Proceedings from the Symposium on Climate Change, Agriculture, Water and Livelihoods

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Introduction

The world's population is predicted to reach 9.73 billion people by 2050, with growth expected to be highest in low-income regions, which have large numbers of people in rural areas, and also dependent on agriculture. They are vulnerable to the impacts of climate change, which are expected to intensify in future. Climate change will undoubtedly affect agriculture's capacity to meet future food demands, as most climate models predict increased water stress due to increased occurrence and intensity of extreme weather events, recession of glaciers, and expansion of arid/semi-arid regions. Therefore, water management is central to meeting food demand and buffering the effects of water scarcity. Agriculture is a major water user, yet remains highly inefficient due to improper irrigation practices.

McGill University's *Water Innovation Lab* and The *Global Framework on Water Scarcity in Agriculture* (WASAG) jointly hosted a symposium on April 4, 2018 entitled "Climate Change, Agriculture, Water and Livelihoods". The speakers and the titles of their presentations are:

Eduardo Mansur
Director of the Land and Water Division of the FAO
Presentation: *Water for food, and drought preparedness*

Dr. Ross Alter
Researcher with the Department of Civil and Environmental Engineering at MIT and with the US Army Corps of Engineers (USACE)
Presentation*: Effects of Agricultural Intensification on Regional Climates*

Dr. Kenneth Strzepek
Researcher with the MIT Joint Program on Science and Policy of Global Change
Presentation: *Characterizing the Uncertainty of Climate Change Projections for Africa*

Dr. Bruce Currie-Alder
Program leader with Canada's International Development Research Centre
Presentation: *Insight from the Collaborative Adaptation Research Initiative in Africa and Asia*

This report provides a summary of the symposium presentations and discussions.

The Food-Water-Energy Nexus

Attempts to mitigate climate change are made to both protect the environment and to ensure human livelihoods by improving sanitation, reducing air pollution and protecting natural resources. The Paris Agreement, signed in December 2015, provides an action plan to limit global warming to below 2°C, and has been ratified by 195 countries. The Sustainable Development Goals (SDGs) and are a global call-to-action to address, amongst others, global concerns such as poverty reduction (1), hunger (2), water quality (6), clean energy (7), sustainable infrastructure (11), climate change (13) and species protection (14, 15). The 2015 Paris Climate Conference (COP21) and Sustainable Development Goals were not intended to be antagonistic yet have become so in many developing countries where striving for a green economy comes at the expense of development and vice versa. Access to electricity is a major economic development indicator, with gross domestic product (GDP) and electricity consumption being positively correlated. Improving access to electricity is thus a primary goal in many developing countries hoping to meet the SDGs.

The African continent and India are in a race to meet their development potential thus may struggle in their efforts to keep the global temperature increase below 2°C, as specified by the 2015 Paris Climate Conference (Dale et al. 2017). In Africa, an estimated 600 million people do not have access to electricity despite the region's ample energy resources. There is immense potential to develop renewable energy in sub-Saharan Africa as it has vast access to geothermal, wind, hydropower and solar resources. However, the region also has large fossil fuel reserves, on which its energy sector is already dependent and which can be developed at a lower cost than renewable energy. Developing renewable energy would thus incur a higher cost, with hydropower having triple the capital costs of coal. It is thus difficult to convince sub-Saharan governments to invest in green energy when fossil fuels present a fast-track to the widespread provision of electricity and subsequent economic development. Additionally, fossil fuels are considered more reliable than renewable resources as they are unaffected by wind speed, cloud cover and weather events. The argument of long-term financial return of renewable energy is perhaps nullified by the prediction that energy production by renewables will be lower in 50 years due to changing weather patterns and high operational costs. There is also a trade-off between clean energy and food security due to higher costs of clean energy and increasing energy demand by agriculture for irrigation, value-addition processes (ie. storage, packaging and marketing) and farm equipment. In developing countries where finance is already a major limiting factor for agricultural productivity, implementing clean energy policies threatens to leave behind smallholder farmers and exacerbate social inequalities. Energy development can also hinder agricultural operations through competition for financial and natural resources. The production of biofuels, for example, requires that arable land be used to produce biomass rather than support food production (Dale et al. 2017).

