Facing the Future: Leveraging Punjabi Social Networks to Grow a Sustainable Tomorrow

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Introduction

Agriculture feeds our global economy. By contributing to the global food supply and supporting the livelihoods for an ocean of small farmers, both predominantly agrarian and service-based economies rely on the success of agriculture. However, climate change threatens to exacerbate pre-existing challenges relating to water shortages and crop viability. As the climate continues to change, small-scale farmers - that we are defining in this project as those owning less than two hectares of land - will be adversely affected due to their smaller capacity to absorb costs incurred from crop failure. Therefore, it is vital that the agricultural industry is prepared for the challenges posed by climate change.
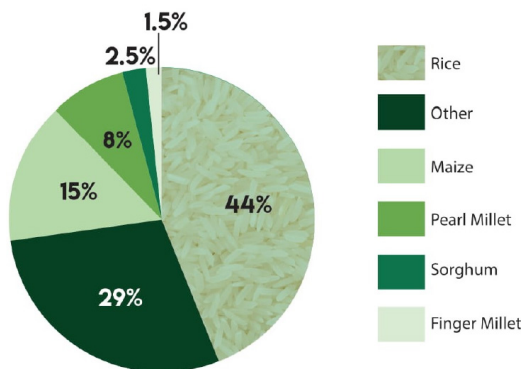
Agriculture in India

India is poised to suffer from climate change: its agricultural sector provides employment for 43% of the country's workforce[1] and accounts for 56% of the country's landmass.[2] Nearly three-quarters of Indian families depend upon rural incomes.[3] The agricultural sector in India has progressively declined to about 17% of the economy, due to the burgeoning industrial and service sectors. A report on The Economic Lives of Smallholder Farmers states[4] that over 65% of the Indian population continue to rely on the rain-fed, small-holder agriculture lifestyle to sustain their livelihoods.

Agriculture & The Climate

There are more than 600 million people in India, nearly twice the population of the United States, suffering from acute water shortages.[5] By 2030, a projected 500 million

people will not have access to safe drinking water. Furthermore, with 80% of India's fresh water supply being used for farming,[6] India's agricultural industry uses more water than China and the United States combined.[7]

The Indian agricultural sector is particularly sensitive to the effects of climate change. Rice accounts for 44% of India's annual grain production and is likely to have drastic decreases in yields as climate change increases the frequencies of droughts in the region.[8] Even by conservative estimates, crop yields could be reduced by 30% in Central and South Asia in the next 20-40 years.[9] A report by the Intergovernmental Panel on Climate Change (IPCC) in 2014 concurs that a decrease of up to 2% per decade in core yields of staple crops like maize, wheat, and rice should be expected.[10] Since wheat and rice alone composed 85% of India's grain output as of 2011,[11] India is likely to feel the drastic effects of climate change.

Punjab, the Granary of India

Punjab's Agricultural History

Punjab is known today as the 'Granary of India,' producing 20% of India's wheat and 9% of its rice; and 2% and 1% of the world's wheat and rice respectively as of 2020.[12] However, this was not always the case: from 1947-1960, the food production yield in India was so poor that it resulted in famine risks. In 1968, Punjab became a part of the Green Revolution, making use of technologies such as genetically improved wheat and rice seeds that allowed for faster harvest with higher yields.[13]

Despite this, the modernization of India has not positively impacted the GDP of the agriculture sector. In fact, since the Green Revolution, the GDP% of the agricultural sector has decreased from 40% since its levels in the early 1970s.[14] Recently, the Indian government has attempted to repeal some laws enacted during the Green Revolution era. In September 2020, the ruling party BJP (Bharatiya Janata Party) enacted three reforms:

1. First Act - creating free, unregulated trade spaces outside mandis (traditional mediatory markets between the farmers and consumers)

Figure 1: India Crop Distribution by Yield %

Pie chart legend:
- Rice — 44%
- Other — 29%
- Maize — 15%
- Pearl Millet — 8%
- Sorghum — 2.5%
- Finger Millet — 1.5%

2. Second Act - creating framework for contract farming deals so that business deals would be strictly between farmers and traders

