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Climate Change: A Looming Threat to Southeast Asia's Water-Food-Energy Future

Interview with Prof. Anu Ramaswami of Princeton University

Confronting the Global Housing Crisis

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SUSTAINABILITY
IN A TIME OF CRISIS

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IN FOCUS

HE XIAOGANG is currently a Postdoctoral Fellow of the "Water in the West" programme at Stanford University, and he will join the Department of Civil and Environmental Engineering at the National University of Singapore in July 2020. Xiaogang is a Princeton-trained Ph.D. Hydrologist with experience in economics, machine learning and environmental policy. His research interests focus on the fundamental understanding of how climate change, variability and human interventions affect drought and flood risk across scales, and how to implement an integrative framework to reduce their societal impact. He received his M.A. in Civil and Environmental Engineering from Princeton University; M.E. in Civil Engineering from the University of Tokyo; B.Eng in Hydraulic Engineering and B.Sc (School of Economics and Management) from Tsinghua University.

Xiaogang has received a number of accolades, including the Science, Technology and Environmental Policy (STEP) fellowship from the Woodrow Wilson School, Princeton Energy and Climate Scholars (PECS) from the Princeton Environmental Institute, and the Young Scientists Summer Program (YSSP) fellowship from the International Institute for Applied Systems Analysis (IIASA).

HE XIAOGANG

Climate Change:

A Looming Threat to Southeast Asia's Water-Food-Energy Future

Nonthaburi, Thailand
In 2011, Thailand experienced the worst flood in half a century. In order to reduce the risk of future flooding, the Thai government has created a water management programme, including building dams in four basins in the northern region, and constructing floodways and flood diversion channels.

Southeast Asia is a global hotspot for climate change and is facing unprecedented challenges towards a secure and sustainable water, food and energy future. More than 660 million people currently live in this area. The population is projected to increase to 760 million in 2050, with 65% of the total population concentrated in urban areas and along low-lying coasts. This makes Southeast Asia particularly vulnerable to global warming-associated natural disasters, including rising sea levels, intensified typhoons and tsunamis, destructive floods, parching droughts, and oppressive heat waves.

Consequently, four countries in this area – Myanmar, the Philippines, Vietnam and Thailand – are on the list of the world's top ten most climate-affected countries for the period between 1997 and 2016, according to the Global Climate Risk Index (Eckstein et al., 2018). These countries are also frequently appearing in global headlines. For example, a severe drought hit Thailand in 2010 and caused USD450 million in crop damages. On the heels of this drought, Thailand experienced unprecedented floods in 2011, resulting in USD43 billion of economic losses and USD16 billion of insurance losses. More recently in 2016, Thailand experienced record-breaking dry and hot conditions, with a compounding impact on agricultural production (e.g. crop failure), human health (e.g. heat stroke), and energy consumption (e.g. increased electricity use).

Scientific literature has demonstrated that events with such severity would not have occurred without the impact of climate change (Christidis et al., 2018), and the risk of similar compounding dry-hot weather has increased over this historical period (Hao et al., 2018). This has manifested in Indonesia, where there is increasing evidence that the 2015 summer droughts and heat waves have become more frequent because of a warming climate (King et al., 2018). These climate extremes in Indonesia not only caused crop failures and reductions in hydropower production at a local scale, but also affected its neighbouring countries through wildfires that even caused smog and haze to reach Singapore.

In general, climate change has direct and indirect impacts on intertwined water-food-energy security through changes in the hydrological cycle, and it is manifested by extreme events such as droughts, floods, heat waves, wildfires, and many others. The impact of climate change not only depends on the hazard characteristics (e.g. severity, frequency), but also on the vulnerability (the propensity to suffer adverse effects) and exposure (the footprint being adversely affected) of the region. Southeast Asia is a hot spot exposed to such extremes because of the strong variability of the monsoon climate and the high population density with relatively low adaptation capacities. Although water-food-energy insecurity tends to have the largest social and economic impacts on a local scale, such impacts can extend to other regions because of the geographical proximity and the increased interconnectedness due to globalisation (for example, through international agricultural trade). Below is a brief summary of the main impacts of climate change on Southeast Asia's water-food-energy sectors.

Village of Kradenan, Central Java, Indonesia
Residents take murky water from a well made in the middle of a dried-up reservoir for daily use.