Most importantly, the agricultural and energy sectors are also in competition for water resources as each require high volumes of water. Whereas energy is typically a low consumer of water, agriculture is the world's highest consumer of freshwater resources, thus rendering freshwater unavailable to other users. Agricultural intensification is also often cited as a major water polluter due to runoff of agrochemicals and siltation of surface water, and degradation of groundwater by percolation of fertilizers. On the other hand, the development of hydroelectric power stations will inherently affect downstream water users as they may experience decreased flows or flooding events. Fossil fuel production can also negatively impact water users by degrading water quality and rendering it unsuitable for domestic consumption. There are also greenhouse gas emissions caused by industries dependent on fossil fuels.

The food-water-energy nexus is inherently affected by climate change which threatens to reduce agricultural productivity, exacerbate water scarcity, and increase reliance on renewable resources despite their lower returns. Addressing these issues is hindered by the widespread uncertainty of climate change projections, with the uncertainty arising both between and within climate models. Recent studies pertaining to sub-Saharan Africa have suggested that the effects of climate change will range from increased rainfall in Central Africa, yield losses in Southern Africa and Sahel, and yield gains in East and Southern Africa. Research by Alter et al. (2015) delves into the impacts of agricultural intensification on regional climate in the Gezira Irrigation Scheme (Sudan) and demonstrates that irrigation can reduce rainfall over the irrigated area and increase precipitation downstream, suggesting that irrigation can create an unsustainable positive feedback loop over irrigated areas, but possibly increase agricultural productivity downwind. The trend is not yet fully understood but can have major implications for irrigation development in SSA, where there is an irrigation potential of approximately 40 Mha. The research also suggests that agricultural intensification via irrigation can contribute to regional water scarcity.

Water Scarcity in Agriculture

More than 1.1 billion people worldwide lack access to water. Many of the water systems that keep ecosystems thriving and feed a growing human population have become stressed. Rivers, lakes and aquifers are drying up or becoming severely polluted. More than half the world's wetlands have disappeared. Therefore, several approaches including water resources planning and management, and drought protection are required to properly allocate limited water resources.

Generally, water scarcity involves all aspects related to restricted water availability. EU (2007) defined water scarcity as a situation where insufficient water resources are available to satisfy long-term average requirements. Van Loon and Van Lanen (2013) stated that water scarcity represents the over-exploitation of water resources when demand for water is higher than water availability. Estrela and Vargas (2012) defined drought as a natural hazard that results from a deficiency of precipitation, which can in turn translate into insufficient amounts of water to meet the needs of ecosystems and/or human activities. Driven both by climate change and poor water management, droughts are becoming more frequent and water scarcity is growing in severity in all regions of the world. The World Economic Forum ranks water security as the top global risk facing societies, economies and businesses over the next ten years.

The FAO is contributing to the SDGs to achieve zero hunger and reduce rural poverty through sustainable management of water and other natural resources. With food demand expected to increase by 100% by 2050 in developing countries (Bruinsma 2009), raising agricultural production to supply the world's food needs is crucial not just for food security, but for economic and social stability (Madramootoo and Fyles 2012). Irrigation is important in the quest to combat food insecurity, as it utilizes only 20% of cultivated land to provide 40% of the world's food supply (Garces-Restrepo et al. 2007). However, irrigated agriculture faces tremendous uncertainty in water supply due to prolonged drought associated with climate change, as well as increased competition from environmental, municipal and industrial water needs (DeJonge et al. 2015). Therefore, optimization of irrigation water, as well as improving irrigation water use efficiency, are essential to ensure sustainable food production.

