Melanie Ho
W.S. Neal High School
East Brewton, AL
Vietnam, Sustainable Agriculture

The Effects of Drought and Salinity on the Vietnamese Mekong River Delta

Vietnam is one of the fastest-developing countries in Southeast Asia despite being the subject of colonization, war, and international ostracism. Vietnam has transformed from a small farming country to a nation with a robust agro-food industry. Now, according to the U.S. Department of Agriculture, Vietnam is the third-largest rice exporter in the world (Foreign Agricultural Service, 2020). This is largely due to the small family farms of the Mekong Delta; ninety percent of all exported rice comes from the region's rice paddies (Consultative Group on International Agricultural Research, 2016). Other major exports grown in the region are maize, sweet potato, and cassava (General Statistics Office, 2010). However, the Mekong Delta's smallholder farms are facing challenges as rising sea levels and hydro-infrastructure bring two problems: droughts and water saltwater intrusion. 1.5 million hectares of smallholder land was affected by salinity in the 2015-2016 harvest year (USDA Food Agricultural Service, 2016). The conditions only worsened in 2019, with the dry season bringing historic drought and salinity levels. Through cross-disciplinary innovation and diplomacy, Vietnam can mitigate the effects of drought and salinity on the Vietnamese Mekong Delta, creating sustainable agriculture as a result.

Since 1986, the "Doi Moi" reforms liberalized international and domestic trade. The Socialist Republic of Vietnam made a drastic transition away from a centralized economy to a market- and industry-based economy. (Centre for Economic Policy Research, 2010). The effects of these reforms can still be seen today: gross domestic product (GDP) increased an average of 6.4% over the past fifteen years (Census and Economic Information Center, 2019). Now, Vietnam is home to over 95 million people, which includes the fastest-growing middle class Southeast Asia (Boston Consulting Group, 2013). These reforms have not only increased manufacturing production but also intensified the agriculture in the Mekong Delta.

The Mekong River begins in southeastern China near the Tibetan Plateau before forming the border between Myanmar and Laos. Then, it transverses Laos, Cambodia, and through southern Vietnam out to the South China Sea (Encyclopedia Britannica, 2019). Annually, moist air is carried from the Indian Ocean. The monsoonal wet season for the Lower Mekong Basin is June to October. Then, the Lower Mekong Basin's cooler dry season occurs from November to February. The months of March and April is an especially hot and dry transition season, disrupting the wet environment necessary for many farmers (Mekong River Commission).

The Mekong Delta Region (MDR) in Vietnam is thirteen provinces and home to approximately 20% of the population, or 21.49 million people. Also known as Vietnam's agricultural "rice bowl," the MDR supplies 57% of rice production. Thus, the MDR is responsible for providing food security to 70% of the population . For being a region of high productivity, the region is, counterintuitively, composed of small farms. Agricultural land spans 2.6 million hectares (ha) (CGIAR, 2016). Meanwhile, the average farm

spans only 1.2 ha. Still, this is significantly higher than the national average, 0.4 ha (Marsh & MacAulay). Population density is concerning. Many grocery stores and markets depend on its location. Also, weather events put floating and coastal homes at high risk of being destroyed (Materials science, Engineering, and Chemistry Conferences, 2018). Many of these household members in the MDR are dependent on their farming for food security, whether it be to provide them economic access to food or subsistence farming. Drought and salinity further compounds the hardships of the dry season.

Water salinity is defined as an excess amount of salt, sodium and chlorine. Sodium, especially, is toxic to water uptake and transpiration. As a result, rice plants have a reduced germination rate, reduced rice plant height, and poor root growth. To farmers, salinity will show itself in rice plants as white leaves and "patchy growth in the field" (Potash and Phosphate Institute, 2000). Farmers will most likely experience lower crop yield or poorer quality rice, meaning it will not meet standards for sales or exportation. In Vietnam, salinity is caused by several factors. First, climate change's rising sea levels can lead to harmful saltwater intrusion. Vietnam's situation along the South China Sea, the Gulf of Tonkin, and the Gulf of Thailand makes it especially vulnerable to sea level rise (Encyclopedia Britannica). Saltwater sea levels are expected to rise 5-7 cm per 10 years (International Water Association, 2018). Parallel to this fact, a sea level rise of 20 cm could lead to the delta waters moving 25 km closer to the sea, and thus saltwater intrusion moving upstream and into rice paddy fields (Climatic Change, 2004).