3. Third Act - eliminates storage limits previously set by the government to control prices

The first act would take away the farmer's ability to rely on a reasonable market price, the second leaves farmers vulnerable to bad deals by big corporations, and the third leaves farmers vulnerable to high storage prices.[15] These reforms were met by a protest of over 200,000 farmers demanding the repeal of the laws.[16]

One long lasting benefit Punjab has seen due to the Green Revolution has been the introduction of agricultural technology to the region. A 2017 survey in Punjab found 98% of farmers possessed their own mobile phones. Farmers in Punjab regularly use mobile phones and internet data regularly in both personal lives and agricultural productivity.[17]

Punjabi Farmer-State Distrust

The distrust between farmers and the state is evident from extended farmer protests and farmer suicides. A main cause for farmer suicides is the financial pressures from crippling debt due to the increasing costs of farming despite its stagnant revenue. The numbers for these suicides are inconsistent because of the government's refusal to acknowledge the statistics.[18] For instance, an article by Times of India reported in 2011 that the Punjab police reported only seven farmer suicides between the years of 2002-2006 while a study by MASR (Movement Against State Repression) estimated at least 20,000 deaths from 1988-2008.[19]

The loss of the lives of these farmers are obviously devastating in themselves, but there is also a gendered dimension to the impact where the surviving family members are predominantly female and are forced to become the sole supporter of the family. Unfortunately, because of existing gender roles, women of Punjab are often less educated than the men and therefore unable to find alternative sources of income to pay off the debt left to them. In desperation, widows are forced to choose between remarrying in an attempt to pay off debts or leaving the family altogether. While the issue of agrarian debt itself does not result in gender biases, it does exacerbate them as daughters are increasingly seen as a burden to the family.[20]

Selecting Punjab as a Case Study

A majority of the farmers from the 2020-21 farmers' protest are from Punjab, which is not surprising considering the infrastructure of Punjab's agrarian sector. Despite its fertile soil and high yield, Punjab's farmers make up only a third of the state's GDP -- a dramatic decline from its 50% share in the 1960s.[21] Given this history, Punjab is an excellent model of a state that was quickly modernized and the risks that come attached.

Aside from the generally low GDP, most of the state's farmers are marginal, small holder farmers. A survey by Chatterjee in 2019 showed that 29% of Hoshiarpur, Punjab's farmers owned less than 1 Ha of land while 27% owned 1-2 Ha of land. This survey is consistent with an earlier 2010-11 Agriculture Census that showed the same numbers for the state of Punjab at large.[22] This makes them ideal for a case study, as small holder farmers are most vulnerable in the face of economic or environmental changes.

One example of India's successful attempt to disseminate information to help farmers anticipate these changes is through television. In 2015, the Prime Minister of India launched "DD Kisan," a television channel dedicated specifically for agricultural news in an attempt to disseminate information to farmers.[23] The launch was promised as part of the Bharatiya Janata Party (India's nationalist and social conservatives political party) campaign prior to the 2014 election and was brought to fruition a year later. Running 24 hours a day, the channel focuses on sharing information such as new farming techniques, water conservation, and organic farming, changing weather conditions and pest and crop disease control techniques. A study by Upadhyay et al. in 2018 consisting of 125 DD Kisan viewing farmers showed that DD Kisan viewers were likely to report high levels of knowledge and medium levels of adoption.[24] Despite overall national-level success, there have not been studies on the levels of success across different states.

Punjab's Demographics

To increase farmer-state trust, it is important to tailor solutions to the needs of different farmer constituents. By exploring the demography of Punjab, the state would be able to disseminate information in a more efficient way across various states, thereby increasing trust as a result. In India specifically, the farming demographic is growing increasingly resistant to change. One critical driver is India's rapidly aging farming

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population. The current trend of agriculture in India suggests that the rural population is decreasing its growth, increasing the average age, and decreasing literacy.

According to the 15th National census survey conducted by the Census Organization of India in 2011, around 63% of Punjab's population live in rural areas. Today, the rural population of Punjab has a growth rate of 7.75%, which trails behind the urban growth rate of 26%. Additionally, children compromise only 11% of the rural population of Punjab.[25] An IZA report quantifies this problem, noting that the rate of individuals in India aged 60 and over is growing at three times higher than that of the general population.[26] Additionally, a UNFPA report notes that the majority of workers are in the 60 to 69 age group with 80% of them being the main workers on their farms.[27] Therefore, as the country continues to rapidly industrialize, younger people are increasingly leaving the countryside to seek employment, leaving the elderly to self-sustain.

