and grain exports were banned. This may have contributed to peak inflation for overall good prices in Egypt of 19 percent, fueling protests in 2011 that led to the overthrow of then-President Hosni Mubarak.[23]

Population growth, which is running parallel to global warming, exacerbates these problems. The United Nations predicts that the world population will grow over 10 percent by 2030 to 8.6 billion people. Densely populated areas like the U.S.-Mexico dryland region are projected to become drier, which will challenge increasing demand for water while the population is expected to grow an accelerated 30 percent by 2030.[24]

As climate change drives this scarcity, it induces individuals to compete over what resources are left. Mercy Corps has studied how, in the Democratic Republic of Congo, different patterns in rainfall and food production are increasing competition for arable land, sparking ethnic tensions and conflict.[25] Even though people could potentially adapt by switching products or activities, more vulnerable populations struggle with the switching costs of such adaptation.

Climate change will also disproportionately affect poor and marginalized communities, exacerbating inequality and making existing grievances more salient as better off communities capture remaining resources or newly productive natural resources. There is empirical evidence that links violent insurgency to feelings of injustice and inequity over economic outcomes.[26] Given that climate change will drive divides politically and economically, it can be expected that climate will have some role to play in future insurgencies, whether worsening them or tipping political unrest into violent action.

The burgeoning global clean energy trade will also give rise to increasing dependence on critical minerals like cobalt, which are geographically concentrated in unstable countries. Already, as a result of fast-paced manufacturing of clean energy technologies, cobalt shortages are expected by the early 2020s.[27] Compounding this existing scarcity, nearly half of known global cobalt reserves are located in the Democratic Republic of the Congo, commonly considered one of the world's most fragile states.[28] The increasing value of mineral resources like cobalt should be expected to increase rent-seeking violence in areas like the DRC, where state capacity is either weak or non-existent. Child slavery is already commonplace in the DRC's cobalt trade, and the resource will only become more valuable in coming decades.[29]

Elsewhere, the increasing importance of lithium is causing increased tension between local and indigenous communities and their governments in the border region between Argentina, Chile, and Bolivia, which is home to 59 percent of known lithium reserves globally. Without proper

---

[23] Joshua Busby, "Warming World: Why Climate Change Matters More Than Anything Else," *Foreign Affairs*, June 14, 2018, https://www.foreignaffairs.com/articles/2018-06-14/warming-world.
[24] U.S. Global Change Research Program, "Fourth National Climate Assessment: Climate Effects on U.S. International Interests." Gregg Garfin et. Al., "Assessment of Climate Change in the Southwest United States," Institute of the Environment, 2013, https://www.swcarr.arizona.edu/sites/all/themes/files/SW-NCA-color-FINALweb.pdf.
[25] Emma Schwartz, "How Climate Change Affects People Living in Poverty," Mercy Corps, April 10, 2018, https://www.mercycorps.org/articles/climate-change-affects-poverty.
[26] Liz Hummer: Youth and Consequences: Unemployment, Injustice, and Violence," Mercy Corps, February 13, 2015, https://www.mercycorps.org/research-resources/youth-consequences-unemployment-injustice-and-violence.
[27] Bloomberg New Energy Finance, "E-Buses to Surge Even Faster Than EVs as Conventional Vehicles Fade," May 21, 2018, https://about.bnef.com/blog/e-buses-surge-even-faster-evs-conventional-vehicles-fade/.
[28] U.S. Geological Service, "Mineral Commodities Summary," 2019, https://www.usgs.gov/centers/nmic/mineral-commodity-summaries.
[29] Akshat Rathi, "Andreessen and Gates invest in an AI startup that's looking for ethical cobalt," *Quartz,* March 5, 2019, https://qz.com/1565371/andreessen-and-gates-invest-in-an-ai-startup-looking-for-ethical-cobalt/.

resource management, the rapidly increasing value of critical minerals could give rise to geopolitical resource competition and border conflict as oil and gas do today.[30]

B. Impaired state capacity as a driver of intrastate and interstate conflict

An important consideration in the relationship between climate change and conflict is the substantial overlap between countries with poor state capacity and countries most vulnerable to climate change. This has the potential to create cycles of instability that fosters sustained violence. That is, climate change damages infrastructure and diminishes overall economic well-being. As a result, states will have to turn attention to economic repair and resource delivery to maintain stability. However, this could divert attention and resources away from tackling climate change, creating a boundless, downward loop of unpreparedness and unrest.

There are different mechanisms through which climate change can impair state capacity. Climate change will cause more frequent external shocks in the form of natural disasters that will decrease state resources whether directly through royalties on natural resource extraction or taxation on an economically productive population. Assuming fewer resources also reduces state capacity, external shocks of this type would reduce the state's capacity to have a monopoly over the legitimate use of violence within its borders, limiting their ability to maintain stability.[31]

As shown in the figure below, countries that score low in peace indexes also tend to score high on climate change vulnerability.[32] While governance and social variables should be included to finetune these indices, they preliminarily suggest a picture of how adaptation to global conflict and stability go hand to hand. The worst-off states will be hardest hit by climate change and decline even further relative to their peers. As previously noted, the effects of climate change—sustained droughts, desertification, and extreme weather events—put a particularly acute strain on poorly governed countries with weak capacity and legitimacy. For a certain subset of countries, commonly known as "fragile" states, these consequences should be expected to have a "tipping point" effect, pushing tenuous peacetime in full-blown conflicts. As previously mentioned, there is strong evidence that climate change caused the regional drought that preceded the Syrian Civil War that began in 2011.[33]

In Syria, the same drought, the worst in the Eastern Mediterranean in 900 years, notably produced vastly different outcomes in neighboring countries, highlighting the importance of state capacity and legitimacy in tipping countries over from temporary political shocks into sustained political conflict. Similarly, in the Lake Chad Basin, climate change worsened food security and political marginalization, which exacerbated existing tensions and drove recruitment to Boko Haram. While climate change will not be directly responsible for state collapse, it will make it more probable in fragile states. It is important to note that major oil exporters are especially vulnerable. Coinciding with climate change is a push to transition to clean energy technologies to reduce emissions. As climate change inevitability worsens, these countries will have to contend

---

[30] Clare Church and Alex Crawford, Green Conflict Minerals: The Fuels of Conflict in the Transition to a Low-Carbon Economy," International Institute for Sustainable Development, August 2018, "https://www.iisd.org/sites/default/files/publications/green-conflict-minerals.pdf.

[31] Samuel Bazzi and Christopher Blattman, "Economic Shocks and Conflict: Evidence from Commodity Prices." *American Economic Journal: Macroeconomics*, Vol. 6(4), 2014, http://dx.doi.org/10.1257/mac.6.4.1.

[32] Institute for Economics and Peace, "Global Peace Index 2018," http://visionofhumanity.org/app/uploads/2018/06/Global-Peace-Index-2018-2.pdf; University of Notre Dame, "Global Adaptation Initiative Index," https://gain.nd.edu/our-work/country-index/rankings/.

[33] Colin P. Kelley et al., "Climate Change in the Fertile Crescent and Implications of the Recent Syrian Drought."

with higher temperatures and droughts all while oil receipts decline. It is hard to imagine a country like Libya or Iraq maintaining or rebuilding stability under such conditions.

If climate change proliferates the number of failed states, it could correspondingly increase the amount of ungoverned space globally, an issue with its own implications for conflict. Areas where central governments cannot assert authority are natural environments for nonstate actors like organized crime networks and insurgencies to engage in violence and illicit activities like human trafficking and narcotics trade. For example, the Afghan civil war in the 1990s gave rise to Taliban control, which presided over 50 percent of global heroin production.[34] While climate change has no direct link with illicit networks, it will likely open more space for it globally, a worry for both developing and developed nations.

C. Shifting balances of power as a driver of geopolitical competition

Climate change will induce a shift to clean energy systems that has the potential induce geopolitical competition across supply chains and different sectors as great power nations like the United States, Russia, China pursue economic dominance in new technologies. The technological and engineering solutions needed to curb greenhouse gas emissions could multiply the value of finished projects like wind turbines and solar panels, electric vehicles, and lithium-ion battery storage, as well as raw materials like rare earth minerals, to levels like oil and gas today, both of which fuel geopolitical competition.

Jockeying between nations for dominance in different energy sectors has already led to increased geopolitical tension between Washington and Beijing. China currently produces 60 percent of solar panels and 71 percent of solar modules worldwide.[35] In response, the United States placed tariffs on Chinese imported solar panels as a means of increasing domestic production. This action has been one in a series of moves that have heightened tensions between the two nations. In the nuclear industry, state-owned companies from China and Russia have established influence abroad by building power plants in places vulnerable to climate and conflict like Turkey and Northern Africa. Meanwhile, profit-driven companies from the United States, lacking that state support and facing onerous export control regulations, fail to compete internationally. Each reactor could reactor as a 60-year anchor for China and Russia to expand their diplomatic influence at the expense of United States and its allies.

International collaboration is also under threat as countries with innovative capacity try to keep control of the science and technology that will drive future economic growth. Concerns that patent protection policies are inadequate to safeguard domestic interests may cause countries to isolate research and development in clean energy. As a result, scientific discovery would be hindered, and potential diplomatic channels closed.

China's aim of becoming a leader on international climate action underscores the country's role and impact in international politics. Since U.S. President Donald J. Trump took office, the paths that the United States and China are pursuing are becoming increasingly divergent. While the Trump administration rescinded its predecessor's Clean Power Plan, the U.S.

---

[34] Ahmed Rashid, *Taliban: Militant Islam, Oil and Fundamentalism in Central Asia*, New Haven: Yale University Press, 2010.
[35] Julia Pyper, "Trump Administration Issues 30% Solar Panel Import Tariff," Greentech Media, January 22, 2018, https://www.greentechmedia.com/articles/read/breaking-trump-admin-issues-a-30-solar-tariff.

contribution to the Paris Agreement, China took over the global leadership in the solar industry as home to eight of the world's ten largest solar companies. Moreover, when much of the U.S. foreign policymaking is looking inward, China is connecting with the world through its Belt and Road Initiative (BRI), an ambitious move to link Asia, Africa, and Europe together economically, and eventually politically, with China at the center. The BRI is thought to be the most ambitious geo-economic mission in recent history spanning approximately 70 countries and is supposed to cover more than two-thirds of the world's population.

The enormous infrastructure gap in developing nations presents one of the largest opportunities in clean energy. Governments of emerging economies have made clear that they want modern, sustainable, and climate-resilient solutions in the infrastructure sector. China, in turn, has made clear it wants to capitalize on this opportunity with its financial institutions and companies playing a leading role. In May 2017, the Chinese government pledged $113 billion in special government funds to stimulate banks and businesses to invest in Africa, Asia, and Europe under its BRI.[36]

In the future, the energy trade may well remain central to the global economy and continue to shape global geopolitics. But two major differences could distinguish the future from the present. First, the energy products being traded would instead be clean energy products—including solar panels, wind turbines, batteries, and nuclear reactor components—whose traded value by mid-century could rival that of fossil fuels today. And second, there would no longer be any inherent reason why some countries are exporters, and some are importers. Although only some countries are endowed with natural fossil fuel resources, any country can participate in the manufacturing supply chain for most clean energy products.

If such a future materializes, trade disputes over energy may frequently erupt, endangering norms of free trade that have increased global prosperity and discouraged international conflict. Because countries will want to reap the benefits of domestically manufacturing and exporting clean energy products, they may flout international trade rules against protectionism. Already, the United States has engaged in tit-for-tat trade disputes over clean energy products with Asian countries even though clean energy composes a small fraction of global energy trade. In the future, such clashes could be much more frequent, especially as China continues its bid to monopolize the production of solar panels, wind turbines, and lithium-ion batteries—the prerequisite technologies to tackle climate change. The resulting world order might reflect the disarray prior to the World Trade Organization's formation. Trade around the world might devolve into smaller, bespoke patchworks of bilateral deals and a convoluted system of antagonistic tariffs.

Worsening climate change will likely see expanded competition over regionally shared resources like water. As previously noted, there is strong empirical evidence linking climate change to droughts and depressed agricultural production. These issues both strain and diminish existing water supplies, which are often shared across national borders. Roughly 40 percent of the world's population and 80 percent of global river flows can be considered transboundary waters.[37] In these areas, water scarcity may provoke cross-border conflict specifically over water resources. For example, the countries surrounding the Nile Basin have threatened war several times because

---

[36] Sean Gilbert et al., "Will China Seize the Biggest Green Opportunity of the Coming Decade?" World Resources Institute, 8 November 2018, https://www.wri.org/blog/2018/11/will-china-seize-biggest-green-opportunity-coming-decade.

[37] UN Food and Agriculture Organization, "Transboundary Waters," http://www.fao.org/land-water/water/water-management/transboundary-water-management/en/.

hydroelectric dams in upstream countries like Ethiopia have impeded water flows necessary for agriculture in downstream countries like Egypt.[38] Elsewhere, water should be expected to feature in a more prominent role in conventional conflicts as it becomes scarcer. For example, in February 2019, India threatened to halt water flows to Pakistan after a suicide attack killed Indian troops stationed in Kashmir.[39]

Climate change will also transform global commons that today are minimally governed like the Arctic and cyberspace. For example, in the Arctic, global warming will melt enough ice to open commercial and military shipping lanes and recoverable energy resources like nickel and copper that are critical to a clean energy future.[40] Today, China dominates global rare-earth mining and may seek to tighten its monopoly over critical minerals by asserting its tenuous claim in the Arctic, which is estimated to hold 25 percent of the world's rare-earth deposits. Beijing may also view the Arctic as a favorable alternative trade route to the Straits of Malacca, a well-known choke point through which over 64 percent of China's maritime trade transited in 2016.[41] However, established Arctic countries like Russia and the United States will likely chafe at China's growing role in the region. Russia jealously guards its sovereign rights as a member of the Arctic Council, which China joined as an observer in 2013. As China continues to invest in the Arctic for economic, scientific, and strategic gain, it will likely seek a formal seat at the table to Arctic governance agenda in its own interest.

Like in the Arctic, the climate-driven global transition toward clean energy will transform cybersecurity dynamics. As more wind and solar capacity is added to the grid, it will be natural to make grids more 'intelligent' to balance increasing amounts of intermittent electricity. As clean energy technologies upgrade our power grids, new threats to cybersecurity will inevitably arise. Major concerns in developed countries' national security are not necessarily natural disasters or terrorism, but threats posed by cybersecurity that its rivals can expose. In March 2018, a joint report by the FBI and Department of Homeland Security showed Russian government cyber activity targeting America's critical infrastructure sectors, including the energy, nuclear, and water sectors, among others.[42] Even though upgraded power grids have the benefit of balancing increasing amounts of intermittent wind and solar generation, the downside is that they will integrate an exponentially increasing number of internet-connected devices, which make these grids vulnerable to cyber-attacks.