Secondly, salinity is magnified by drought. Upstream dams are generating electricity but causing droughts for the coastal regions of the MDR. Damming and storing water causes less water and sediment to flow to the MDR. As a result, because of low freshwater discharge, the Mekong River is not able to push back seawater from the South China Sea's rising tides. The water to salt ratio becomes disproportionate, resulting in harmful amounts of salt in the delta's irrigation water (CGIAR, 2016). The combined effects of drought and salinity can be observed in Vietnam's seasonal weather patterns. For example, although more freshwater was present during the wet season, salinity only reached 15 km into the delta. Conversely, the dry season's salinity intrusion was as far as 50 km upstream (Wassmann, 2004). According to one assessment, this can be attributed partly to upstream provinces such as An Giang, Can Tho, and Dong Thap damming and using freshwater before it could flow further down to the lower Mekong Delta provinces (CGIAR, 2016). But, more broadly, dams in other countries are also affecting the delta.

Most diversion of freshwater comes not from Vietnam but from large hydropower projects in other Asian countries. As China and many Southeast Asian countries' economies continue to develop, more hydropower infrastructure is being planned to meet the increasing demand for electricity. Future hydropower dams are being planned. In addition to China's eleven dams, eight more are being planned along the upper Mekong River. Also, after the Xayaburi and Don Sahong dams, Laos has an ambitious seventy-two large dams planned, of which twelve are under construction and twenty being planned (Asia Times, 2019). Upstream dams are affecting not just Vietnam but also Thailand and Cambodia. In 2019, the Mekong River Commission (MRC) reported 40 billion cubic meters of water were withheld from a combined 10 dams. The MRC also foretold the river flow being reduced by half due to dam equipment testing in January 2020. Rightfully predicted, the first three days saw the normal water flows of 1,200 to 1,400 cubic meters per second of water output drop to 504 to 800 cubic meters per second (MRC, 2019).

Satellite imaging shows the Mekong River turning aquamarine “ocean” blue instead of its normal brown (National Aeronautics and Space Administration Earth Observatory, 2020), meaning seawater is unable to be met with important river water and sediments. These hydropower structures are examples of how non-climatic drivers of drought are similar to the effects of climate change, except these non-climatic drivers are condensing similar impacts into dramatically smaller timelines.

Fluctuations in the Mekong River’s salinity threaten the large population living in the Mekong Delta. The threshold for salinity in drinking water is 1 mg/l, while salinity for irrigation is 4 mg/l (MRC, 2018). In 2016, salinity reached as high as 4 grams per liter, which occurred in the Tien and Hau Rivers. The most severely affected* farms were “burnt out,” having dry and cracked fields. Drought and salinity affected 400,000 ha of cropland. Furthermore, 208,394 households did not have freshwater for personal use (CGIAR, 2016). The MDR’s 2020 dry season surpassed the historic drought of 2015-2016. As recently as 2020, Vietnam had the highest levels of salinity and drought recorded. According to personal interviews with the region’s farmers, normally, a month of salty waters would be manageable. However, this has not been the case, salty waters arrived and stayed for at least four months (Al Jazeera, 2020). Until now, droughts were told as the consequence of climate change or meteorological events like El Nino.