For the population that remains in Punjab's rural sector, 69% of their households remain un-matriculated. Specifically, 90% of agricultural labour households are un-matriculated.[28] Although the 2011 Census reports that literacy rates in the rural sectors of Punjab is 75% and increasing, another study recorded "a mean academic score below 40%" and an insignificant difference between Private and Public School performance.[29] Low performance at the basic level of education effectively reduces access to higher education which is already halting due to economic in-accessibility.[30] Therefore, without access to quality education, the possibility of upward mobility in rural communities of Punjab significantly diminishes. Amongst several, a notable consequence of limited education in rural Punjab is that the population enters the labor force before completing matriculation or pursuing higher education.[31] Thus, the replacement generation of the agricultural population of Punjab lacks a basic level of education.

Rural Punjab's increasingly old and uneducated population is creating a demographic landscape that potentially drives agricultural growth levels down. A study conducted in 2019 by The Bulletin of Education and Research reported that in Punjab, younger people utilize computer based technologies more than senior individuals.[32] However, younger individual's affinity to adopt technology is significantly affected by their level of education. As reported by The University of British Columbia, many studies have found that there is a positive correlation between an individual's level of education and their rate of tech adoption.[33] Similarly, Olumide, Richard, Folake, and Kaka, found that age as well as level of education significantly influence an older person's attitude toward perceived usefulness and perceived ease of use of technology.[34]

A study in the Indian Research Journal of Extension Education complemented the implications of the aging and increasingly pessimistic demographics mentioned above, finding that old farmers in India tend to be very strict in following their traditional beliefs and indigenous knowledge system and do not rely on new sources of information.[35] As of 2014, over 60% of farmers in Punjab who had access to internet information were not using internet-related sources for agricultural purposes.[36] Part of the reason was that Indian farmers prefer interpersonal customer relations through cell phone and in-person mediums.[37] The preference for interpersonal sources of information is psychological and seen empirically around the world; especially when farmers grow up used to information being traditionally exchanged through in-person formats, farmers struggle to transition to nameless, virtual providers like robocallers and automated redirected messages.[38] Farmers instead utilize forms of communication that build off trust. Inter-personal information is particularly important in states with high levels of distrust toward the government, as is the case with Punjab. An article in the Journal of Workplace Learning notes that "community-level social learning is often a coping mechanism against the prevailing limitations of the formal system and a response to deepening social, political and epistemic inequalities of their existing systems."[39]

Social-Network Based Policy in Punjab

The continued importance of interpersonal relationships in Punjab farmers' adoption of technology leads us to a policy approach that leverages farmer's social networks. In this paper, we'll define a social network as a form of social innovation that builds upon "interpersonal ties among a group of like-minded individuals, connected through flow of information, goods, services or participatory action around a common goal."[40] Social-networking initiatives have sprung up across various states in India in recent years, attempting to leverage word-of-mouth effects in low-educated, rural areas.

A series of community workshops were held in Kerala by village resources center (VRC) to improve social learning of new agricultural techniques. These workshops were found to be extremely effective in increasing community adoption of new technologies. It was noted that in particular, two types of learning were prominent: 1) direct learning from those who attended who were drawn by the allure of learning from experts in-person, 2) in-direct peer learning after the event drawn by respect by peers. The latter was significantly stronger, and it was concluded that farmers "continue to rely more on personal interactions with their peers, friends, agricultural professionals, local institutions, media and extension farm advisers for new technology." It was also noted that farmers typically tended to network with farmers they knew within villages. To initiate networking across villages, it was stressed the continued importance of a robust local institutional system (e.g., VRC).[41]

An empirical analysis was held Manipur involving 64 farmers pooled from eight villages to better understand the role of farmers' networking at workshops in the adoption of a new variety of rice. The authors, Jyothi and Devarani, noted the importance of village leaders, finding that most villages tend to have a few actors who are trusted by the village for diffusion of information. If these actors are contacted and provided with all the required inputs, they act as highly effective informal extension agents among the rural villages and enhance the rate of diffusion of the variety in a shorter span of time. They found further that farmers who attend multiple workshops are more likely to develop into new central actors within villages, and that villages tend to be open to having multiple village leaders. The authors of this study also note that one method of improving the scale of workshops is to contact village leaders who tend to be more open to change via phone and other ICT methods.[42]