4. Policy Recommendations

This section outlines the recommended policies and relevant organizations or agents of change that can adopt such policies.

A. Improve aid targeting to climate and conflict vulnerable states

---

[38] Julian Hattem, "How Egypt Is Slowly Losing Its Hold Over the Nile River," *World Politics* Review, July 7, 2017. https://www.worldpoliticsreview.com/articles/22640/how-egypt-is-slowly-losing-its-hold-over-the-nile-river.
[39] Jeffrey Gettleman, "India Threatens a New Weapon Against Pakistan: Water," *The New York* Times, February 21, 2019, https://www.nytimes.com/2019/02/21/world/asia/india-pakistan-water-kashmir.html.
[40] Andrew Erickson and Gabe Collins, "China's New Strategic Target: Arctic Minerals," *The Wall Street Journal*, January 18, 2012, https://blogs.wsj.com/chinarealtime/2012/01/18/china%E2%80%99s-new-strategic-target-arctic-minerals.
[41] China Power Team, "How much trade transits the South China Sea?" Center for Strategic and International Studies, 27, 2017, https://chinapower.csis.org/much-trade-transits-south-china-sea/.
[42] Latif M. Nurani, "Cybersecurity and the Electric Grid," American Bar Association, August 15, 2018, https://www.americanbar.org/groups/infrastructure-regulated-industries/publications/infrastructure/2017-18/spring/cybersecurity-and-electric-grid/

Countries and regions around the world differ in their vulnerability to climate change and conflict; in many cases, countries are highly vulnerable to both, like Somalia. Recognizing this fact, there should be an international effort to improve the resilience of such countries to both climate and conflict. While there are currently efforts of the international community to support these two vulnerabilities independently, there does yet seem to be an approach that considers their nexus. Such an approach would benefit not only the efficiency of resource-limited international aid organizations and multilateral development banks but also intelligence and defense communities, which need to foresee and intervene earlier in potential conflicts.

As a first step towards building this approach, these organizations or agencies could collaborate to develop a comprehensive indicator of vulnerability to conflict due to climate change, so that the international community can better target resources. While there already exist indices of climate change vulnerability, there are not yet any that incorporate state capacity, active conflicts, and other factors known to lead to conflict. Likewise, since climate does not depend on national borders, such an index should consider transboundary risks like shared resources between countries.

B. Create new international norms and rules for climate-affected spaces

Uncertainty can be thought of as one of the main drivers of geopolitical competition. In myriad of ways, climate change will drive increasing geopolitical uncertainty by changing existing incentive structures in the Arctic and in cyberspace. The United Nations should focus heavily on forging consensus and creating new norms and treaties to govern state behavior in these spaces. The World Trade Organization (WTO) should also determine new rules to incorporate the particular benefits that clean energy technologies hold that might push countries to flout international trade rules. If done correctly, new international norms and rules can do what they have always done: allow nations to pursue their own self-interest while reducing the transaction costs for diplomacy and reducing uncertainties that lead to conflict. In regions where it is possible, regional blocs should integrate their power grids to promote cross-country cooperation and interdependence. Such efforts would reflect the successful European Coal and Steel Community model, which used economic interdependence to promote peace and eventually political integration.

C. Invest collaboratively in innovative technologies to prevent resource scarcity

In addition to these efforts, the world's developed countries can band together to invest in new clean energy technologies that would alleviate the scarcity of both traditional resources like water and food and clean energy economy resources like critical minerals. Mission Innovation, which gathers the world's largest economies in a commitment to double clean energy research and development spending, could extend its work to include innovation on desalination and reducing cobalt needs in lithium-ion batteries. These efforts would go a long way to reduce resource scarcity and avoid potential bottlenecks before they arise.

5. Feasibility and Challenges

This paper seeks to create an ambitious framework for policymakers around the world so that they can begin to categorize the myriad of ways that climate change will directly and indirectly change civil war, insurgency, political unrest, interstate conflict, and geopolitical competition.

While this paper does provide some solutions to problems that will inevitably arise, it is important to acknowledge that such solutions come with their own challenges.

First, foreign aid, despite its good intentions, can come with negative consequences. There is strong evidence that large, concentrated aid flows into a conflict zone can increase the intensity of violence.[43] Humanitarian and development aid can be co-opted by violent actors. Aid itself can also be thought of as a rent worth committing violence to secure. Any aid associated with climate associated conflict prevention should be disbursed slowly and carefully.

More work should also be done to determine which countries are at the intersection of climate vulnerability and instability, as they are the most at risk. Climate change will have differential impacts on communities and countries based on population characteristics, economic systems institutions and governances, and the characteristics of local and national economies.

Last, in the geopolitical context, it is important to acknowledge that it is difficult to compel countries to sign international compacts that establish norms against their own self-interest. Simply put, countries like Russia and China will resist a global push to establish rules of the road on cyberspace or the Arctic if rules contradict their own strategic aims. However, the United Nations should look to broad-based agreements like the Convention on Law of the Seas as templates to formulate new pacts that reduce strategic ambiguity.

6. Conclusions

There is abundant evidence drawing a causal link between climate and conflict. However, there is little literature so far systemically cataloging the ways that climate change and the global transition to clean energy will affect existing conflicts, create new ones, and shift geopolitics around the globe. While scientists, entrepreneurs, and policymakers are working toward mitigating climate change, some amount of warming has already occurred —and even more is inevitable. However, the conflict outcomes associated with a warming planet are not set in stone. By identifying solutions that can "de-link" conflict from climate, the world can forego some of climate change's worst potential effects. Preventative aid targeted at the most climate and conflict-prone countries can go a long way to stemming violence before it occurs. Acknowledging that climate change will change the global commons that UN compacts should shift to recognize this fact. New treaties can reduce the ambiguity that creates mistrust and conflict around the world among the world's superpowers. Climate change will take place over decades, but policies can be adopted today that determine the future of conflict. Policymakers need not delay.

[43] Daniel Strandow et al, "Foreign Aid and the Intensity of Violent Armed Conflict, AidData, May 2016, "http://docs.aiddata.org/ad4/pdfs/wps24_foreign_aid_and_the_intensity_of_violent_armed_conflict.pdf

7. Appendix

	Environmental/Impact Drivers			Socioeconomic Impacts			Geopolitical Impacts		
	Climate effects	Resource effects	System Effects	State Capacity	Resource distribution	Migration	Winners and losers	Changing Global Commons	Failed States
SUBNATIONAL | Civil Society Actors & Private Sector									
Humanitarian & Disaster Relief	X	X			X	X			X
Advocacy/ Media	X				X	X	X		X
Hyper-local	X	X		X	X	X		X	X
Extraction and manufacturing				X				X	X
Energy generation	X		X				X	X	X
NATIONAL | Heads of State/National Governments									
Conflict Vulnerable	X	X		X	X	X			
Climate Vulnerable	X	X		X	X	X			
Developed Countries			X				X	X	X
Developing Countries			X				X	X	X
Resource Rich									
Militaries	X			X		X			X
INTERNATIONAL | Regional Organizations and International Community									
Development Banks							X		
Regional Multinational Organizations						X	X	X	X
Global Organizations				X			X		X

Question to ask or data you need	*Does the required data exist or else how would we measure it?*
Climate Data	
Which countries are most vulnerable to climate?	
Existing Temperature Data/Sea Water Level	Yes
Reliable models of temperature, sea water level, and extreme event projections	Not necessarily at a local scale
Stability Data	
Which countries are most vulnerable to conflict?	
What causes radicalization and insurgency?	

What is the effectiveness of development aid to resist climate-driven conflict?	What is the effectiveness of development to aid non-climate conflict?
How many conflicts are there now, where are they, and can we accurately measure them? How can you measure the influence on climate on ongoing conflict?	
How does economic performance affect conflict?	
How do governance parameters (transparency, corruption) affect conflict?	
Natural Resource Data	
Which countries are most vulnerable to resource scarcity?	Agricultural and water data
Where are there shared resources or transboundary agreements?	
Where are there resource imbalances/inequality and to what degree?	
Do we have reliable models of resource availability and prices?	
Do we have reliable population growth projections? How does population growth and urbanization impact conflict?	
Energy demand projections	
Which countries will be most affected by changes in need for in-demand commodities? Which countries have access to rare resources?	

Category	**What**	**How**	**Who**
1. Improve resilience of climate and conflict vulnerable states		Use map of conflict and climate vulnerable areas as guide to develop measures to address potential conflicts and conflicts in progress: - Maps of countries incorporating risks to extreme weather events, impacts on social structure, labor, health, migration, needs, capabilities, aid, inequality - Time phased - Identifying transboundary risks - Incorporate climate change considerations into national security decisions https://www.adaptationcommunity.net/?wpfb_dl=58	USAID EU UN Intelligence Community International Finance Institutions

	- Resistance to resource scarcity, minimize resource distribution inequality, build governance capacity (to prevent state failure)	Resilient international markets through multilateral rules on short notice restrictions on exports, Humanitarian and developmental aid **Challenge:** Effectiveness and negative counter effects of aid. Political priorities of countries.	
2. Mitigate conflicts over global commons		- New or strengthened international regimes in global commons (i.e. Arctic, Cyber, Trade) **Challenge:** How do you get countries to abide - Use of standardized principles (i.e. fundamental principles for transboundary agreements) - Transform power grids to strengthen cross-country cooperation and interdependence	
3. Alleviate resource scarcity	Traditional (water and food) and new materials (critical minerals)	- Collaborative R&D to lessen dependence on key materials like cobalt and resource dependence on oil	-Members of Paris agreement meetings -CERC

Critical Minerals Are an Unappreciated Risk of a Full-Scale Clean Energy Transition

Kat Burnham, Lucia Chuquillanqui, Wojciech Krawczyk, Wenjia Ma, Alexander Nassikas, Guy Packard

1. Executive Summary

The current global energy regime has generated both miraculous prosperity around the world as well as societal tension and conflict, and a significant carbon debt. A rapid, full-scale transition to a clean energy economy is needed to eliminate greenhouse gas emissions and to avoid global climate catastrophe. The raw material inputs required for a transition of this scale are enormous and carry with them major underappreciated security risks of their own.

Without careful planning and regulation, clean energy industrial supply chains can create familiar national security risks related to the overreliance on a handful of minerals. Securing and safely managing their life-cycle – extraction, processing, trade, use, and recycling – has real geopolitical implications. Governments must work better with each other and with non-state actors to prepare for a clean and secure energy future.

The following white paper provides an overview of how clean energy technology both enhances and degrades national security, specifically tracing the mineral supply chains necessary to underwrite a full-scale clean energy transition. It concludes with a set of specific policy recommendations for how to mitigate these national security concerns.

2. Energy Transition Context

Since 1973, 25-50% of interstate wars have been linked to oil.[44] No other commodity has had as large an impact on geopolitics and international security. These conflicts stem both from direct strategic competition over oil reserves and indirect economic and diplomatic pressures.[45] Global energy markets, and the fierce competition embroiled within them, remain a dominant feature of international relations in the world today.

Nations like the United States and China have prioritized energy independence to alleviate exposure to oil price volatility and conflict in the Middle East. However, the global nature of commodities and their supply chains raises prospects for conflict and breeds instability in resource rich countries. This instability has been particularly visible in oil-rich nations, which feature clashes over trade route control, financing for insurgencies and petro-aggression, in which oil revenues are used to help insulate aggressive leaders from domestic opposition and allow them to engage in risky foreign policy adventurism.[46]

---

[44] Colgan, Jeff. "Fueling the Fire: Pathways from Oil to War," International Security, 2013. 147-180.

[45] El Gamal, Mahmoud and Amy Myers Jaffe. *Oil, Dollars, Debt and Crises: The Global Curse of Black Gold*. Cambridge University Press. 2010. 162.

[46] Jeff D. Colgan, "Fueling the Fire: Pathways from Oil to War," International Security, Vo. 38, No. 2 (Fall 2013).

3. Clean Energy: National Security Benefits

A clean energy economy, including nuclear, solar, and wind technologies, provides four significant national security benefits.[47] First, renewable energy can be produced domestically, with zero reliance on a global fuel supply and more predictable market prices. Second, renewable energy is rapidly deployable and inexhaustible. Third, high renewable energy penetration enhances the resilience of the entire electrical grid, making it less vulnerable to extreme weather events or acts of terrorism. Fourth, decentralized electricity generation offers a more dynamic and adaptive energy deployment pathway, avoiding costly technological lock-in.

(1) Clean energy independence: Solar, wind, geothermal, and hydro sources are widely available, but since they are not equally distributed, the most effective composition of renewables varies depending on geographical location. With an adequate development and implementation of renewables, countries can reduce reliance on fossil fuel imports from those who often choke fuel supplies as a tool in geopolitical conflicts. Renewables and nuclear have zero and very low-cost of fuel respectively. This would effectively end uncertainties regarding oil and gas prices, thus creating a more stable environment for the economy.

(2) Easier and faster to rebuild and restore power: In case of catastrophic events, dispersed grids are easier to rebuild. Centralized grids rely on big power generation units connected to end users with miles of transmission lines and large electrical substations. Reconstruction of this complex infrastructure is time and resource intensive. Distributed energy resources are close to end users thus require fewer materials and labor to restore. Renewable technologies can also be sited and built in a much shorter time frame. While large centralized power stations can take 4-8 years, a wind or solar farm can be deployed in 1-3 years.[48]

(3) Enhanced resilience: The current centralized infrastructure is aging and thus vulnerable to natural disasters and targeted threats. Between 2012 and 2016, extreme weather events caused 96% of the total customer-hours disrupted in the U.S., mostly due to damaged transmission and distribution networks.[49] A decentralized grid, with power generation distributed among smaller facilities, minimizes the risk that a single point failure will cause a blackout for thousands of people as small-scale grids supply only local communities. Decentralized grids provide an ultimate form of diversification of the energy mix. With millions of geographically dispersed electricity generation units, single point failures will have a minimal effect on national security.

(4) Reduce technological lock-in. In 2018, the average size of coal power plants in the U.S. was more than 200 megawatts (MW)[50], and the market trend for both coal and gas plants is

---

[47] American Council on Renewable Energy. "The Role of Renewable Energy in National Security." Issue Brief. 2018. https://acore.org/wp-content/uploads/2018/10/ACORE_Issue-Brief_-The-Role-of-Renewable-Energy-in-National-Security.pdf

[48] Development Timeline for Utility-Scale Solar Power Plant, Solar Energy Industries Association. Available at, https://www.seia.org/research-resources/development-timeline-utility-scale-solar-power-plant; Assumptions to the Annual Energy Outlook 2018, U.S. Energy Information Administration. Available at, https://www.eia.gov/outlooks/aeo/assumptions/pdf/electricity.pdf

[49] The Real Electricity Reliability Crisis, Rhodium Group (2017) https://rhg.com/research/the-real-electricity-reliability-crisis-doe-nopr

[50] EIA, 27 gigawatts of coal-fired capacity to retire over next five years

to build bigger units. Such multimillion-dollar investments create a technological lock-in while distributed clean energy generation offers a more dynamic pathway as they can be gradually developed by individual end-users. The potential of renewable energy production gives end-users another opportunity – to become energy producers. In decentralized electrical grids (DERs), energy generated from solar panels (which are the most available and accessible way of generating electricity for end-users) is easy to deploy and becomes economically competitive because of decreasing levelized cost of energy (LCOE) from renewables.[51]

4. Clean Energy: National Security Risks

There are significant economic, social, and material risks associated with a rapid, full-scale clean energy transition. Major transformations and dislocations in economic structure and activity are likely, which in turn may lead to widespread joblessness and exacerbated inequality. The most underappreciated risk, however, is the dependence on the mining of critical minerals.