The Vietnamese government’s Ministry of Agriculture and Rural Development (MARD) has taken steps to build better infrastructure, such as new irrigation systems in the Mekong Delta Integrated Climate Resilience and Sustainable Livelihoods Projects (2019). However, infrastructure itself is not sustainable without running the risk of increasingly expensive spending as drought and salinity inevitably worsen because of external global forces, like climate change and mainstream hydropower projects. Delta sustainability requires hardware—infrastructure—as well as software—agricultural practices, technology, and water management—combined (CGIAR, 2016). Vietnam will need to implement solutions, “software,” such as modified crops, water management systems, and water diplomacy with other countries.

An early, practical solution towards sustainable agriculture could be transitioning to climate-resilient crops. Fruits and vegetables can be naturally salt- or drought-resistant. For instance, mango is a drought-tolerant fruit, and coconut, papaya, jackfruit, tamarind, and guava are salt-tolerant fruits (CGIAR, 2016). Also, cotton has a high salt- and drought-tolerance followed by beets, spinach, broccoli, peanuts, soybeans, and cowpeas. Salt-tolerant varieties of rice also exist and will need more funding for better implementation in the MDR. Salt-tolerant varieties have been developed in many countries. According to the International Rice Research Institute (IRRI), commercial salt-tolerant rice varieties in Vietnam have been released such as

- OM2717
- OM2517
- OM3242

Plus, there has been developing research into water-efficient crops: the IRRI is developing a rice crop with alternate wetting and drying technology (AWD), which is able to reduce water use by 30% and greenhouse gas emissions by 30-70%, all without decreasing rice yields. Finally, saline, brackish water is

highly suitable for aquaculture, which is known for shrimp farming. Currently, the MDR's rice-shrimp rotation model has proved to be more sustainable. This would lead to better use of freshwater for irrigation, and capitalize on water salinity to satisfy the demand for shrimp (Climate Change Management, 2019). In the end, increased aquaculture transitions away from rice monoculture and diversifies the diets of the Vietnamese. With great success, the MDR's aquaculture has contributed 41% of the nation's aquaculture production (CGIAR, 2016). For the Mekong Delta, encouragement of these agriculture techniques would be able to reduce the demand for water.

Another solution would be underground storage of floodwater to use during the MDR's dry season. Underground Taming of Floods (UTFI) will protect fields from being hurt by overflowing. Instead, water flows through a series of irrigation canals and into ponds. Then, ponds are connected to groundwater reserves for storage. This would help against groundwater depletion, homes and infrastructure damage, and water security during the dry season. The UTFI method has been proposed as an alternative to damming, and it would also create a better relationship between upstream and downstream provinces because targeted areas would have to work together. UTFI has been piloted in South Asian countries like India (International Water Management Institute). Vietnam and other countries meet the same requirements to become a recipient of UTFI and have much to gain from more UTFI testing in the MDR.

Finally, international collaboration will be necessary to stop the harmful effects of hydropower. Hydropower was seen as a better alternative to energy produced by coal, and the Chinese began planning projects in the 1960s. However, new sustainable energy sources have been found. In fact, many international organizations, such as the World Bank and the Mekong River Commission, have taken opposition to the construction and use of hydropower dams along the Mekong River. The World Bank refused to fund construction. The Mekong River Commission has requested a ten-year moratorium, or ten year halt of all dam construction. Data has shown investment into exporting electricity may bode well for the economy, but hydropower is the wrong investment in the long-term. Tertiary effects would damage the economies further along the Mekong River. Thailand and Cambodia have stopped construction of some dam projects (Al Jazeera). Instead, investments into wind and solar power river-dependent regions untouched.

To build sustainable agriculture, using scientific research to improve crop resilience, using innovation to repurpose water, and using economics to analyze the farming communities. Then, as salinity and droughts affect the Mekong Delta Region, simple collaboration between agricultural institutions and households will not be enough. Large-scale water diplomacy and management needs to take place. Farmers and families will need to have a voice in government meetings. Then, governments will need to take action on behalf of those families to ensure the security of their food and livelihoods. Creating sustainable agriculture in the face of global challenges like climate change and mainstream hydropower dams will, in the end, require global collaboration.

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