Impacts of drought and water scarcity

Water scarcity is a global issue and is quickly becoming a trigger for crises. Water scarcity and drought impact poverty and economic growth, health and well-being, gender inequality, and the environment. Crops fail, livestock die, families face food shortages and famine, people are forced to migrate and conflicts arise. Cities affected by water scarcity, strain the existing infrastructure with increasing costs for citizens, businesses and government.

Increasing water shortages, frequent droughts, and global warming (Hirich et al., 2016) are threatening the reliability of irrigation water supplies. While the human population and demands for freshwater resources are increasing, drought and recurring water scarcity can put global food security at risk by severely disrupting agricultural production (Lei et al. 2016; Ihuoma and Madramootoo, 2017). Other impacts of droughts include destruction of riverine ecosystems and wetlands, deterioration of water quality, intrusion of saline water, groundwater contamination, and lower groundwater levels.

Mitigating the impacts of drought and water scarcity

Water scarcity and drought require a proactive action for mitigating their impacts and there is a need to prevent drought-induced famine. This could be achieved through water reuse and recycling, increased efficiency of domestic, agricultural and industrial water use, and water saving campaigns supported by public education programmes. Tension is rising between states competing over water claims. There is an increasing need to strengthen regional cooperation on water-related challenges and solutions, particularly in water-scarce and drought-affected areas. Building resilience to water scarcity and drought requires collaboration across sectors and stakeholders. Given the size and scale of the challenge, there is need for global leadership that brings together actors from across a range of sectors, to work proactively to address water scarcity and drought. This is one of the goals of the Global Framework on Water Scarcity in Agriculture (WASAG). It is an initiative for partners from all fields and backgrounds to collaborate in supporting countries and stakeholders in their commitments and plans related to the 2030 Sustainable Development Agenda, the Paris Climate Agreement (including implementing nationally determined contributions) and other plans and programmes related to agriculture and water.

Example of Stakeholder Collaboration for Climate Adaptation

The Collaborative Adaptation Research Initiative in Africa and Asia (CARIAA) is a seven-year program that is jointly funded by Canada's International Development Research Centre (IDRC) and the UK's Department for International Development (DFID), with the goal of building the resilience of vulnerable populations in three climate hotspots in Africa and Asia: deltas, semi-arid lands and glacier/snowpack-dependent river basins. These goals are addressed by generating knowledge, developing scientifically validated policies and encouraging capacity building, thereby addressing Article 7[1] of the Paris Climate Accord (2015). CARIAA also puts added emphasis on engaging impoverished women and youth in the capacity-building activities. By engaging with communities, practitioners and policymakers, CARIAA hopes to inform effective adaptation policies and practices across the identified climate hotspots.

The three aforementioned climate hotspots were selected based on their strong climate signals and the significant populations that they support, most of whom are impoverished and vulnerable to the impacts of climate change. Nearly two thirds of the world's population reside in these hotspots, with approximately 500 million people living in delta regions, 1.3 billion people residing in glacier/snowpack-dependent river basins in the Hindu Kush Himalayan (HKH) mountain region and 2.5 billion people living in semi-arid regions (De Souza et al. 2015). Identifying regions with strong climate signals and the resident vulnerable population is important for improving existing knowledge on region-specific issues to enable the realization of Sustainable Development Goals (SDGs). Improving the knowledge base will support the creation of linkages for capacity development, and the compilation of robust evidence across similar landscapes. CARIAA summarized some major findings, grouped under five broad areas: knowledge of climate hotspots, barriers and enablers to effective adaptation, dynamics of climate migration, impacts of gender and social difference and, the role of individuals, households and communities in adaptation.