5. Clean Energy: Economic and Social Risks

Deploying gigawatts of renewable energy entails enormous upfront capital cost that will be difficult for societies to bear, especially for developing nations struggling with other aspects of sustainable development they might consider more pressing, such as nutrition, health care, and poverty alleviation.

For developing countries dependent on fossil fuel exports, the impacts of complete decarbonization might be severe. A complete transfer towards renewable and clean energy implies leaving the most cost-effective products underground and choosing potentially more expensive alternative choices. The startup of the energy transformation will be challenging to these countries' economy. Without effective social guardrails in place, an energy transition may lead to mass unemployment in these countries, which in turn exacerbates social tensions, threatens political stability, and could result in the eruption of violence.

The benefits of clean energy development are distributed among the whole country, yet the losses in fossil fuel sectors are condensed in smaller areas, creating regional inequality. This is seen in the United States with the decline of the use of coal. In the Appalachian region of the country the number of coal jobs hovers at historic lows and is less than one-third the level in the 1980's.[52] This shift in economic structure can have devastating societal impacts on localities.

6. Critical Supply Chain Vulnerabilities

Discussions surrounding decarbonization pathways often ignore the risks associated with securing the reliable extraction of raw materials necessary to realize existing climate targets. Clean energy technologies depend on mining-intensive supply chains for critical raw materials, many of

---

https://www.eia.gov/todayinenergy/detail.php?id=7290

[51] Lazard. "Levelized Cost of Energy and Levelized Cost of Storage." 2018. https://www.lazard.com/perspective/levelized-cost-of-energy-and-levelized-cost-of-storage-2018

[52] Volcovici, Valerie. "EXCLUSIVE-Most U.S. States Lost Coal Mining Jobs in 2017 – Data." Reuters, January 18, 2019. https://www.reuters.com/article/usa-coal-jobs/exclusive-most-u-s-states-lost-coal-mining-jobs-in-2017-data-idUKL8N1PC6AC.

which are scarce or sourced in conflict areas, or both.

Should national governments move to realize the climate targets set forth in the Paris Agreement, demand for these materials will skyrocket.[53] For example, according to the World Bank, demand for minerals required for solar panels (e.g. copper, iron, molybdenum, zinc) may increase 300% by 2050 and metals required for energy storage may see a 1200% rise in demand.

Under aggressive legislative efforts to combat climate change subnational and international geostrategic competition will shift from a focus on controlling fossil fuel extraction and trade, to controlling the extraction and trade of minerals like rare earth elements, lithium, and cobalt.

Rare Earth Elements

One particularly critical material flow for advanced clean energy technologies comes from a section of seventeen different elements of the periodic table, collectively known as rare earth elements. Due to their extraordinary and unique chemical and physical properties, rare earths are now considered essential for a wide-variety of applications like fiber-optics, advanced weapons systems, magnets, and importantly, clean energy technologies like photovoltaics and batteries. For many applications, there are no viable substitutes. The energy from solar and wind may be renewable, but the materials these technologies depend on are anything but. Very little rare earth material can be recycled or recovered economically.[54]

Although the name "rare earth" is something of a misnomer (most of them are as terrestrially abundant as common industrial metals like nickel and zinc), their extraction and refinement processes are complex, expensive, environmentally damaging, and concentrated in an astonishingly small number of countries, mainly China. China virtually commands the rare earth market as it produced 80% of the world's supply in 2017.[55]

The United States previously dominated the global market for all stages along the rare earth supply chain up through the 1990s, but ceded production to lower-cost and unregulated Chinese firms. A 2010 U.S. Government Accountability Office report acknowledged the security risks inherent in a supply chain dependent on China and concluded that it would take up to 15 years to rebuild the U.S. rare earth supply chain.[56]

Non-Chinese sources of rare earth oxides, including in the US and Malaysia, have struggled to compete with China's low costs and their own environmental regulatory standards. California-based Molycorp re-opened the only existing rare earth mine in the US in 2013, and then

---

[53] Arrobas, Daniele La Porta, et al. "The growing role of minerals and metals for a low carbon future." The World Bank: Washington, DC, USA (2017).

[54] Parthemore, Christine. Elements of security: mitigating the risks of US dependence on critical minerals. Center for a New American Security, 2011.

[55] U.S. Geological Survey. "Mineral Commodity Summaries 2019." 2019. https://minerals.usgs.gov/minerals/pubs/mcs/2019/mcs2019.pdf

[56] U.S. Government Accountability Office. Rare Earth Materials in the Defense Supply Chain, GAO-10-617R. 2010.

filed for bankruptcy only two years later.[57,58] In Malaysia, the Ministry of Environment moved to block Australia's Lynas Corporation's operations, citing a build-up of toxic waste vulnerable to flooding or other natural disasters.[59]

China's economic control of rare earths became particularly acute when Beijing instituted an embargo on rare earth exports to Japan in 2010 after Japan had detained a Chinese fishing trawler captain. The sharp decline in rare earth exports caused worldwide prices to spike and a flurry of US Congressional attention and panic regarding their market exposure.[60] During this time period, some important steps were taken to address US rare earth supply chain vulnerability and to support domestic production. A slew of legislative bills were introduced to address these concerns and a congressional caucus on rare earths was established in 2011. In September 2013, the House passed H.R. 716, The National Strategic and Critical Minerals Production Act of 2013.[61]

More recently, in 2017, President Donald Trump issued Executive Order 13817, conceding that US reliance on the imports of "certain mineral commodities" creates a "strategic vulnerability" for its economy and military. The Order defined a "critical mineral" as follows: (1) a non-fuel material essential to the economic and national security of the US, (2) whose supply chain is vulnerable to disruption, and (3) which serves an essential function in the manufacturing of a product, the absence of which would have significant consequences for our economy or our national security.[62] Indeed, in fulfilling Trump's Executive Order, the US Department of the Interior listed rare earth elements, lithium, and cobalt as having reached this definition of criticality.

So far, these efforts have succeeded in boosting recognition of the criticality of rare earths but have largely failed at structurally relieving supply chain risk. China still maintains a virtual monopoly on rare earth production, in both the light and heavy classes of rare earths and Molycorp entered bankruptcy, ending US domestic production for the foreseeable future.

According to the US Geological Survey, globally known reserves of rare earth elements exist in China (50%), Russia (17%), the United States (12%), India (2.5%), and Australia (1.5%), with the remaining 17% in countries like Brazil, Malaysia, Canada, and South Africa.[63] USGS estimates that these and other undiscovered worldwide reserves are large enough to meet rising global demand. Therefore, supply chain vulnerability should not be assessed from a standpoint of absolute scarcity but rather from an overreliance on imports from China, whose 2010 embargo reveals their true control over the global market.

The US has long known about the national security risks inherent in an overreliance on

---

[57] Gholz, Eugene. Rare earth elements and national security. Council on Foreign Relations, 2014.

[58] Deveau, Scott, and Kiel Porter. "Neo Performance, Carved from Remains of Bankrupt Molycorp, Plans $235 Million IPO." News Media. The Denver Post, November 7, 2017. https://www.denverpost.com/2017/11/07/neo-performance-molycorp-235-million-ipo/.

[59] Lee, Liz, and Melanie Burton. "Australia Rare Earth Miner Lynas Eyes Legal Options on Malaysia Plant Review." Reuters, December 4, 2018. https://www.reuters.com/article/us-lynas-corp-malaysia/australia-rare-earth-miner-lynas-eyes-legal-options-on-malaysia-plant-review-idUSKBN1O30VI.

[60] Morrison, Wayne M., and Rachel Tang. "China's rare earth industry and export regime: economic and trade implications for the United States." (2012).

[61] Humphries, Marc. "Rare earth elements: the global supply chain." 2013.

[62] White House. "Presidential Executive Order on a Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals." Executive Orders, December 20, 2017. https://www.whitehouse.gov/presidential-actions/presidential-executive-order-federal-strategy-ensure-secure-reliable-supplies-critical-minerals/.

[63] Humphries, Marc. "Rare earth elements: the global supply chain." (2013).

importing raw materials like fossil fuels. Given their criticality to technologies that nations may soon depend on, mitigating rare earth supply chain risks should be similarly prioritized. During a recent Congressional hearing on "The Need for Leadership to Combat Climate Change and Protect National Security," US Representative Kelly Armstrong (R-ND) specifically cited China's monopoly of rare earths as a national security concern: "We are as close to energy secure as we have ever been, and as we transition here, we won't be."

Nations have codified a geostrategy centered largely around the extraction and consumption of fossil fuels over the last two hundred years. As nations seek to secure the safe and reliable supply of materials necessary for clean energy infrastructure, the current geopolitical competition may be won or lost over the supply and demand of rare earths. Lithium and cobalt pose similar threats to a clean energy future.

Lithium and Cobalt

In addition to rare earths, the US Department of Interior's 2018 report demarcated lithium and cobalt as minerals critical to national security.[64] Both elements are vital components for energy storage and advanced battery technology, including those used in electric vehicles. And both elements exist in ample supply on earth. However, their mining practices have exacerbated social tensions and conflict in countries like Chile and the Democratic Republic of the Congo, which control the majority of lithium and cobalt production, respectively. As consumption of these critical minerals rises, nations would be wise to implement safeguards that ensure their just and sustainable extraction.

The amount of lithium resources is not a limiting factor to scaling clean energy production, according to the USGS. They project that worldwide reserves of lithium are enough to meet global demand to the year 2100. Of the 39 million metric tons of global resources, 13 million tons are in economically recoverable reserves.[65] And although the United States does not currently produce large amounts of lithium, it does have significant lithium reserves. Furthermore, not only will a surging market for lithium batteries increase discovery of new lithium deposits, but the market pressure will also likely lead to more recycling: "Lithium can be recycled indefinitely, whereas oil can be used only once."[66] However, like rare earths, both lithium and cobalt reserves are concentrated in relatively few countries, with significant, unquantified reserves in Bolivia and Afghanistan.[67] Chile, for instance, controls 76% of known lithium reserves. The Democratic Republic of the Congo controls 51% of global cobalt reserves.[68]

Global lithium demand has tripled since 1980, but that growth is likely to accelerate dramatically under policies that electrify the transportation sector over the next several decades.[69] Electric vehicles currently make up a tiny fraction of the number of cars on the road.[70] Adhering

---

[64] US Department of the Interior, "Final List of Critical Minerals 2018." 23295-23296.

[65] Schulz, Klaus J., John H. DeYoung, Robert R. Seal, and Dwight C. Bradley, eds. Critical Mineral Resources of the United States: Economic and Environmental Geology and Prospects for Future Supply. Geological Survey, 2018.

[66] Schulz, Klaus J., ibid.

[67] Hensel, Nayantara D. "Economic challenges in the clean energy supply chain: the market for rare earth minerals and other critical inputs." Business Economics 46.3 (2011): 171-184.

[68] Hensel, Nayantara D. Ibid.

[69] U.S. Department of Energy. Critical materials strategy. 2011.

[70] Joselow, Maxine. "The U.S. Has 1 Million Electric Vehicles, but Does It Matter?" New Media. Scientific

to aggressive climate mitigation scenarios calls for every car and truck on the road to be electric, and barring a revolution in battery technology, these are likely to be powered by a lithium-ion battery. Some hybrid-electric vehicles today use nickel-metal hydride batteries, but these require a rare earth element called lanthanum. Automakers thus find lithium-ion batteries, which do not use rare earths but may contain cobalt, nickel, or manganese, more attractive[71]. Tesla, for example, after recognizing the conflict-prone nature of cobalt as well as significant cost-savings, has sharply reduced the amount of cobalt needed in its batteries, and aims to be cobalt-free soon.[72]

At constant 2011 global production rates, one study estimates that the world contains about 150 years of cobalt supply.[73] Serving steady, present-day demand, the study suggests no geologic shortage of cobalt over the long term. However, a doubling, or a tripling of cobalt demand may exhaust the recoverable pool by 2050.

Nevertheless, policymakers have more immediate concerns than running out of lithium and cobalt. The history of fossil fuel extraction presents a useful historical lesson: abundance does not protect against conflict. With poor governance, corruption, weak regulatory enforcement, a lucrative industry can fuel social conflict, instability, as well as human rights violations. This is the story of mining for cobalt and other minerals in the DRC.[74] Minerals mining and trade in the DRC and other failed states inadvertently funnels cash into militias that undermine or impede the growth of sustainable political and economic environments necessary for safe and reliable resource flows. These and other impacts consequently present as major supply chain vulnerabilities to import-dependent countries like the United States.[75]

To address this vulnerability, Congress included a miscellaneous measure in the 2010 Dodd-Frank Wall Street Reform and Consumer Protection Act that compels companies to track and report their mineral supply chains out of Central Africa. Previously, manufacturers and corporations saw little incentive to track where their mineral inputs had originated. The Dodd-Frank measure should be applauded and expanded to include other critical minerals like lithium and rare earths.

The booming demand for lithium and other minerals for use in modern technologies has led to a scramble over a much older resource: water. The mining industry depends on water extraction for processing; in one region of Chile, the industry is estimated to be responsible for more than 70% of all water consumption.[76] Worse, companies like the lithium salt mine operator Sociedad Quimica y Minera (SQM) are able to extract water without any legal consultation with

---

American, October 12, 2018. https://www.scientificamerican.com/article/the-u-s-has-1-million-electric-vehicles-but-does-it-matter/.

[71] Hensel, Nayantara D. Ibid.

[72] Sanderson, Henry. "Tesla's Cobalt Decision Could Hit Demand for the Battery Metal." Financial Times. May 03, 2018. Accessed May 14, 2019. https://www.ft.com/content/1c154770-4eb6-11e8-a7a9-37318e776bab.

[73] Mudd, G. M., et al. "Quantifying the recoverable resources of by-product metals: The case of cobalt." Ore Geology Reviews 55 (2013): 87-98.

[74] "Profits and Loss: Mining and Human Rights in Katanga, Democratic Republic of the Congo." Amnesty International. Accessed May 14, 2019. https://www.amnesty.nl/actueel/profits-and-loss-mining-and-human-rights-in-katanga-democratic-republic-of-the-congo.