In Telangana and Jharkhand, a study was conducted on "group farming" and the effects of network characteristics within a farm on productivity compared to "individualistic" family farming, still the most common practice in India. Conducting surveys in the state of Kerala and Telangana, the study demonstrated that group farming potentially provides the participant farmers a variety of benefits thanks to network effects like diverse skills and tool-sets and communal bargaining power with existing governments and markets.[43]

The continued prevalence of rural Punjab's aging and educated population and the success of initiatives in similar demographic areas leads us to believe that similar policy proposals enacted within Punjab may be successful.

Previous Punjab Pilots with Social Network Policies

One important pilot study conducted in Punjab was an effort by the Columbia Water Center (CWC), a research organization based out of Columbia University dedicated to addressing water-scarcity, to provide tensiometers to smallholder farmers. A tensiometer is a device which can determine the water level in the soil, enabling farmers to better regulate their water usage, in order to avoid excessive depletion of water. The CWC provided 525 rice farmers with tensiometers in 2020, and tracked their water usage and conducted multiple surveys. Of the drafted farmers, 85% utilized the tensiometers they were provided, and all of these farmers indicated their intention to convert their entire farming system to use a tensiometer in the next farming cycle. "Farmers who completed the trial reported an average of 22 percent water savings over conventional methods, and 24 percent energy savings." Even more powerful, however, has been the training and information the CWC has been able to provide farmers in the region, building upon its relationships with farmers in Punjab. With volunteers explaining to farmers how crop diversification can benefit them and providing them training as to how they can successfully diversify their business, the CWC has seen an uptick in the number of farmers farming a variety of crops, such as onions, cauliflowers, and sugar cane.[44]

Another pilot study in the region which indicates the need for word of mouth information is the program Paani Bachao Paise Kamao. Started by the Punjab government in 2018, this program provides monetary incentives to farmers to reduce their water usage, as well as providing field-level support for farmers to enroll in the pilot and implement better water proactics while coordinating with the state government. This program suffered a lack of enrollment due to COVID, but prior to that was quite successful, as they focused on "building trust with the farmer community in [the] project villages." Over the course of the past few years, the program has saved over Rs 38.74 lakh worth of water (500-600 thousand gallons), a sizable amount relative to the agricultural sector in Punjab. These pilot studies demonstrate the importance of using word of mouth from trusted sources in order to

induce meaningful change in the region.

Our Solution

Network Policy Requirements

From Agarwal (2010), we suggest that the conditions for designing an effective network policy solutions are: (1) small size, (e.g., groups of 10–12 or 15–20 individuals); (2) socioeconomic homogeneity or marked social affinities among members; (3) participatory decision making in production, management and distribution; (4) checks and penalties for containing free riding and ensuring accountability; and (5) group control over the returns and a fair distribution of the benefits, as decided transparently by the members.

Policy Enactor

We believe that the ideal enactor of this policy framework is the Agricultural Technology Management Agency (ATMA) under the Central Government of Punjab. It is an organization that seeks to improve adoption of new technologies through various initiatives driven by stakeholders at the state, central, district, and village governments. ATMA runs pilot programs across districts within Punjab that are designed to be converted into long-term policies. From 1998 to 2005, ATMA ran pilot programs in 27 districts. It's successful policies are currently operational In 676 Districts. Rather than create a new actor or organization, we propose that we use ATMA. Currently, a third of ATMA's budget is unallocated to any activity, and budgetable for new initiatives.

The "Farmer Field Schools" (FFS), is an experienced-based learner ATMA initiative that operates sessions, with 25-30 farmers. The goal of FFS is to leverage in-person learning and create community leaders who will act as extension agents in their local networks. The sessions are run bi-weekly and cover "best practices" presentations and in-person "field days" to apply concepts learned in the classroom.[45] Since ATMA already runs a program (FFS) designed to leverage social networks to increase technological productivity, our proposal seeks to build off it and improve its existing efficacy and access.