By the 2050s, even while on a sustainable development path, one out of five people in Southeast Asia will still be water insecure.

WATER SECURITY

Water security is a multifaceted concept and involves both quantity and quality of water available. This article focuses on water quantity, and briefly talks about how climate change can affect both the supply side – water availability – and the demand side – water usage – of the water security equation. Given the tropical climate of Southeast Asia, water supply is largely associated with monsoon rainfall, the variability and distribution of which are already affected by the intensified hydrological cycle because of the warming climate. This has been observed over the low latitude countries, where extreme rainfall has become more frequent and intense in rainy seasons, leading to floods, and reduced rainfall causing prolonged droughts in dry seasons. Such extreme events and the rapid swings between them pose a substantial risk for water management practices, especially for reservoir operations as there exists a trade-off between short-term flood-control and long-term water storage imperatives to meet water supply requirements. In addition to monsoon rainfall, Himalayan glaciers and mountain snowpacks supply water to millions of people in Southeast Asia through three major rivers, the Irrawaddy, Mekong, and the Salween, the flow patterns of which will be significantly altered because of the high sensitivity of glaciers and snowmelt to rising temperatures. Feeding these mechanisms into physically-based models and looking into the future, all countries in Southeast Asia will experience reductions in per capita water availability because of climate change and rapid population growth (Satoh et al., 2017).

On the demand side, there is a trend of growing total water demand over the entire Southeast Asia, driven by increased water use in industrial, municipal, and agricultural sectors. At the country level, this trend is most prevalent in Indonesia. This is because growing income rates along with rapid urbanisation and overall heightened energy use cause a large increase in per capita water use. Water scarcity estimates can be made by comparing the differences between water demand or withdrawal, and water supply. Between 2006 and 2015, 65 million people (11% of total population) in Southeast Asia were exposed to severe water stress. This number is expected to increase to 127 million by the 2050s (Satoh et al., 2017). At that time, even while on a sustainable development path, one out of five people in Southeast Asia will still be water insecure. Avoiding such a situation will require reconciliation of water demand and supply, and better management of the trade-offs between different sectors.

Tacloban City, Philippines
Typhoon Haiyan destroyed countless homes, flooded cities and towns and left more than 4,000 people dead and 1,100 missing after hitting the country in November 2013.

The reliability and availability of renewables could be affected by long-term climate change.

ENERGY SECURITY

Based on the latest Energy Outlook from the International Energy Agency (IEA), 45 million people in Southeast Asia were living in darkness in 2019 (Birol et al., 2019). Ensuring electricity access is a key aspect of energy security but will be challenging given the rapid growth in energy demand (66% increase by 2040), and the commitment to reduce fossil fuel energy production to meet the emission goals of the Paris Agreement. To address these challenges, Southeast Asia is planning to add more renewables to its energy production portfolios. However, the reliability and availability of renewables could be affected by long-term climate change. Currently, Southeast Asia's total energy production is 24% renewables, where 18% comes from hydropower and is mostly led by Vietnam, Malaysia, and Indonesia (IEA, 2019). The problem is that hydropower generation is vulnerable to droughts because of evaporative loss in reservoirs and reduced effective generating capacity due to water shortages. This can be seen in the historical 1997-1998 drought, which reduced hydropower generation in Vietnam by approximately 20% (Shadman et al., 2016). Potential drought-caused reduction of hydropower will be more significant in Malaysia, Indonesia, and the Philippines because these countries have large numbers of planned micro-hydropower plants, which are more sensitive to increased temperatures compared to large hydropower plants.

Despite the fast growth in renewables, fossil fuel power plants still dominate the energy production landscape in Southeast Asia. Heightened temperatures due to global warming can reduce the performance of thermoelectric power plants, thereby affecting production efficiency. Also, the projection of more frequent droughts will put additional pressure on cooling water demand because of reduced water availability. This is likely to exacerbate the conflicts between energy generation and food production, for instance, whether water should be allocated for hydropower production or for downstream irrigation purposes to ensure food security.

Nusa Penida, Bali, Indonesia
Indonesian farmers grow seaweed using a traditional method. It takes 15 to 30 days for seaweed to grow during low tide. It has recently been found that seaweed farming could be a powerful new tool to sequester carbon and offset greenhouse gas emissions.