[75] Parthemore, Ibid.

[76] Babidge, Sally. "Contested value and an ethics of resources: water, mining and indigenous people in the Atacama Desert, Chile." The Australian Journal of Anthropology 27, no. 1 (2016): 84-103.

local and indigenous peoples.[77] Indigenous peoples and mining companies have been in direct competition for water in the Atacama for decades, driving conflict and unrest. A recent report found that excessive water extraction by mining companies in northern Chile damaged watersheds and ecosystems, increased desertification, and destroyed agriculture and livelihoods of local populations, driving mass migration to the cities.[78]

A zero-carbon future will place immense pressure on markets to scale up the extraction, processing, and trade of rare earths, lithium, cobalt, and other critical minerals to keep pace with explosive demand. It is up to policymakers in nations all over the world to ensure these clean energy material flows occur in ways that mitigate environmental degradation and social conflict.

Nuclear Supply Chain

Nuclear power is a generation source that, while carbon-free, has significant supply chain concerns both in the near term and in the future. There may be a need for nuclear power to take a larger role as the world increasingly moves to decarbonize. Currently, the nuclear fuel cycle utilizes uranium, but could potentially include thorium with the implementation of new nuclear technologies such as molten salt reactors.

In 2017, only 7% of the uranium needed to fuel the United States' reactors was supplied by domestic mines,[79] the rest being supplied mainly by Canada, Australia, Kazakhstan, and Russia. The uranium suppliers from Kazakhstan and Russia are state-backed businesses which lead to questions of United States energy independence if these countries decided to withhold supplies. China also has a stated goal of acquiring one-third of its uranium through foreign equity in mines and joint-ventures overseas.[80] Uranium fuel is not only critical for the country's reactors but also for military use in weapons and fuel for its nuclear submarines and aircraft carriers. The Trump administration is currently investigating this lack of energy independence via a "Section 232" probe. The results of the national security investigation were formally submitted by the U.S. Commerce Department to the White House on April 14, 2019. President Trump will now have 90 days to decide to act upon the recommendations.[81,82] As the nuclear industry pursues new technologies there is talk of utilizing thorium as a new fuel source, as it three times more abundant than uranium. Utilizing thorium as a primary fuel would require the development of new supply chain infrastructure. The top reserves of thorium reside in India, Brazil, Australia, USA, Egypt,

---

[77] Babidge, Sally. Ibid. 91.

[78] Larrain, Sara, and Colombina Schaeffer. "Conflicts over water in Chile: Between human rights and market rules." Santiago: Chile Sustentable (2010).

[79] DiChristopher, Tom. "Nuclear Wasteland: The Explosive Boom and Long, Painful Bust of American Uranium Mining." News Media. CNBC, August 4, 2018. https://www.cnbc.com/2018/08/04/the-miners-that-fuel-americas-nuclear-power-and-atomic-arsenal-are-di.html.

[80] "China's Nuclear Fuel Cycle." Informational. World Nuclear Association, January 1, 2019. http://www.world-nuclear.org/information-library/country-profiles/countries-a-f/china-nuclear-fuel-cycle.aspx.

[81] Preiss, Rainer. "U-Turn For Uranium As U.S. Decides If Miners Pose National Security Threat." News Media. Forbes, February 28, 2019. https://www.forbes.com/sites/rainermichaelpreiss/2019/02/28/U-turn-for-uranium-as-u-s-decides-if-miners-pose-national-security-threat/#3c9858066043.

[82] Shepardson, David, and Valerie Volcovici. "U.S. Agency Submits Uranium Import Probe to White House." Reuters, April 15, 2019. https://www.reuters.com/article/us-usa-trade-uranium/u-s-agency-submits-uranium-import-probe-to-white-house-idUSKCN1RR1RB.

Turkey, and Venezuela.[83] It needs to be recognized that not all of these countries are friendly to open-market business models and therefore it is important to secure and develop dependable sources in the event of future needs.

7. POLICY RECOMMENDATIONS

Around the world, countries are evaluating and planning their pathway to a sustainable future. The rare earth minerals and materials essential to the growing clean energy system create foreign policy concerns and resource vulnerabilities. These issues are central to international relations, environmental protections, and national security. If unaddressed, these issues may become exacerbated, leading to strained relations along the supply chain and higher costs for consumers.

There are three key areas of recommendations to address sensitive supply chain issues:

1. Identify and Monitor Conflict Minerals and Materials
2. Stimulate Innovative Research and Design
3. Strengthen Multilateral Cooperation

1. Identify and Monitor Conflict Minerals and Materials

As outlined in the Security Risk section of this paper, the United States' 2010 Dodd-Frank Act adequately prevents flow of the "3TG" conflict minerals: Tungsten, Tantalum, Tin, and Gold. The Act improves transparency of supply chains and enforcement of regulations. However, it is severely limited in its current scope. It is recommended that the U.S. expand and enhance the Dodd-Frank Act to address other minerals associated with conflict and security concerns.

Minerals such as cobalt, lithium, and other rare earth minerals as identified by the Department of the Interior and other appropriate domestic bodies such as the U.S. Geological Survey are appropriate additions. As our energy consumption and technology needs shift, it is incumbent on planners to regularly update the list of critical materials and incorporate them into the Act as needed.

Internationally, countries that do not monitor the supply of sensitive materials and enforce regulations are strongly encouraged to adopt a similar policy to a modern Dodd-Frank Act. It is critical to create a supply chain that is transparent and does not mimic the egregious harms of past markets as outlined in the historical section of this paper. Mining and transporting the materials for a zero-carbon future may impose severe environmental degradation or burdens on the local communities.

Newly created policies to enhance transparency on the mineral and metal supply chains must appropriately integrate protections for natural resources, labor, and the local community to minimize the social and environmental damage from resource extraction. It is further recommended that all countries implement and honor whistleblower policies to hold stakeholders accountable when they break these regulations and guidelines.

---

[83] "Thorium." World Nuclear Association, February 1, 2017. http://www.world-nuclear.org/information-library/current-and-future-generation/thorium.aspx.

2. Stimulate Innovative Research and Design

Countries must act sustainably as the energy supply chain evolves. Rare earth minerals and sensitive materials may become difficult to obtain for reasons related to conflict, costs, man-made environmental degradation, and/or climate related damage. These are serious concerns in global energy security and it is reasonable to invest in research and design of alternative sources. It is recommended that research is conducted to create synthetic materials or identify new materials that may be more abundant or more easily recycled to support clean energy and renewable infrastructure. If rare earth minerals and conflict materials prove to be too hazardous, alternative sources for energy technologies may be a necessary solution.

There are important economic, environmental, and security benefits associated with minimizing waste. To further reduce the pressure on the mineral supply chain, it is advised that researchers analyze and propose effective methods to improve recycling rates of materials already in our products. As the electric vehicle market grows, for example, those batteries containing cobalt, lithium-ion, nickel, and other materials should be reused in other products rather than disposing them in landfills or other deposits.

3. Strengthen Multilateral Cooperation

There are international bodies in place poised to manage relations and guidelines concerning rare earth minerals. The United Nations Framework Convention on Climate Change (UNFCCC) exists to manage the global response to the threat of climate change. The UNFCCC facilitated the collaboration and approval of key international agreements such as the Kyoto Protocol in 1997 and the Paris Agreement in 2015. It is recommended that the UNFCCC prioritize supply chain and material concerns on future agendas for the meeting of the parties. The UNFCCC will be a major player in this transitioning energy economy.

Similarly, the International Energy Agency (IEA) is another reputable leading entity that may be a key organization to convene participating countries, supply chain experts, and advocates on international supply discussions agreements. Indeed, there are a range of international agencies, including but not limited to the Organization for Economic Co-operation and Development (OECD), the World Trade Organization (WTO) and others that are highly capable and pertinent to international energy security and economy. Each has a particular expertise and jurisdiction that inevitably will engage in future clean energy material supply chain management in some capacity. Additional multilateral coordination is required to determine the respective roles for these intergovernmental organizations in oversight and relations with regards to critical minerals.

Inherent to rare earth mineral and sensitive material extraction are environmental concerns. In addition to each country's domestic policies on natural resource management, the international community has a duty to ensure long-term viability of the supply chain and protections for entities impacted by the use of these materials. It is strongly recommended that the U.S. Senate ratify the UN Convention on the Law of the Sea (UNCLOS).[84] The Convention already reflects current U.S. practices related to marine resource management. Seabed mining

---

[84] "United Nations Convention on the Law of the Sea." United Nations, March 28, 2018. http://www.un.org/Depts/los/convention_agreements/texts/unclos/unclos_e.pdf.

encapsulates the overlapping concerns of climate change impact and resource extraction.[85] This body could be particularly useful to resolve territorial disputes and ensure environmental protections as the melting Arctic sea ice opens a new corridor and the potential for seabed mining for minerals.[86] Over 140 countries are party to UNCLOS, and it is strongly advised the U.S. joins them to engage in crucial conversations going forward.

8. CONCLUSION

Climate change is the existential threat to our collective well-being. The clean energy path forward is still forming and unique to all countries. Rare earth elements and other critical minerals play a unique role in the burgeoning clean energy sector, a role whose risks have remained underappreciated. As the international community transitions to a low-carbon energy system, we must learn from our past mistakes in energy procurement and manage new supply chains carefully. Innovative research and trusted international guidelines will help ensure that stakeholders minimize corruption, violence, and environmental harms. Rigorous evaluation and continuous enforcement of resources that build clean energy technologies are key to national and international security.

---

[85] Koltz-Ryan, Marta. "An Arctic Race: How the United States' Failure to Ratify the Law of the Sea Convention Could Adversely Affect Its Interests in the Arctic". University of Dayton Law Review. 2009, https://udayton.edu/law/_resources/documents/law_review/anarctic_race.pdf

[86] Sandalow, David B. "Law of the Sea Convention: Should the U.S. Join?." Brookings, August 19, 2004. https://www.brookings.edu/research/law-of-the-sea-convention-should-the-u-s-join.

Impacts of Climate Change on Human Health

Charlotte Hough, Gregory Boudreaux, Kathleen Kirsch,
Matthew Burnett, Trevor Dean Arnold

1. Executive Summary

Effective policymaking requires accurate foresight, local knowledge, and international support to make decisions for the public good. Anthropogenic climate change poses a pressing threat and mitigation and adaptation strategies must include a focus beyond direct impacts to include ramifications in migration, agriculture, and health sectors. The current allocation of social resources is skewed towards countries and regions in the world that are less vulnerable to the impacts of climate change. In this paper, we recommend bolstering global human and social capital using established institutions with varied capacities in health, modeling, and climate science. We propose combining the expertise of the World Health Organization (WHO), SERVIR, and the Intergovernmental Panel on Climate Change (IPCC), with national health and environment ministries and local epidemiologists in a consortium that will connect global health impact trends with local knowledge. Mindful of previous climate change mitigation efforts, this consortium is designed to leverage existing institutions and complement solutions like the Paris Agreement. IPCC and SERVIR could apply climate science modeling in collaboration with epidemiologists and health scientists, such as partnering with the WHO to develop health-risk models for regions to inform adaptive policies. These models would be informative, not prescriptive, and provide decision makers with the tools to prepare healthcare sectors and create adaptation plans. This paper is focused on the health impacts of climate change, and thus we begin by reviewing the pathways that cause risk and harm to human health. We then discuss our recommendation to adapt to the health-related effects of climate change by combining predictive climate models and epidemiological models to inform health system planning and build a globally resilient healthcare system.

2. Background

Anthropogenic climate change poses a pressing threat to human society as well as the rest of the earth's ecosystem. Greenhouse gas emissions resulting from fossil fuel use continue to accumulate in the earth's atmosphere, leading to surface warming of the land and oceans. Due to this and feedback effects in the atmosphere, oceans, biological systems, and ice sheets, Earth's temperature has been slowly rising. This leads to temperature extremes, changes to precipitation patterns, and variation in storm location and frequency. These, along with other secondary effects of climate change, will have strong impacts on biological and human activities (Nordhaus, 2013). Many of these impacts have already been observed (IPCC, 2018).

Climate change acutely threatens human health. Primary effects include direct biologic consequences from extreme weather, heat waves, and urban air pollutants. Secondary effects are changes from biophysical and ecological processes such as food yields, water flows, and disease vectors. Other tertiary effects stemming from this include displacement, resource conflict, and mental health effects (McMichael, 2013). The subsequent discussion will detail the impacts of

climate change on health stemming from air pollution, mitigation consequences, changes in vector ecology, water quality, food supply, extreme heat and severe weather, as shown in Figure 1.

Figure 1: Climate change impacts on human health

3. Analysis of Impacts

A. Air Quality

Air pollution and air quality issues have historically been identified as both driving forces and consequences of global climate change. The impacts of deteriorating air quality on human health broadly fall into three categories: impacts of outdoor air pollution, indoor air pollution, and aeroallergen concentration. An estimated 3.7 million deaths annually can be attributed to outdoor air pollution (WHO, 2016). When investigating outdoor air pollution, the effects of both ozone concentrations in the air and the concentration of particulate matter less than 2.5 microns in diameter ($PM_{2.5}$) must be considered.

Ozone levels and the health impacts associated with their presence depend on both the amount of anthropogenic ozone emitted and meteorological conditions, such as temperature, relative humidity, and the vertical mixing of air because of pressure gradients. In the United States, the worst ozone events tend to occur when the local air mass over a given area stagnates over time, allowing ozone to accumulate. Changing wind patterns due to climate change have already begun to increase these stagnation events, leading to increased, consistent exposure to the health impacts of ozone concentration. Additionally, evidence has shown that factors influenced by climate change, such as higher temperatures, can negatively influence human resilience to given levels of airborne ozone concentration (Jhun, 2014). Specifically, high particulate matter concentrations are associated with serious health outcomes such as lung cancer, heart disease, and chronic obstructive pulmonary disease, a progressive lung disease characterized by breathlessness and reduced lung functionality.

Climate change will dramatically alter precipitation patterns and humidity levels, which will then change $PM_{2.5}$ concentrations in the air. While $PM_{2.5}$ accounts for most of the health burden associated with outdoor air pollution in the United States, it is not clear whether climate change's meteorological consequences will cause a net increase or decrease in $PM_{2.5}$ concentration levels. However, $PM_{2.5}$ which stems from natural causes such as wildfires is highly susceptible to local weather conditions. As climate change-induced wildfire events increase in frequency and magnitude, populations downwind will be increasingly vulnerable to the negative health impacts of $PM_{2.5}$. A Harvard study found that by 2050, changes in wildfire frequency in the Western United States are expected to increase atmospheric organic carbon by 40% and elemental carbon aerosol concentrations by 20% (Spracklen, 2009).