Site of Implementation

We recommend that the central government chooses the Sangrur subdistrict. We chose this particular district due to its relevance in farmer protests

demanding a price floor on crops. In 2020, groups of farmers from the Sangrur subdistrict led coordinated hunger strikes in response to the governmental policy changes regarding sale of crops mentioned in the introduction. Agarwal notes that the prior constitution of neighbourhood groups is preferred in a social-networking solution and provides a strong foundation for cooperation.[46] Thus, we propose that the farmer protests reveal the existence of mobilized farming community groups within Sangrur. Additionally, Sagrur has existing groups with a degree of social and economic heterogeneity. Thus, Sangrur is a prime candidate location for this policy's implementation.

Our Policy Proposal: A Multi-Pronged Approach

Prong 1: Data-Collection

We believe that defining clear metrics that probe the entire FFS ecosystem could help define the effectiveness of the policy's implementation. Further, as the effects of climate change become more pronounced and challenges may change, consistent data-collection will help to meet farmers' most urgent needs.

We propose that ATMA allocates more time within each in-person and online FFS session for data collection. Data collection will take the form of a quick survey that farmers can fill out for a monetary incentive. The metrics that ATMA should focus on to determine community nodal individuals are:

Figure 2: Potential questions for FFS Survey

Farmer	FFS Lectures	Ecosystem (ATMA)
# of farmer acquaintances (network)	# of farmer attendees per session	Total # of enrolled students
# of household members	# of questions asked by attendees	# of density of FFS programs in district
# kg per acre produced each year	# of new practices taught in one year	

Farmer	FFS Lectures	Ecosystem (ATMA)
Farmer sentiment about year production 0-10 (0=extremely unsatisfied, 10=extremely satified	# of lessons given	

Jyothi and Devarani note that the key to leveraging social networks is to identify the nodal persons ("broker") within a network, usually with a high degree of centrality, and train them so that they can train the others in the network in turn.[47] In order to measure the second metric suggested for farmers, "# of farmer acquaintances", we suggest asking the following questions in an end-of-session survey.

1. How many people did you talk to about last week's FFS material?

2. How many people did you interact with in the past week outside your direct family?

3. What were peoples' attitudes toward the new technologies introduced in FFS when you talked to them?

In order to measure the level of Farmer's perceived utility of FFS group sessions, we suggest that the end-of-session survey includes

1. From 0-10 rank your satisfaction with your farming practices learned this year

2. From 0-10 rank your satisfaction with your farm's productivity this year

3. From 0-10 rank your satisfaction with the FFS's group sessions

The rest of the metrics listed above should be gathered every year by an ATMA oversight committee separate from FFS in order to minimize bias in collection. We believe that the top-line metrics are "# of farmer acquaintances (network)" and "# of new practices adopted per year" because if we could maximize both then we can conclude that the most amount of relevant information is being disseminated efficiently.

Existing FFS are often multi-month projects designed to cover the introduction of a new seed or crop technology. Because farmers can attend a limited number of FFS and each one takes a significant amount of time, we suggest it is critical that the topics taught in the FFS are topics farmers care about. Therefore we believe that a pre-session survey is appropriate and should ask farmers:

1. What topics would you like to address in this session?

2. What practices would you like to learn in this field activity?

3. Do you have any suggestions for the program?

We believe that collecting data for these metrics would allow program decisions, structures and goals to be data-driven. This way we would be able to identify when, why and how the program falls out.

Prong 2: Increasing Access to In-person Curriculum

We believe that concerted efforts toward increasing participation by small-scale, lower income farmers could increase overall adoption of sustainable and productive farming practices in Punjab. According to Punjab's Directorate General of Agriculture, there are 48 FFS workshops held per district annually.[48] As these districts have an average size of 1000 square miles, some farmers may live large distances from a workshop and lack the means of attending on a bi-weekly basis.

Historically, two reports found that traveling a large distance to FFS has been a key cause of non-attendance in comparable initiatives in Latin America.[49][50] When the Food and Agriculture Organization (FAO) launched a third-party FFS in India, they reported that significant amounts of money needed to be allocated to travel allowances to ensure equitable access. The FAO found that around 25% of total expenses needed to be allocated to travel allowances to enable low-income farmers to attend.[51]

The current FFS program is an optional event that farmers choose to attend in their free time. As a result, the audience is self-selecting; farmers who have the means to travel and can afford taking time away from work are more likely to participate. Currently, Punjab's FFS program does not utilize 20% of its budget.[52] Therefore, we propose that ATMA invests these unallocated funds into free transportation for attendees. By allocating funds towards a free source of transportation, the FFS program can expand access to workshops in low income communities.