[1]the global goal on adaptation of enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change

Climate Hotspots

To fully evaluate the impacts of climate change and the implications of 1.5°C global warming, it is essential to know the regions with the strongest climate signals and the vulnerable populations supported in these regions. The CARIAA research findings fill in the data gap identified by previous IPCC Assessment Reports (AR1-4) for the HKH region. These findings will improve the assessment of 1.5°C global temperature. The results give greater insights on the implications of 1.5°C temperature in different parts of the world, as the effects are not expected to be equally distributed. Temperature increases in mountainous regions, for instance, are expected to be higher than the global average increase, with 1.5°C global warming translating to a 2°C warming in the Hindu Kush Himalayan region. Similarly, a 2°C increase in global temperature increase would increase temperatures in HKH by an estimated 2.7°C and may reduce glacier size by 30%, causing water insecurity for the 800 million people living downstream. In South Asia, some areas experience nighttime temperatures exceeding 30°C which poses significant health risks whereas colder temperatures have been recorded in the US' Corn Belt region. Alongside global temperature increases, global precipitation is projected to increase by 3-5% per degree of warming yet thirty African countries exhibit a decrease in rainfall. These findings point to increased localized climate variability and support the importance of regional climate studies to develop effective mitigation strategies.

Effective Adaptation

To implement effective and sustainable adaptation strategies, it is imperative to know the barriers to adaptation from a region-specific perspective. Gathering such evidence requires researchers to ask questions such as:

- what does adaptation mean to different individuals in each region?
- how will climate change impact these individuals and what are some of their current adaptation measures?
- who adapts and when (impacts to different members in the society as well as different members within a household unit)?
- what are the turning points, pathways and critical moments with regards to seasonality?

Climate adaptation is also influenced by social justice, which informs the adaptation options with respect to climate financing. Examples of current adaptation measures include flood-resistant housing and toilets in India, solar-powered irrigation pumps to replace diesel powered pumps in Pakistan and increased accessibility of existing technology in Ghana.

Climate Migration

Climate migration is also expected to intensify as projected increased drought and flood occurrence, desertification, sea level rise and changing weather patterns will likely compromise the livelihoods of vulnerable populations (especially those reliant on agricultural activities). Using an original dataset of 12 000 households, CARIAA investigated individual responses to climate change in the river deltas of India, Bangladesh and Ghana. Results demonstrated that most migration occurs within the boundaries of a country and is typically driven by education and/or job opportunities, with most migrants be willing to return to their home region should the opportunity arise. A significant number of the survey respondents attributed their migration to loss of agricultural productivity livelihood due to flooding, particularly in coastal regions. Thus, economic migration and climate migration are interlinked as climate change affects a region's productive capacity thus its economic opportunities.

Gender and Social Difference

Empowering women and youth plays a major role in effective climate adaptation, with previous studies showing that women can be resilient and successful at adaptation rather than treated as victims. The influence of power, decision-making and cultural beliefs shape vulnerability. Cultural beliefs with regards to women and youth sometimes exacerbate vulnerability. Households are not homogenous hence gender, age and ethnicity determine vulnerability within a household unit.

Private Adaptation

Results from the PRISE (*Pathways to Resilience in Semi-Arid Economies*) consortium in semi-arid areas has shown that several adaptation projects are dependent on decision-making by private actors or stakeholders such as households and firms. Value chain analysis, multi-level climate risk assessments and identification of adaptation investment options create economic opportunities. Rao et al. (2017) provide strong examples of economic opportunities generated by value chain development through improved production and postharvest practices and risk assessments.

In summary, the variability of climate hotspots suggests that adaptation must be region-specific, as vulnerability is often "place-based" which implies that geographical elevation, coastal proximity, location relative to a floodplain or soil aridity index are equally huge determinants of vulnerability. To improve effective adaptation, the importance of inclusivity cannot be overemphasized. Efficient and effective collaboration is at the helm of affairs to achieving sustainability adaptation to climate change. However, this is often complex and requires a multi-disciplinary approach with support from several regions, reporting specific information from a particular region. The work by CARIAA researchers and other similar research programs show that effective collaboration is attainable and produces notable results.

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