Air quality changes attributable to climate change can also manifest in impacts on aeroallergens and respiratory diseases. Aeroallergenic diseases disproportionately affect children, the elderly, and people with weakened immune systems. Increases in temperature and CO_2 levels associated with climate change have the potential to extend the growing season of aeroallergens such as ragweed, resulting in greater flowering and pollen production. Additionally, as pollen grains may release their contents after contact with heavy rain, increases in rainfall associated with climate variability may be associated with greater susceptibility to allergic reactions in vulnerable populations.

Poor indoor air quality is associated with adverse health outcomes as well. Although most exposures to high levels of ozone take place outdoors, outdoor air quality is necessarily reflected in indoor air quality and given the amount of time that humans spend indoors, the impacts of reductions in indoor air quality due to climate change will undoubtedly be felt. For example, research has shown that although indoor levels of $PM_{2.5}$ concentration due to wildfires is about 50% of outdoor concentration, about 80% of the exposure to this particulate matter is felt indoors (Fisk, 2015).

B. Changes in Vector Ecology

Vector-borne diseases, which include malaria, Lyme disease, plague, and leishmaniasis, are spread by insect vectors (mosquitos, ticks, fleas and sand flies, respectively). The distribution, abundance, behavior, and ability of these vectors to spread disease is influenced by changes in climate.

Regional shifts in climate can impact disease transmission. For example, climate interactions with blacklegged ticks which are a vector of the bacterium *Borrelia burgdorferi* – the causative agent of Lyme disease. The incidence of Lyme disease may increase as milder winters and earlier onset of spring increase the length of the disease transmission season, increase the rodent population that ticks feed on, and increase the density of ticks. Changes in human behavior due to milder weather may also increase human exposure to infected ticks (Luber et al. 2014).

Climate change may also make regions that were previously inhospitable, habitable by certain disease vectors. For instance, with higher temperatures, the distribution of malaria has encroached into highland areas that were previously unaffected as they become more inhabited by mosquitos (Portier et al. 2010). The United States, a country that has not been significantly affected by tropical diseases such as dengue and chikungunya, will be increasingly vulnerable as the mosquito vectors of these diseases move north with climate change (Reidmiller et al. 2018).

However, predicting the impact of climate change on vector ecology is complicated by various competing factors. For example, higher temperatures can lead to increased transmission of malaria, but prolonged droughts reduce the number of water bodies required for mosquitoes to reproduce. Likewise, adaptation to climate change by countries, such as changing land use to grow crops more suited to different climate conditions, or greater use of irrigation to make up for lower rainfall, may impact vector ecology, and urbanization may reduce exposure to disease vectors (Portier et al. 2010; Hess et al. 2015).

C. Water Quality

Climate change impacts on water quality also affect human health. The WHO estimates that inadequate water, sanitation, and hygiene were responsible for 829,000 annual deaths from diarrhea and 1.9% of the global burden of diseases in disability-adjusted life years (DALYs) in 2016 (WHO, 2016). Waterborne illnesses can result in gastrointestinal, respiratory, immunological, hematological, nutritional, and other adverse health consequences (NIH, 2010).

Changes in precipitation and temperature impact the prevalence and geographic range of waterborne diseases globally. Local conditions can affect these relationships, some regions experiencing increasing amounts of waterborne illness with excessive rainfall and others experiencing a higher number of cases during droughts (USGCRP, 2017). The effects also impact algal blooms and extend to recreational waters, with outcomes remaining pathogen-specific (NIH, 2010).

Increased precipitation patterns and higher temperatures have been linked to an escalation in the incidence of diarrheal disease, bacterial infections, and parasitic infections, such as cryptosporidiosis and leptospirosis. Heat waves can increase populations of temperature-sensitive pathogens such as *Vibrio* (USGCRP, 2017). The World Health Organization estimated that in 2030, the risk of diarrhea will be up to 10% higher in some regions than if no climate change occurred, though further research on exposure-response relationships is needed (WHO, 2003). Projected changes in water-related disease transmission are also affected by the availability and resiliency of water and sewer infrastructure. Health impacts vary across different populations, with low-income groups, the elderly, children, pregnant women, and people with chronic medical conditions facing disproportionate risks to their health due to climate change (USGCRP, 2016).

D. Food Supply

Climate change has the potential to affect human health through its impacts on global food supply and food security. According to the World Food Programme (WFP), 793 million people worldwide are undernourished, and as the climate experiences increasing variability, the potential exists for food security issues to become more pronounced (WFP, 2019). Climate change will affect the frequency and intensity of natural disasters such as droughts and floods. These climatic events have the potential to destroy crops and interfere with agricultural supply chains, effectively hampering access to staple food sources in agriculture-based economies.

The Philippines, which is beginning to experience irregular and persistent typhoons, is one agriculture-based nation that will feel the many-pronged effects of climate shocks on food security in the coming years. In late 2018, Typhoon Mangkhut struck the Philippines and caused 12 billion pesos (around 230 million USD) of upfront damage to rice paddy fields (Cruz, 2018). In addition,

this typhoon caused a delay in the country's onion and tomato harvest, forcing farmers to choose between flooding the market with over-harvested produce and driving down prices, or wasting massive amounts of their crops.

The Philippines is just one example of the possible effects of climate change on agriculture and food security. While rising global temperatures may contribute to higher agricultural yields in some countries, other countries will feel the opposite effect. In low-income nations, which disproportionately depend on regional food systems and agriculture, climate variability will take a toll on agricultural land productivity. The Food & Agriculture Organization of the United Nations (FAO) predicts that the effect of climate change on cropland will be small before 2030; however, after that year, the productive capacity of cropland, particularly in sub-Saharan Africa, which is already food-insecure, will begin to deteriorate. Additionally, developing regions such as sub-Saharan Africa, which have a comparatively smaller ability to compensate for this change in agricultural productivity via food imports will likely begin to feel the effects of cropland productivity more quickly (Killman, 2008).

Even in countries which feel relatively small effects of climate change on food supply chains, increasingly volatile food prices will begin to affect labor market outcomes. Climate change will create temperature and precipitation patterns more hospitable to weeds and pests which have the potential to affect crop production. Higher CO_2 concentrations in the air, coupled with higher temperatures, will boost competition between weeds and crops in the northern hemisphere, and invasive weeds such as privet and kudzu, will render previously uninhabitable northern cropland more hospitable to invasion, and the accompanying costs of weed growth on agricultural productivity will have a ripple effect through the food system (NCA, 2014).

E. Extreme Heat

Extreme heat can be characterized as days in which surface temperatures are higher than the average historical records for the same day. Extreme heat days differ depending on the season and the climate zone. A period of these events that lasts days to weeks is considered a heat wave. On top of mortality consequences, effects from extreme heat events also include increased hospitalization (e.g. heart disease), reduced productivity for agriculture and indoor work, increased wildfires, and more severe droughts.

The main driver of deaths from anomaly events is via cardiovascular systems. Treatment for this shock can include hospitalization or help from family members and friends, but these solutions may be feasible for some populations. For instance, evidence shows that mortality consequences disproportionately affect younger (<5 years old) or older (>65 years old) persons who have less individual mobility and rely on others to care for them (Carleton, 2018). When a young or elderly person takes a cardiovascular shock, they are more vulnerable to serious consequences. Solutions beyond direct policy action may require more connected communities and better technology to prevent these shocks.

Extreme heat can be attributed to a system of climate and other local factors like evaporation, precipitation deficits, tree and shrub types, and climate zone. Evidence shows that extreme heat days increase forest fires, leading to mortality, displacement of people, exposure to particulates ($PM_{2.5}$), and other pollutants for health impacts that may decrease life and increase risk of allergens or asthma. Climate change and increased carbon emissions have been correlated

with a trend of more extreme heat days depending on your region (Hess et al. 2015). Although the trends are heterogeneous, considering extreme heat is a valuable risk aversion strategy to protecting vulnerable communities.

F. Severe Weather

Severe weather events are also expected to increase in frequency and magnitude as a direct result of anthropogenic climate change. Drought, extreme heat, extreme precipitation, and tropical storms are all intrinsically related to air and water temperature, as well as the level of CO_2 in the atmosphere, both of which have clear linkages to a changing climate. Geographic areas more prone to drought and extreme heat, such as the Southwestern United States, have seen recent summer temperatures spike to record levels, and with this heat has come record depletion of water resources. In Texas and Oklahoma, for example, record heat waves and drought conditions in 2011 contributed to more than $10 billion of damage to agriculture alone (NCA, 2014).

Climate change has also contributed to more frequent heavy rainfall events, as warmer air has the capacity to hold more water vapor than cooler air. Since 1991, the amount of rainfall falling in heavy precipitation events has increased dramatically, rising as much as 30% above the 1901-1960 average (NCA, 2014). Apart from the clear loss of life and property damages which will come because of increased flood events, these events will have consequences for public health as well. Most U.S. cities' sewer systems operate under a combined wastewater and stormwater system, in which the two are mixed, treated, and released together. Under heavy rainfall events, these systems could be overwhelmed, which poses a public health risk due to untreated sewage directly leaking into the natural environment (C2ES, 2018).

G. Consequences of Mitigation

Climate mitigation strategies, which can be defined as strategies designed to reduce or prevent greenhouse gas emissions, can have direct impacts on human health. Primary climate change mitigation methods focus on community development and the built environment, land use, clean energy generation, energy conservation, and carbon capture and storage. Concurrently to cleaning our energy resource mix, beneficial electrification can also reduce greenhouse gas emissions. Given that these climate mitigation strategies alter the human environment, they have the potential to create health co-benefits as well as adverse health impacts. This discussion reviews many of the significant impacts of climate mitigation on human health.

Mitigation often requires changes to community development and the built environment as well as new ways of thinking about land use. For example, the construction of urban vegetation is a strategy to reduce ambient concentrations of ozone, PM, and other pollutants. Health co-benefits may result from reducing the heat island effect (Portier et al., 2010).

Climate mitigation requires major changes to the global energy mix, by increasing the use of renewable and clean energy sources in power generation and transportation fuel. These mitigation measures can have diverse impacts on human health. Many of these changes can be characterized as co-benefits. Increased deployment of wind, wave, solar and nuclear energy can reduce cardiovascular disease by reducing particulate or other air pollution emissions. Reduced reliance on fossil fuels will reduce the release of neurotoxicants including arsenic, mercury, and

other metals in the environment (Portier et al., 2010).

Concurrently, many of these changes in the energy mix may have adverse impacts on human health. A cleaner energy mix may require more nuclear generation, particularly in the short term. There are various potential risks to human health throughout the nuclear fuel cycle, from production to waste disposal. Nuclear production can influence local ecology, increasing water demands, temperature and currents, which can impact life cycles of disease vectors and animals that comprise vector-borne and zoonotic disease cycles. Similarly, increased solar energy deployment will require additional solar PV cell production, which comes with environmental risks; cadmium and cadmium compounds like CdTe (cadmium-tellurim), used in cell production, are known human carcinogens. More research is needed around the impact of biodiesel as a transportation fuel on human health. Hydrogen fuel cell production has associated implications of leakage on skin cancer risk. Hydropower generation can impact local ecologies where dams are built, which can increase or decrease waterborne disease (Portier et al, 2010). Of note, a decrease in waterborne disease would be beneficial for human health.

As the global energy mix becomes cleaner and more renewable, beneficial electrification will help reduce greenhouse gas emissions. However, there are potential cancer risks from electric vehicles, specifically in the production and disposal of portable electric storage systems. Heavy metals used in batteries for electric vehicles present manufacturing and disposal challenges that create significant risk of neurological defects (Portier et. al, 2010).

Energy conservation strategies will influence human health in a positive way. Reducing reliance on vehicle transportation can lead to health co-benefits like weight loss and improved cardiovascular health, as well as reduced risk of depression, dementia, diabetes, breast cancer and colon cancer (Woodcock et. al, 2009). In general, greenhouse gas reduction is associated with cancer reduction for cancers that also occur with those pollutants. Short-lived climate pollutants (SLCP) are also air pollutants, so there is a positive health impact to reducing them (Portier et. al, 2010).

4. Policy Recommendations

As the above analyses show, there is a strong linkage between climate change and adverse health repercussions. We recommend adapting to the health-related effects of climate change by **combining predictive climate models and epidemiological models to inform health system planning and build a globally resilient healthcare system.** The ability to synthesize climate predictions with epidemiological modeling could have an enormous impact on the capacity of nations and communities to prepare for climate-related health consequences – without it, countries may be unprepared for health crises that are caused, or intensified by, climate change.

This recommendation should utilize existing datasets and expertise, serving to link previously discrete entities. A cross-sectoral consortium of stakeholders would enable the collaboration needed to link climate science and health experts, local and regional experts, and policymakers, to design and implement solutions. A proposed structure for the consortium is illustrated in Figure 2.

The consortium would facilitate necessary collaboration between the WHO, SERVIR, and IPCC. The IPCC was created in 1988 by the World Meteorological Organization (WMO) and the

United Nations Environment Programme (UNEP); it provides governments with scientific information to inform climate policies. The IPCC can provide the climate science expertise and link with emerging modeling from SERVIR. SERVIR is a partnership between the National Aeronautics and Space Administration (NASA) and the U.S. Agency for International Development (USAID) providing satellite-based Earth monitoring, geospatial data, mapping, and predictive models to improve decision making in developing nations. IPCC and SERVIR could apply climate science modeling in collaboration with epidemiologists and health scientists, such as partnering with the WHO to develop health-risk models for regions to inform adaptive policies. These models would be informative, not prescriptive, and provide decision makers with the tools to prepare healthcare sectors and create adaptation plans.

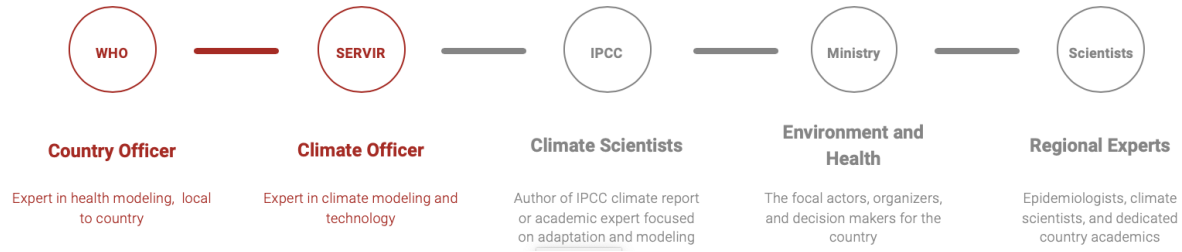


Figure 2: Proposed consortium membership

Intersectoral problems require intersectoral collaboration. Integration of climate and health models is an important first step towards resilient health systems, but collaboration between relevant policymakers and stakeholders is key to successful implementation. The proposed consortium must include policymakers from national environmental and health ministries as well as local climate scientists and epidemiologists, who understand the local contexts intimately, to steer the development of effective and constructive climate-related health models and regional adaptive health system planning. Consortium participants will engage in technical capacity building and sharing of best practices to ensure that nations and communities have the expertise to flexibly develop and adapt climate-related health system adaptation plans. This can improve collaboration within government agencies, across sectors, and within geographical regions.