We propose that ATMA invest in some form of travel allowance for farmers who live substantial distances from the field sites, whether it be through day-of transportation passes or reimbursements. We believe that FFS should have a phone number or email address where farmers can submit a request for transportation or transportation financial assistance. Financial assistance should be provided on a need basis in order to ensure that our target farmer segment is attending FFS workshops.

Prong 3: Diversifying Curriculum of In-person Workshops

FFS covers topics such as new seed and fertilizer usage.[53] We propose that we diversify the curriculum and format the existing in-person, multi-day workshops to better align with what farmers care about. Leading topics that we may introduce to farmers may include some of the following:

Rotational Topics: covering important seasonal topics. An example of a rotational topic would be the importance of curtailing the spread of COVID-19 by adopting practices such as hand washing, physical distancing, and other precautions.

Forward-Thinking Sustainable Solution: As the impact of climate change continues to exacerbate India's water crisis, it is important that workshops showcase new agricultural practices and crops that increase farming communities' resiliency. Further, it is vital that the agricultural sector's crop distribution becomes more diversified, and, through the building of trust in this pilot program, we suggest an emphasis on encouraging a transition away from rice and wheat cultivation.

Private-Sector exposure: Showcasing easy-to-use digital private sector solutions that farmers can interact with and try out. Having extension agents hand-pick solutions that are easy to use, and provide real-time assistance could help introduce farmers to private-sector products.

Lessons Learned From Other States FFS: FFS are run all over India, in a decentralized manner. States adopt and run their own variations of FFS. Though this makes sense as it enables FFS to tailor to village-specific needs, it creates inconsistencies among methods used. In Prabhupara, a local FFS reported success in introducing new aquaculture farming techniques that has not been tried out in any other state.[54] Inviting guest speakers from other states to expose

new technologies to Punjab could be fruitful.

Best Practices for Managing Large Social Groups: The Punjab government supports the formation of self managed, independent farmer groups. The members work together to achieve this goal by pooling together their existing resources, gaining better access to other resources and to share in the resulting benefits. The groups take the form of social media groups. Empirically, social media groups can become inefficient with size. The larger the group chat, the less people post content due to social fear for example. Teaching community leaders the importance of having different "channels" for different purposes (feedback, announcements, etc), and the know-hows for creating well-managed social networks could be fruitful.[55]

Individual Discussion: Farmers may have questions about why things worked after the FFS. Hosting in-person help sessions for real-time question and answering could be another topic area. FFS is an in-person, multi-day event that involves farmers training on a shared demonstration plot: a field where a specific crop being taught in a session is grown as part of a demonstration. Farmers may run into issues when adopting new techniques on their own plots of land that may not surface on the shared demonstration plot. Additional individual conversations and online sessions could provide a constant presence between the government extension service and the local farmer as an "extra help" session. An article from the journal on Agricultural Economics found that this "constant presence" among participating farmers builds farmers' confidence and credibility of government agents, which in term expedites the diffusion of new ideas in communities.[56]

Conclusion

India is one of the largest agricultural states in the world, and its farmers face the brunt of the consequences of changing climates. It is increasingly important farmers adopt new practices to adapt to climate change. The state of Punjab is often regarded as the breadbasket of India. Punjab has a large rural, uneducated, and aging population of farmers who are empirically more likely to resist adoption of new technology and are also the ones facing the brunt of extreme weather conditions. Farmers continue to prefer inter-personal and in-person sources of information over internet sources. In this proposal, we suggest leveraging farmers' social networks and trust in local actors to help accelerate adoption of new techniques.

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The current Farmer Field Schools program offers a great opportunity for promoting sustainable farming practices. However, it falls short due to accessibility issues, a lack of direct data collection, and its limited curriculum. Therefore, we propose that free transportation to workshops be offered, future programmatic changes are based on findings from systematic data collection efforts, and the curriculum of FFS workshops are greatly expanded. With these changes, we believe that farmers in Punjab will be better prepared for the impacts of climate change and related issues.

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