In addition to droughts, energy security is jeopardised by other types of climate extremes such as floods, heavy storms, strong winds and wildfires, which disrupt transmission lines and cause power outages. These short-term seasonal shocks increase the volatility of electricity prices and disproportionately affect communities with different coping capacities, especially vulnerable communities such as the elderly, hospital patients, and lower-income households. These communities' electricity demand for cooling purposes and medical care may be the most urgent but they have fewer resources to bear the burden of increased energy costs.

FOOD SECURITY

Food insecurity is prevalent in Southeast Asia. In 2018, the number of people experiencing moderate or severe food insecurity in this region was about 134 million (FAO, 2019). Among those people, approximately 61 million are undernourished and are mainly low-income households in Indonesia, Myanmar, and the Philippines. Because of the tropical climate of the region, most staple crop production (e.g. 55% of total rice production) is rain-fed and therefore particularly vulnerable to climate change-induced precipitation changes (e.g. trends and variability). In general, climate change has both short- and long-term effects on food security. In the short-term, food production is mainly affected by the climate shocks of extreme events (e.g. droughts, floods, and heat waves), which can cause crop failures, lead to production interruptions and reduce food availability. This was reflected during the 1998-2002 drought in Cambodia, where rice production decreased by 20% (ADB, 2014).

In addition to food availability, other aspects of food security, such as food access and stability, are also directly or indirectly affected by climate extremes through channels of food trade, markets and policies (He et al., 2019). These effects are no longer limited to local places where extreme events occur, but can ripple into regionally (e.g. within Southeast Asia) and globally interconnected food markets, further threatening the food security of countries like Singapore, which relies strongly on international food trade.

There is increasing evidence that the yield of staple crops (e.g. rice, maize, and cassava) in Southeast Asia will decline in the long run (OECD, 2017). Compounded with these short-run climate shocks, this will potentially reduce farm household income, increase the cost of agricultural products, and drive increased allocation of land towards irrigation-intensive agriculture in order to buffer the decline of crop production from rain-fed agriculture. Consequently, the heightened irrigation water demand will increase the conflicts of water used for other sectors (e.g. energy). From a health perspective, the warming climate could reduce farmworkers' productivity due to occupational heat stress. Intermixed with increased healthcare expenditures, this could reduce the available income that can be spent on food purchase, which indirectly influences food security (OECD, 2017).

Environmental sustainability, transboundary risk and climate uncertainty should jointly be considered when planning for future mitigation and adaptation strategies...

Khlong Yai Reservoir, Rayong Province ,Thailand

By conducting risk assessments, policymakers can determine the potential severity of drought and flood threats in individual sub-basins in the region and devise local measures accordingly.

Deforestation in a tropical rainforest due to illegal logging to create palm oil plantations.

FORMIDABLE CHALLENGES BUT ENORMOUS OPPORTUNITIES

Besides climate change, there are other factors not covered in this article that could influence the water-food-energy security in Southeast Asia. These include dramatic changes in land use such as deforestation, and intensive human water management projects such as dam building in the Mekong river. It is also worth mentioning that environmental sustainability, transboundary risk and climate uncertainty should jointly be considered when planning for future mitigation and adaptation strategies, so that regional water-food-energy security goals can be achieved in a robust and adaptive way. Given the increased interconnectedness of the water, food, and energy sectors, integrated approaches across multiple disciplines (e.g. hydrology, climate, economics, and the social sciences) need to be utilised to minimise trade-offs and maximise potential synergies. But challenges still exist in terms of how to develop a flexible, coherent and policy-relevant platform that could harness the latest advances in each field, which are oftentimes scale-dependent and require different types of datasets (He et al., 2019).

Fortunately, emerging opportunities exist to aid us towards a better understanding and predictability of the climate-water-food-energy relationship, including progress in hyper-resolution Earth system modelling (e.g. Schneider et al., 2017; Wood et al., 2011), proliferation of geospatial big data from various sources (e.g. Sheffield et al., 2018), and advances in artificial intelligence, especially deep learning algorithms (e.g. Reichstein et al., 2019), among many others. By leveraging these opportunities with interdisciplinary and collaborative efforts, we can transcend existing norms and frameworks and gain new insights to address existing and emerging challenges related to water-food-energy security. These interdisciplinary approaches can also be used to promote environmental education in the classroom, where knowledge about the climate, water, food and energy can be imparted to our youth to transform their thinking for a more resilient and sustainable future. ∞

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