5. Conclusion

The threats of anthropogenic climate change are felt globally. Changes in air pollution, vector ecology, water quality, food supply, extreme heat, mitigation consequences, and severe weather may all have significant adverse human health impacts. To adapt to the health-related effects of climate change, we recommend combining predictive climate models and epidemiological models to inform health system planning and build a globally resilient healthcare system. A proposed consortium of existing actors such as the WHO, SERVIR, the IPCC, local policymakers from national environmental and health ministries, and local climate scientists and epidemiologists could synthesize climate predictions with epidemiological modeling. This will bolster resiliency in national and local healthcare systems globally, enabling them to adapt to a changing climate.

References

Al Jazeera News (August 2018). *Extreme heat, wildfires and the cost of climate change.* https://www.aljazeera.com/programmes/countingthecost/2018/08/extreme-heat-wildfires-cost-climate-change-180805093739416.html (extreme heat)
C2ES: Extreme Precipitation and Climate Change. (2018, March 29). Retrieved from http://www.c2es.org/content/extreme-precipitation-and-climate-change/

Carleton et al. (2018). Valuing the Global Mortality Consequences of Climate Change Accounting for Adaptation Costs and Benefits. (n.d.). Retrieved from https://epic.uchicago.edu/sites/default/files/CIL_Mortality_Research_Summary_v03.pdf
Climate Impact Lab Report

Crimmins, A., J. Balbus, J.L. Gamble, C.B. Beard, J.E. Bell, D. Dodgen, R.J. Eisen, N. Fann, M.D. Hawkins, S.C. Herring, L. Jantarasami, D.M. Mills, S. Saha, M.C. Sarofim, J. Trtanj, and L. Ziska. (2016). U.S. Global Change Research Program. *The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment*. 312 pp. http://dx.doi.org/10.7930/J0R49NQX

Cruz, E. D. (2018, September 17). Philippine paddy rice losses from typhoon exceed forecasts. Retrieved from https://www.reuters.com/article/us-asia-storm-philippines-rice/philippine-paddy-rice-losses-from-typhoon-exceed-forecasts-idUSKCN1LX03W

Dai, A. (2012). Increasing drought under global warming in observations and models. Nature Climate Change, 3, 52. Retrieved from https://doi.org/10.1038/nclimate1633 (extreme heat) https://www.nature.com/articles/nclimate1633?utm_source=feedblitz&utm_medium=FeedBlitzEmail&utm_content=559845&utm_campaign=0

Fann, Brennan, T., Dolwick, P., Gamble, J., Ilacqua, V., Kolb, L., . . . Ziska, L. (2016, April 04). Ch. 3: Air Quality Impacts. World Health Organization. Retrieved from https://health2016.globalchange.gov/air-quality-impacts

Fisk, W. J. (2015, January 06). Review of some effects of climate change on indoor environmental quality and health and associated no-regrets mitigation measures. Retrieved from https://www.sciencedirect.com/science/article/pii/S0360132314004417?via=ihub

Hess, J. J., Saha, S., Schramm, P. J., Conlon, K. C., Uejio, C. K., & Luber, G. (2015) Projecting Climate-Related Disease Burden. Climate and Health Program, Centers for Disease Control and Prevention, Atlanta, GA, USA.

IPCC, 2018: Summary for Policymakers. In: *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty* [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E.

Lonnoy, Maycock, M. Tignor, and T. Waterfield (eds.)]. *World Meteorological Organization, Geneva, Switzerland, 32 pp.*

Jhun, I. (2014, August 10). Effect modification of ozone-related mortality risks by temperature in 97 US cities. Retrieved from https://www.sciencedirect.com/science/article/pii/S0160412014002141?via=ihub

Killman, W. (2008). Climate Change & Food Security: A Framework Document. Retrieved from http://www.fao.org/forestry/15538-079b31d45081fe9c3dbc6ff34de4807e4.pdf

Luber, G., K. Knowlton, J. Balbus, H. Frumkin, M. Hayden, J. Hess, M. McGeehin, N. Sheats, L. Backer, C. B. Beard, K. L. Ebi, E. Maibach, R. S. Ostfeld, C. Wiedinmyer, E. Zielinski-Gutiérrez, and L. Ziska (2014). Ch. 9: Human Health. Climate Change Impacts in the United States: The Third National Climate Assessment, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 220-256. doi:10.7930/J0PN93H5.

McMichael, A. J. (2013) *Globalization, Climate Change, and Human Health.* The New England Journal of Medicine. 368. P. 1335-1343.

McMichael, A. J., D. H. Campbell-Lendrum, C. F. Corvalán, K. L. Ebi, A. Githeko, J. D. Scheraga, and A. Woodward. (2003) *Climate Change and Human Health - Risks and Responses*. World Health Organization.

"Mortality and burden of disease from water and sanitation," World Health Organization Global Health Observatory, accessed March 2, 2019, https://www.who.int/gho/phe/water_sanitation/burden_text/en/

NCA4: National Climate Assessment- Extreme Weather. (2014). Retrieved from https://nca2014.globalchange.gov/report/our-changing-climate/extreme-weather

Nordhaus, William. *The Climate Casino*. United States of America: Yale University Press, 2015.

Portier CJ, Thigpen Tart K, Carter SR, Dilworth CH, Grambsch AE, Gohlke J, Hess J, Howard SN, Luber G, Lutz JT, Maslak T, Prudent N, Radtke M, Rosenthal JP, Rowles T, Sandifer PA, Scheraga J, Schramm PJ, Strickman D, Trtanj JM, Whung P-Y. (2010). A Human Health Perspective On Climate Change: A Report Outlining the Research Needs on the Human Health Effects of Climate Change. Research Triangle Park, NC:Environmental Health Perspectives/National Institute of Environmental Health Sciences. doi:10.1289/ehp.1002272

Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.) (2018). Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II. U.S. Global Change Research Program, Washington, DC, USA, 1515 pp. doi: 10.7930/NCA4.2018

Spracklen, D. V., Mickley, L. J., Logan, J. A., Hudman, R. C., Yevich, R., Flannigan, M. D., & Westerling, A. L. (2009, October 20). Impacts of climate change from 2000 to 2050 on wildfire

activity and carbonaceous aerosol concentrations in the western United States. Retrieved from https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2008JD010966

Sudarshan, A. (2018). The Impact of Temperature on Productivity and Labor Supply: Evidence from Indian Manufacturing. Retrieved from https://www.anantsudarshan.com/temperature-and-productivity.html, Under Peer Review, Journal of Political Economy

Woodcock, J., et al., Public health benefits of strategies to reduce greenhouse-gas emissions: urban land transport. Lancet, 2009. 374(9705): p. 1930-43.

World Food Programme- Climate Impacts on Food Security. (2019). Retrieved from https://www.wfp.org/climate-change/climate-impacts

Wuebbles, D.J., D.W. Fahey, K.A. Hibbard, D.J. Dokken, B.C. Stewart, and T.K. Maycock. (2017). *Climate Science Special Report: Fourth National Climate Assessment, Volume I* U.S. Global Change Research Program, Washington, DC, USA, 470 pp, doi: 10.7930/J0J964J6.

Environmental Migration:
a Pathway to Climate Resiliency

Sarah Gill, Valeria Vargas, Josh McGhee, Cristián Stewart, and Sarah Claudy

---

1. Abstract

Migration in response to changing weather patterns and natural disasters acts dually as a healthy coping strategy and as a challenging force that exacerbates already extant fragilities and tensions. It is clear that environmental-refugees, of various types and from both voluntary and involuntary migration, already exist in significant numbers around the world. However, distinctions between when this migration is helpful and when it increases inequality and the risks of conflict are more subtle. Looking at examples from Syria, we identify successes and shortfalls in the preparation and response to climate-driven migration. We track the rise of Nationalist Populism in Europe and its links to closed off migration policy and a vicious spiral of lack of integration. As climate-driven disasters, both in the form of natural disasters and slow-onset change, increase in frequency and severity, the need for policy action and international harmonization is ever more urgent. National governments can target their legislation to better enable work by NGOs, local bodies and policy setting agencies at all levels can work to proactively prepare for the specific environmental harms and types of migration that are most likely to affect them. Migration can be a healthy strategy to mitigate the worst of the effects of climate change on human lives, but to ensure that migration today is healthy and does not inadvertently reduce the ability of future migration, careful policy consideration is necessary.

2. Summary

Climate-related migration is a multifaceted issue that encompasses politics, economics, and national security. While it can occur across short distances with lower costs, it has the capacity to span a wide region and cross national borders, creating larger issues. Short term migration is exacerbated by natural disasters, such as hurricanes or tsunamis. However, longer term migration is generally caused by slower developing phenomena, such as droughts. As a result, climate-related migration has different types of effects on certain socio-economic regions. Agrarian practices are heavily affected in developing countries, as there is a reliance on rural livelihood and it is how many households adapt to their region. With climatic uncertainty, countries with weaker institutions may find that as climate alters their yields, their resources become limited if people migrate into other parts of their country. Conversely, resources become less scarce as people move away from developing countries facing uncertainty, creating an economic imbalance.

Through international cooperation and trans-border agreements, legal systems can be set up so that migration is less burdensome on host countries. Additionally, it can relieve the resource

stress on countries who are most affected by climate change. National governments can establish unified ID systems that would make migration a uniform system and would allow incoming immigrants quicker access to safe housing, assist in their to return to work, and help reestablish their children in schools. Lastly, capital allocation and resilience systems can be developed to limit the effects migration may have. Similarly, migration can also have strong impacts on the political climate of the world, instead of being impacted by politics. Migration stress has created political unrest, specifically in the Middle East, and has driven governments toward conflict. Recently, it has been implied that climate-related migration has contributed to the rise in populism amongst EU member states, and further burdened the status of politics in the Middle East. Organizations like IOM, UNHCR, Human Rights Watch, and other governmental organizations can coordinate efforts to harmonize policy on a national level. We suggest that countries look at the trends of the Maldives' inward migration after the 2004 tsunami to understand that governments must have national resiliency plans set up to prepare for climate disasters. Additionally, it is imperative that governments understand the necessity for risk management efforts or humanitarian assistance to address sustainable development practices for increased human mobility. International harmonization of these policies would make migration less burdensome for everyone.

3. Types of Migration

Climate change migration encompasses a variety of different types of migration, which vary in location, duration, and demographic composition. What these modes of migration have in common is that while they are initiated by changes in environmental factors, they are directly triggered by economic determinants. The International Organization for Migration writes, "environmental change is shown to be a trigger for independent migration decisions when livelihoods are negatively affected – e.g., crops are lost, generally on more than one occasion. In such cases, livelihood stress is the direct cause of migration and environmental factors act as the trigger" (IOM, 2009). Other scholars find that temperature has a significant effect on migration, through the mechanisms of decreased agricultural productivity and reduced economic growth (Bohra-Mishra et al, 2013). As such, it can often be difficult to differentiate climate change migration from economic migration, as the two are often inextricably combined.

The type of climate change migration that is least likely to be confounded with economic factors is short distance, temporary, internal migration caused by sudden-onset environmental disasters such as typhoons, hurricanes, extreme temperatures, and flooding (Bohmelt et al, 2013). Sudden natural disasters have the capacity to displace large numbers of people for relatively short periods of time; displaced persons typically return to their homes once the infrastructure has been adequately rebuilt (Brown, 2008). Such hazards displaced over 24 million people around the world in 2016, three times the number of people fleeing conflict (Kellet et al, 2017).

Moreover, as argued by Kellet et al (2017), the types of slow-onset climate-related hazards include drought, desertification, salinization, ocean acidification, glacial retreat and sea-level rise, and changing trends in seasons. Further, slow-onset hazards are more likely to drive people to migration through other mechanisms, such as economic downturns, violence, or lack of adequate government response. As compared to sudden-onset drivers, slow-onset drivers will displace more people permanently, yet in less of a "headline grabbing" way (Brown, 2007). As environmental factors worsen, people might shift from cyclical migration to more permanent migration; on the

other hand, if environmental changes are slow enough and tolerable, populations may choose to adapt to the new conditions rather than migrate (Kellett et al, 2017).

The academic community lacks a coherent theory of potential climate migrants' decision calculus, and instead draw from other segments of migrant decision theory (Koubi and Stoll, 2016). For example, some economists assume that potential climate change migrants compare their individual expected earnings in their place of origin to their expected earnings in potential destinations (Lilleor and Van den Broeck, 2011). Others believe that earning calculations are made for a family as a whole, with options for singular household members to migrate and send back remittances (Kellett et al, 2017). Additionally, the existence of migrant networks and/or a "culture of migration" can contribute to potential migrants' decision process, as well as the factors of political instability and violence (Koubi and Stoll, 2016). Environmental factors, thus, are accounted for in current academic models not as an independent component, but as an additional "stressor" which can decrease potential earnings or increase the risk of violence at the origin site. Furthermore, environmental factors make their way into the costs of migration: individuals develop personal bonds with their home location and leaving it can be both financially and psychologically costly. For this reason, cyclical migration can be less costly than permanent, as in cyclical migration, individuals have the opportunity to return periodically to their original homes (Koubi and Stoll, 2016).

Despite a lack of complete academic consensus regarding the precise motivation behind cyclical migration, it can be loosely described as a repetitive migration pattern in which migrants move from their place of origin when experiencing economic downturns and return to their homes when conditions recover. Cyclical migration often occurs when drought or persistent heat waves reduce agricultural yields, inducing people to move to locations where more crops can be sown or income can be otherwise diversified (Kellett et al, 2017).

4. Case Study: Syria

The origins of the Syrian civil war, which began in March 2011, has brought several streams of migratory processes, both within and towards abroad. Studies in recent years have addressed the causes of this conflict aiming to show whether climate change has anything to do with these migratory processes and to what extent, if anything, it is related to this conflict. All studies that have tackled the Syrian civil war and its relationship with climate change have studied whether a three-step causal argument holds, namely: (i) that climate change anthropogenic emissions were a relevant factor that generated drought suffered in Syria; (ii) that this drought, in turn, catalyzed a large-scale migration within that country; and (iii) that the latter phenomenon was an essential driver in the first unrests that later on became into Syria's civil war (Selby et al., 2017).

Some authors consider that there is enough evidence to confirm that anthropogenic climate change generated migration movements from the countryside to urban cities (in particular, the unprecedented drought in 2006/07 and 2008/09), together with other elements (e.g. World Bank, 2016; Kelley et al., 2015). Others say that there is no evidence to reach that conclusion (Selby et al., 2017). What is out of question regarding the subject, however, is that the human displacement that happened right before the beginning of the civil war is only one of many causes that triggered the civil war.

The extreme drought in Syria that occurred between 2006 and 2010 is one of the worst on record in the area. It affected 60% of the country's territory, with destructive consequences. Agricultural production, a quarter of the country's GDP, fell by a third, cereal prices doubled, and diseases related to child nutrition rose sharply. Around 75% of the peasantry lost their crops, and 85% of the cattle died, disappearing practically from the northeast of the country, the worst hit area. This led to the impoverishment and ruin of around one million three hundred thousand rural people, many of whom were forced to migrate to urban cities due to the government's inability to cope with the situation, as it is explained below. In 2008, rainfall in the north and northeast of Syria fell by 35% compared to the annual average, affecting one of the main streams of the Euphrates River, Jabur, which dried up completely (Kelley et al., 2015). Although Syria is already an arid country, with 68% of its territory at risk of desertification, this drought damaged Syria considerably, impacting on the natural, climatic and biological processes of desertification that were already in process. In addition, other human action-driven problems were added, such as poor management of water resources and soil, which worsened the situation. Drought destroyed rural livelihoods in a country where the agricultural sector employed as much as 40% of the labor force, in addition to representing 25% of gross domestic product (Gamero Rus, 2018). Rainfed areas in the northeast of the country were most affected, with almost 75% of families in the area suffering a total crop loss during the 2007-2008 agricultural season, leading to increased poverty and food insecurity in an already vulnerable and highly agriculturally dependent region. On the other hand, overgrazing and a rapidly growing population further aggravated the process of land desertification. Many families in the region entered a poverty circle, suffering first-hand from the fall in wheat production, which fell by 82% between 2007 and 2008. This fall affected the ability of families to feed themselves, but also led to the depletion of emergency wheat stocks in the country. Likewise, in view of their greater impoverishment and the challenge of satisfying basic needs, families were forced to sell some of their essential assets such as livestock, which led to its devaluation, which reached 70% less than its real price.

The linkage of this drought with climate change is supported by different studies based on the standardized precipitation index, which shows that the forces of climate change have been active in the Mediterranean region for at least a century and that human activity has only exacerbated an existing trend (Gamero Rus, 2018). Further, Kelley et al. (2015) analyze the trends in both temperature and rainfall in the last one hundred years and find that since 1900 the Fertile Crescent area, an area stretching from Egypt through Palestine, Lebanon, Kurdistan, Syria and Iraq to the Persian Gulf, has warmed to between 1 °C and 1,2 °C, and the length of the rainy season has been reduced by around 10%. These findings suggest an anthropogenic influence on temperature and precipitation, being statistically significant (P-value < 0.06, based on a Kolmogorov−Smirnoff test) of the 2006-2010 Syrian drought. Moreover, human influence on this drought is supported by additional theoretical and observational evidence observed by Kelley et al. (2015).

As a result of this climatic but also social and economic disaster, many impoverished families in the area, farmers, pastoralists and rural families, all dependent on agriculture, were forced to abandon their places of origin and seek shelter and employment in urban cities. This was the most direct social consequence: 1.5 million people moved from the Syrian countryside to the boundaries of urban cities (Kelley et al., 2015). Therefore, the agricultural and economic collapse, and the large-scale migration process were caused by a complex combination of factors, including the declining groundwater levels, inefficient irrigation and hydric resources management by the government, population growth, poor governance, and anthropogenic influence (Femia and

Werrell, 2012; Kelley et al., 2015; Selby et al., 2017). Additionally, the implementation of a free market program contributed to the rural migration to cities (al-Hindi, 2011).

The migration generated by all these variables, climate change included, entailed that those families that abandoned their rural cities had to confront and fight for resources with "local poverty". In fact, the already overcrowded Syrian cities plunged into an economic depression, lack of resources and increasingly deficient infrastructure, saw the arrival of new masses of impoverished people struggling for water, food, and scarce employment opportunities. The government's inability to meet the needs of the population, its totalitarian character unable to expand frameworks for action towards a more democratic and participatory models of decision-making, led to widespread social discontent, both rural and urban. In this context, some authors reinforce the role of the disaffected rural communities as a trigger of the conflict, which emphasizes the role of the rural communities in the protests against the government, compared with other countries of the region during the "Arab spring" (Gamero Rus, 2018).

Selby et al. (2017) refute Kelley et al.'s perspective, criticizing the theory that migration from the countryside to cities were due to anthropogenic climate change, and that migration from the northeast were significant for the unrest that catalyzed the civil war. They do not doubt whether there is enough evidence of a link between drought and migration, but rather if this bonding was of the importance and scale claimed by Kelley et al. (2015).

Neither critics nor supporters of the climate change-driven migration theory believe that droughts were the only causes of the Syrian civil war. Notwithstanding that, and beyond to what extent migration is due to climate change, the existing arguments and the evidence shown so far are conclusive enough to be a starting point for us to understand that climate change-driven migration brings problems that were impossible to imagine years ago.

5. Migration Influencing Politics

Far-right Populist parties have been gaining support in Europe. These parties characteristically espouse distrust of globalization and elites, including a disdain for immigration. While the success of these parties to pass legislation has been limited (see Schein 2018), their support has resulted in bleed over of ideology into other, more legislatively effective parties and they have had some success in passing measures that limit immigrant integration into host nation society. These findings are concerning, as migration is predicted to continue to rise as the effects of climate change are increasingly felt. If this migration is, causally linked to the success of far-right Populist parties, their presence may have a destabilizing effect on the host nation and result in diminishing capacity or willingness to house and integrate additional migrants.

Gaining Support:

Many factors, both global and local, contribute to this political movement, however immigration plays a significant role. Increases in globalization, perceived insecurity and income inequality (and specifics around these such as erosion of labor-market protections and changes in technology) have been cited as factors in the recent rise of far-right Populism (Guiso et al. 2018, Rodrik 2018). A differentiating factor of far-right Populism from the left-leaning variety seen largely in South and Central America is a mobilizing along ethno-national and cultural cleavages

(Rodrik 2018). This mobilization may be facilitated by the presence of groups who are perceived to be different or an out-group, increasing the salience of individual's own racial and ethnic identities (see Blumer 1958). Migrants, immigrants, and refugees often fit well into this category of "other."

The gain in support of far-right parties in Europe, has been linked to increases in immigration, with a trend having been established on national and multinational levels. In their 2017 study of 14 European nations Davis and Deole found a significant, positive relationship between immigrants as a share of total population and propensity to vote for far-right candidates or parties. This relationship was mediated by several factors including individual level of education (with less educated individuals being more sensitive to changes in immigration), level of cultural cohesion before the immigration (with nations who felt stronger cultural ties or valued their natural culture more highly being more sensitive to changes in immigration), and level of unemployment (with nations facing higher unemployment being more sensitive to changes in immigration). These findings are reinforced by Guiso et al. (2018), who also propose a mechanism between economic insecurity and anti-immigrant sentiment, via the relationship between national GDP and distrust of others. However, economic insecurity need not be present for the relationship between immigration and far-right votership to hold as Iacono (2018) discusses in his overview of the shift in Swedish politics. Much of the anxiety there has been around integration and the stability of the welfare state. This anxiety is despite the toll of immigration so far and in projections not imposing a threat to Sweden's fiscal stability (Iacono, 2018). Another promising mechanism is via cultural anxiety. Hainmueller and Hopkins (2014), demonstrate a significant connection between attitudes towards immigrants and anxiety around cultural change in Western Europe. However, even this is inadequate to explain all of the effect.

Even transient exposure to refugees has been shown to significantly affect individual attitudes and propensity to support far-right parties. As Hangartner et al. found in their 2018 analysis of a natural experiment in the Aegean Sea, microeconomic explanations of cultural and economic impact are inadequate to explain the effect of immigration on political views. The researchers took advantage of geographical difference in the Greek islands (distance from Turkey) and the influx of refugees between 2015 and the 2016 agreement between the European Union and Turkey which effectively closed this migration route. Some Greek islands in the Aegean Sea received two to four refugees per capita, in transit as they crossed from Turkey to mainland Europe, while other islands (by nature of distance from Turkey) received zero refuges. Prior to the exposure, the residents of these islands did not significantly differ on demographic characteristics (including political orientation). After exposure the difference in political views on immigration between exposed and unexposed islands was equivalent to the difference between the second most restrictive European nation and the second most liberal European nation. Residents exposed to refuges in transit demonstrated a significant increase in hostility, not only towards Syrian refugees, but also towards immigrants in general and Muslim residents of Greece (who have been a significant minority in Greece for centuries). After exposure, residents who were previously moderate and left leaning as well as those who were previously extremist and right leaning were more likely to vote for the far-right party in the next election. Exposed residents were more likely to believe that refuge children should not be allowed into Aegean schools and less likely to support Muslim representation in the Greek parliament. These findings are especially striking because refugees passing through these islands exited within 24 hours, and most continued their journey out of Greece. The representation of the long-standing Muslim population in the Greek parliament should be unrelated to temporary exposure to Muslim refugees and no refuge children were

actually being sent to Aegean schools. This transit of refuges posed no cultural or economic threat to the island residents and caused nothing greater than a temporary inconvenience to daily life. Nevertheless, this exposure was enough to significantly impact individual political and personal views, with hostility growing proportional to number of arrivals. These effects were not short lived, the final survey and interviews were carried out 12 months after the closing of this rout.

Limited Policy Success:

Despite swelling support, far-right Populist parties have had limited success in changing immigration policy. Schain (2018) explains part of this failure as a result from intra-party politics such as far-right Populists being largely kept out of ruling coalitions. Further, Schain has noted a propensity for these extremist parties to either split or moderate over time, especially when they have gained access to ruling coalitions. However, this extremist movement should not be expected to dissipate on its own or without notable policy effects.

Far-right Populists have had notable successes in immigration policy, on matters of integration and selection of immigrants. As Lutz (2019) shows in their study of Western European countries from 1990 to 2014, far-right Populist parties have had significant success in limiting migrant rights and freedoms. When far-right Populist parties are allowed to be part of the government they have been able to pass policy restricting migrant integration into society. This capability has been attributed to the contagion of the far-right parties having a much greater effect on mainstream right parties on the more political dimension of minority and migrant integration than on the more global-economic dimension of actual immigration numbers.
Furthermore, while Lutz shows that these parties had no significant successes in limiting actual numbers of immigrants, during the period studied, they had success in making immigration more selective. Policy was shifted to favor economic and labor migrants over full family and humanitarian migration.

Finally, as Schain (2018) and Guiso et al. (2018) both note, the rise and political success of far-right Populist movements has had a contagion effect on other more mainstream parties. These mainstream parties have faced electoral pressure to address far-right core issues such as immigration. While Lutz (2019) demonstrated that as of 2014 this contagion had only reached policies that were more political in nature and individual to a nation (such as integration policy), rather than policy that is also directly informed by global and economic forces (such as immigration numbers), this may not hold over time. Another mainstay of far-right Populist ideology is Nationalism, which has recently encompassed a kind of anti-globalism in many parties. If these parties have success in reducing the influence of globalization in their nation and their nation's role in the global community, then broader issues of immigration may become much more flexible and vulnerable. Despite limited success so far in actually decreasing immigration, far-right Populist successes in limiting rights and freedoms of immigrants, the contagion of their ideology to other parties and overall the psycho-political effects on host and pass-through nations are reason for concern.

Decreased Willingness for Further Immigration:

The hardening of nations against migration can be expected to hinder the possibility for current migrants to find stability and prosperity and inhibit the prospects for future healthy migration. The success of migration as a coping strategy in response to climate change depends

largely on the accessibility of economic opportunity abroad. If access to this opportunity is shut off, it will harm host nations, sending nations, and migrants. Host nations may miss out on the economic benefits of immigration in the labor force (e.g. see OECD 2014 and World Bank 2006). Migrants and sending nations will miss out on the stimulus of remittances from workers abroad, and the ability to temporarily or permanently flee environmental disasters and large-scale or entire region impacts of climate change such as changing weather patterns. Due to the mediating effect of economic stability and education, it is possible that the concerning link between immigration and support of anti-immigrant political groups can be diminished through non-migrant pathways. However, this link should be considered when crafting proactive and reactive immigration policies.

6. Recommendations

We believe Temporary Circular Migration is an ideal program to fill shortages of labor supply in host countries and address excess labor demand in the other country. A program under this rationale is believed to be successful in the case of Colombia and Spain (Zapata-Barrero, et. al, 2012). The program has been running since the 1990's under different names and started being a bilateral agreement between the two countries, and in later years other organizations also helped them in the logistics (Rinke, 2011). The program is considered a triple win because the government of Colombia is able to fulfill the excess labor supply in times of extreme rains caused by climate change, specifically la nina; the government of Spain is able to fill labor supply shortages on the agriculture sector; and the Colombian farmers have jobs year-round without having to change industries for the periods of rain. Additionally, there is an increase of remittances in Colombia, which encourages the transfer of the know-how in both countries.

The second policy reform we believe is necessary, is the need for harmonization of definitions and relevant policies internationally that can be implemented nationally as well as sub-nationally. For instance, there should be a standardized identification requirement across all countries to legally accept climate change refugees with positive consequences that are twofold. From the receiving country's perspective, it will avoid putting all the stress and weight on only a few countries and governments who are more sympathetic with the cause. Moreover, from the refugee's point of view, it will ease the process to know what they need in order to legally become a resident, while also speeding up their process of integration back into society. Furthermore, we have the cases of Peru and Argentina, that had no specific laws to host refugees of the type of crisis that Venezuela is currently going through; however, both governments adapted and changed their policies to be able to accept the refugees legally allowing them access to the formal market. Even though these refugees are not due to climate change, policy flexibility is needed and it needs to be harmonized internationally to allow for longer term migration due to climate change.

Lastly, each country needs to have a national plan for integration when receiving city or country immigrants. In many current cases we have seen how due to the failure of immigrants to integrate into the receiving society, tensions between the incoming and receiving citizens arise. Furthermore, each government should have national and subnational plans to provide basic education, health care, and job market opportunities for the incoming population. In line with this, long term plans need to start being implementing as well, from the right infrastructure investment to foster incoming populations to investing in the right infrastructure to avoid complete collapse in the more vulnerable areas to climate change shocks. The Maldives is an excellent example of policy measures to be taken when a national plan is not in place. Even though they had reactive

policy measures, they were able to somewhat successfully recover after the tsunami of 2004.

7. Responsible Organizations

There are many organizations that are already helping facilitate types of migration due to climate change, and among the top in terms of operational and on-the-ground support are the International Organization for Migration (IOM), the United Nations/ UN High Commissioner for Refugees (UNHCR) and Mercy Corps. In terms of prioritizing research and policy advocacy for environmental migration for policy makers, there are the Human Rights Watch, the Wilson Center and Amnesty International. Moreover, the national governments also play a crucial role on all the developments and progress that has been done on this matter. We believe coordination and efficiency gains between these organizations are crucial to continuing and improving the work that is already being done by these organizations.

Specifically, we see a need for national and international laws and agreements to be in line with each other. In other words, international agreements need to be respected in all countries, so they can be lawfully enforced upon all. Additionally, it is imperative for national governments to have plans in place in case of extenuating circumstances. For example, after the 2004 Great Indian Ocean Tsunami, the government of the Maldives swiftly created a task force to establish a National Disaster Monitoring Centre (NDMC) to handle the relief efforts, including providing services for Internally Displaced Persons. Instead of creating ad hoc agencies to help fix things after the fact, governments can benefit from a proactive planning stance that would save time and create efficient responses to natural disasters that could create the possibility of forced migration. The Maldives struggled to gain legal authority for such preparations, as their Disaster Management Bill was not passed until 2015, a decade after the disaster. However, in that time, the NDMC had created a National Emergency Operations Plan, which provided a toolkit for disaster relief in terms of handling the migration of Internally Displaced Persons. Legal reforms for improved governance can boost efficiency in the case of natural disasters and save time when there is a need for migration due to climate change-related natural disasters.

8. Feasibility and Challenges of Migration Recommendations

As nations across the globe begin to harmonize their approaches to handling migration, very realistic challenges to handling the complexity of the situation are realized. In the discussion about decreased willingness for further immigration, sustainable migrant integration into host societies may become increasingly difficult. In the event that a link between immigration and support of anti-immigrant policies does exist, the acknowledgement of diversity will become increasingly difficult in countries that may be welcoming said immigrants. Many indigenous citizens are reluctant to change from outside influences, especially in rural communities where labor can be more limited than urban communities (Lutz, 2019). The ability of host countries to successfully integrate incoming migrants will be a big challenge for all policymakers, as they must be able to accommodate their constituents but also make immigrants feel welcome and a part of the new society.

The notion of harmonizing current policies on a global scale requires oversight on an international level. Currently, the UN has an agreed upon Global Compact for Migration that was

made effective and updated in 2018. Much of its text is based on the UN Declaration of Human Rights and other staples of migration policy (UN, 2018). The Compact recognizes that there needs to be shared responsibility and cooperation that addresses the struggles and risks for the communities and individuals that are most unstable in the newer era of migration. Additionally, it "aims to mitigate the adverse drivers and structural factors that hinder people from building and maintaining sustainable livelihoods in their countries of origin, and so compel them to seek a future elsewhere" (UN, 2018). While this goal is idealistic, it clearly addresses the fact that there are structural factors that may hinder quick and healthy migration practices. Many recommendations that can be made must be upheld by the UN, specifically by this document through an annual updating system. However, the UN needs the ability to ensure that subnational governments will uphold any promises that they make regarding migration. These structural differences may cause a backlash in the migration process and could delay the development of a harmonized international plan.

While it will take time to create an international plan to attack the problems that face migration, many countries may push back on the reasoning that people must migrate in the first place. Experts across the world mostly agree that a rapidly changing environment is one of many reasons why people migrate, but they differ in their approach to the idea. According to Brown (2008), there are "alarmists" and "sceptics". Alarmists see the environment as the primary cause for population displacement, emphasizing natural disasters that create refugees. However, the term refugee can be sensitively applied, as it is often an institutional displacement caused by lack of proper infrastructure or government support. Thus, sceptics have raised questions about models that are used to estimate who really needs to be forced to migrate, rather than the positive pull factors from more luxurious countries (Laczko). This creates a controversy in the ability to dissect climate change-related factors from other migration factors, such as economic relief or domestic conflict (as seen in the Middle East). By categorizing the reasons why people migrate, potential host countries have the ability to delay, if they want, immigrants from coming to their countries. For instance, a country could potentially say that they will only accept immigrants if a natural disaster has immediately torn apart their community, not an impending, long term climate issue. Until there is a uniform decision-making process about why people must move to new countries, there will most likely be pushback from host countries that have limited space.

References

Bohra-Mishraa, P., Oppenheimera, M., Hsiangc, S. (2014) Nonlinear permanent migration response to climatic variations but minimal response to disasters. National Academy of Sciences.

Blumer, H. (1958). Race Prejudice as a Sense of Group Position. *The Pacific Sociological Review*, *1*(1), 3. https://doi-org.proxy.uchicago.edu/10.2307/1388607

Davis, L., & Deole, S. S. (2017). Immigration and the Rise of Far-Right Parties in Europe. CES*ifo DICE Report*, *15*(4), 10–15.

Gamero, J. (2018). Cambio climático, migración, conflicto y pobreza: el caso de Siria. Universidad Carlos III, Madrid.

Guiso, L., Herrera, H., Morelli, M., Sonno, T. (2018). Populism: Demand and Supply. Manuscript submitted for publication. Retrieved from http://www.heliosherrera.com

Hangartner, D., Dinas, E., Marbach, M., Matakos, K., & Xefteris, D. (2018). Does Exposure to the Refugee Crisis Make Natives More Hostile? *American Political Science Review*, *113*(2), 442–455. https://doi.org/10.1017/S0003055418000813

Hainmueller, J., & Hopkins, D. J. (2014). Public Attitudes Toward Immigration. *Annual Review of Political Science, 17*, 225–249. https://doi.org/10.1146/annurev-polisci-102512-194818

International Organization for Migration (2009) Migration, Environment and Climate Change: Assessing the evidence

Kelley, P., Mohtadib, S., Canec, M., Seagerc, R., & Yochanan, K. (2015). Climate change in the Fertile Crescent and implications of the recent Syrian drought. PNAS.

Kellet J., Nadin, R., Stapleton, S., and Watson, C. (2017) Climate change, migration and Displacement: The need for a risk-informed and coherent approach. Evidence Ideas Change (ODI)

Koubi, V,. Stoll, S., and Spilker, G. (2016). Perceptions of environmental change and migration decisions. Climatic Change. 138. 10.1007/s10584-016-1767-1.

Iacono, R. (2018). The Rise of the Radical Right in Scandinavia. Retrieved from the Institute for New Economic Thinking website: https://www.ineteconomics.org/perspectives/blog/the-rise-of-the-radical-right-in-scandinavia

Laczko, F., & Aghazarm, C. (n.d.). *Migration, Environment and Climate Change: Assessing the Evidence* (Rep.). International Organization for Migration.

Lutz, P. (2019). Variation in policy success: radical right populism and migration policy. *West European Politics*, *42*(3), 517–544. https://doi-org.proxy.uchicago.edu/10.1080/01402382.2018.1504509

OECD (2014). Is migration good for the economy? *Migration Policy Debates.*Paris: OECD Publishing. Retrieved from https://www.oecd.org/migration/OECD%20Migration%20Policy%20Debates%20Numero%202.pdf

Rinke, Tatiana. (2011) Temporary and Circular labor migration between Spain and Colombia. The state of Environmental Migration

Rodrik, D. (2018). Populism and the economics of globalization. *Journal of International Business Policy : JIBP*, *1*(1/2), 12–33. https://doi-org.proxy.uchicago.edu/10.1057/s42214-018-0001-4

Schain, M. A. (2018). *Shifting Tides: Radical-Right Populism and Immigration Policy in Europe and the United States.*Washington, DC: Migration Policy Institute.

Selby, J., Dahi, O., Fröhlich, C., & Hulme, M. (2017). Climate change and the Syrian civil war revisited. Political Geography.

World Bank (2006). The Potential Gains from International Migration. *Global Economic Prospects 2006.* 25-55. Retrieved from http://documents.worldbank.org/curated/en/507301468142196936/841401968_20051031 90201050/additional/343200GEP02006.pdf

Zapata-Barrero, R., Faundez Garcia, R., & Sanchez Montijano, E. (2012). *Circular Temporary Labour Migration: Reassessing Established Public Policies*(Vol. 2012, Ser. 498158, Rep.). Hindawi Publishing Corporation. doi:10.1155/2012/498158

Appendix I Agenda

Inter-Policy School Summit 2019
Climate Change and National Security
Agenda

INTER-POLICY SCHOOL SUMMIT at Harris Public Policy

March 1st-3rd, 2019
The University of Chicago Harris School of Public Policy

THE UNIVERSITY OF CHICAGO Harris Public Policy

THE ASPEN INSTITUTE ENERGY & ENVIRONMENT PROGRAM

THE PEARSON INSTITUTE FOR THE STUDY AND RESOLUTION OF GLOBAL CONFLICTS

EPIC | ENERGY POLICY INSTITUTE AT THE UNIVERSITY OF CHICAGO

GC GRADUATE COUNCIL THE UNIVERSITY OF CHICAGO

HSG

FRANCE CHICAGO CENTER

Career Development Office HARRIS SCHOOL OF PUBLIC POLICY THE UNIVERSITY OF CHICAGO

Friday, March 1st, 2019: Harris Family Forum at the Keller Center

1307 E 60th St, Chicago, IL 60637

5:00 – 5:30 PM	**Registration**
5:30 – 5:40 PM	**Opening Remarks** Introduction: Luis Gonzales Carrasco Speaker: Katherine Baicker, Dean of the Harris School of Public Policy
5:40 – 6:05 PM	**Keynote Remarks: A Climate for Security** Introduction: Sid Ramakrishna Speaker: Sharon Burke, New America Foundation
6:10 – 7:00 PM	**Panel Discussion** Discussants: Sharon Burke, New America Foundation Amir Jina, University of Chicago Bob Rosner, University of Chicago Marilyn Shapley, Mercy Corps Moderator: Greg Gershuny
7:00 – 8:30 PM	**Dinner and reception** (Sky Suite, 4th Floor of the Keller Center)

Saturday, March 2nd, 2019: Sky Suite at the Keller Center

1307 E 60th St, Chicago, IL 60637

8:00 - 9:00 AM	*Breakfast & Coffee*
9:00 - 10:45 AM	**Session I** (Sky Suite) Participants will divide into groups representing one of six impact areas: Health, Agriculture, Labor, Energy, Conflict/Migration, Coastal Groups will address the following questions: i. Identify the concrete impacts in each assigned issue area. The impacts may include socioeconomic, political, and/or environmental. ii. Identify organizations that play a role or should play a role in responding to the impacts, from National/Local Government, Intergovernmental Organization, International/Domestic Nongovernmental Organization to Private Sector. iii. Identify and provide additional data needed for these analyses.
10:45 - 11:00 AM	**Coffee Break**
11:00 – 12:30 PM	**Session 1** (Continued)
12:30 - 1:30 PM	*Lunch*
1:30 - 3:30 PM	**Session II** (Breakout Rooms) Groups will summarize the impacts, responsible organizations, and data for discussion on the March 3.
3:20 - 3:40 PM	**Coffee Break**
3:40 - 5:30 PM	**Session II** (Continued)
6:00 - 7:30 PM	*Dinner Reception*

Sunday, March 3rd, 2019: Sky Suite at the Keller Center

1307 E 60th St, Chicago, IL 60637

8:00 - 9:00 AM	*Breakfast & Coffee*
9:00 - 11:00 AM	**Roundtable Discussion** Moderator: Greg Gershuny Each group will present a 5-minute summary of their findings to date and then the whole group will discuss.
11:00 – 12:30 PM	**Session III** Participants will divide into their groups from the day before, and analyze the following questions: i. Are the responsible organizations identified in Session I common across different impact areas? What are their tradeoffs or positive spill overs between different issue areas? ii. What reforms or policies should be considered to address the challenges presented by the impacts? iii. Are these policies feasible/realistic? How would they be financed? How should resources be allocated to implement the policies? Are there any legal risks or concerns? iv. Which stakeholders would be involved in carrying out these policies? What is the best evaluation mechanism to ensure accountability?
12:30 - 1:30 PM	*Lunch*
1:30 - 2:30 PM:	**Session IV** Participants Finalize Presentations and Results.
2:30 - 4:30 PM	**Final Presentations**
4:30 - 5:00 PM	**Closing Remarks by Co-Executive Directors**

Appendix II
Participants & Members of the Executive Board

Participants

Team Agriculture

Parth Khare	University of Chicago
Bibind Vasu	University of Chicago
Naelle Verniest	Sciences Po
Smiti Yadav	Sciences Po

Team Coastal

Ammara Ansari	University of Michigan
Kristopher Eclarino	University of California - Los Angeles
Marcelo Mautone	University of Technology of Uruguay UTEC
Shannon McEwen	University of Chicago
Emma Sperry	University of Chicago

Team Conflict

Cathy Chen	Yale University
Benrey Rodriguez, Laura	University of Chicago
Dan Misch	University of Chicago
Gonzalo Pons	University of Chicago
Sagatom Saha	Princeton University

Team Energy

Kat Burnham	University of Chicago

Lucia Chuquillanqui	Syracuse University
Wojciech Krawczyk	University of Maryland
Wenjia Ma	University of Chicago
Alexander Nassikas	Yale University
Guy Packard	University of Michigan - Ann Arbor

Team Health

Trevor Dean Arnold	University of Chicago
Gregory Boudreaux	Michigan State University
Matthew Burnett	Yale University
Kathleen Kirsch	University of California - Berkeley
Charlotte Hough	New York University

Team Labor

Simran Handa	Carnegie Mellon University
Iqra Nasir	University of Michigan - Ann Arbor
Ellie Price	University of Chicago
Allison VonBorstel	University of Chicago
Jordan Weiszhaar	University of Chicago

Team Migration

Sarah Claudy	University of Chicago
Sarah Gill	University of Chicago
Joshua McGhee	University of Maryland

Cristian Stewart	London School of Economics and Political Science
Valeria Vargas Sejas	University of Chicago

Partners: Aspen Institute's Energy & Environmental Program

Greg Gershuny	Interim Director - Energy and Environment Program
Kate Henjum	Program Associate - Energy & Environment Program
Anna Giorgi	Assistant Director - Energy & Environment program

University of Chicago IPSS Board Members

Adam McGriffin	Advisor
Luis E Gonzales	Co-Executive Director
Sid Ramakrishna	Co-Executive Director
Jonathan Torres	Vice President of Budgeting & Fundraising
Stephen Crano	Coordinator of Budgeting & Fundraising
Eliana Yun	Coordinator of Budgeting & Fundraising
Jennifer Boughton	Vice President of Logistics and Event Management
Analiese Wagner	Coordinator of Logistics and Event Management
Belen Michel Torino	Coordinator of Logistics and Event Management
Wanyu Sun	Vice President of Applications and Program Content
Mahmoud Abouelnaga	Coordinator of Applications and Program Content
Takahiro Minami	Coordinator of Applications and Program Content
Nicolás de la Maza Greene	Vice President of Communications and Marketing
Kimberly Brown	Coordinator of Communications and Marketing
Katy Koon	Coordinator of Communications and Marketing