

Security and Climate Risk

# Converging Crises in North Korea: Security, Stability & Climate Change



Woodwell Climate  
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Security and Climate Risk

# Converging Crises in North Korea: Security, Stability & Climate Change

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*A banner exhorts workers in the northeastern city of Hamhüng. By Joseph Ferris III*

# Key Findings

The stability of the Democratic People's Republic of Korea (DPRK, or North Korea), a nuclear-armed country, presents a serious concern to global security and in particular to the security of the Indo-Pacific region. Climate change will introduce a series of stressors to North Korean society, which could upset its fragile governance and resource base and lead to instability or conflict.

This study projects climate impacts on crop yields by 2030, inland flooding by 2050, and sea levels by 2050 in North Korea:

- Climate projections show rice and maize yield failures will become more likely along the Western coastline, North Korea's historical breadbasket.

— North Korea will experience significant intensification of extreme rainfall and increased flooding due to climate change.

— Coastal areas are increasingly at risk from sea level rise.

The subsequent societal effects of these changes could be wide-ranging and grave, ultimately increasing regional instability, exacerbating underlying tensions, and introducing new escalatory pressures and misinterpretation risks. Opportunity lies in understanding and mapping the climate impacts that North Korea will face in the coming decades, and supporting global and regional initiatives to increase climate resiliency in the country.

## Introduction

North Korea has adopted a posture of belligerence with regard to the international community, grounded in self-sufficiency (tempered by dependencies on China), and a nuclear arsenal which successive leaders have prioritized over the needs of its people. North Korean citizens, starved of both nutrition and information, may not be aware of the fragility of their situation. What is clear is that their livelihoods, and potentially the stability of the regime, are vulnerable to impending climate change.

This report, part of a series looking at the nexus between climate change and security in and between nuclear-armed states, surveys major climate effects in North Korea, with regard to how they may influence the stability of the Kim regime and regional dynamics. Climate change has the capacity to further compromise North Korea's already precarious ability to provide public goods for its population and thus maintain regime stability, multiplying threats for the Korean peninsula and the entire region.

# Climate Impacts: Food Insecurity, Floods, and Sea-level Rise



Apartment blocks in Hyesan, near the Chinese border. By Stefan Bruder

Long-term regime stability is a perennial concern in North Korea, which regularly threatens its neighbors and the United States.

Climate impacts may weaken the ability of the Kim regime to deliver basic public services and governance functions, such as provision of food, shelter, safety, and energy. Multiple climate impacts will likely worsen food insecurity, damage infrastructure, induce migration, and constrain resources. Ordinary citizens of North Korea will bear a disproportionate share of the burden. These additional stresses could create pockets of domestic upheaval that could negatively influence the country's general stability. The implications for regional security, including an escalatory conflict leading to nuclear weapons use, are complex and concerning. New climate projections provide a lens through which to understand how security and climate in North Korea may interact over the next three decades.

Given the paucity of existing research on climate change in North Korea, this study projects future climate impacts at selected locations of interest to serve as examples for future research. Discussions about climate change are largely absent from both international coverage and North Korean state media. An exception is disaster management: Kim Jong Un has made several high-profile visits to affected areas directly after disaster events to survey destruction and oversee rebuilding efforts, including most recently in 2020.<sup>1</sup>

Throughout the Korean Peninsula, warmer temperatures and increases in humidity will drive monsoons northward<sup>2</sup> and produce greater intensity in typhoons.<sup>3</sup> More intense storms already appear to be affecting North Korea; the Korean Central News Agency (KCNA), in an uncommon occurrence, highlighted severe damage from intense rains in August 2020 and from Typhoon Maysak and Typhoon Haishen in September 2020.<sup>4</sup> Heat waves and heat mortality risk will also likely increase, as will extreme precipitation events, damaging infrastructure and agriculture.<sup>5</sup> This paper focuses on climate impacts in three main areas: food insecurity from crop yield reductions; flooding at key strategic sites, population centers, and major agricultural areas; and sea level rise in population centers.

# Food Insecurity

Food insecurity has been a persistent humanitarian concern in North Korea for decades due to poor planning, deforestation, and substandard farming techniques.<sup>6</sup> A recent USDA study identified North Korea as one of the most food-insecure countries in the world, with more than 59% of the population suffering food insecurity in 2020.<sup>7</sup> Damaging rains in 2020 caused a reduction in yields, and in 2021, after all major non-governmental organizations (NGOs) had left North Korea, Kim Jong Un publicly and starkly warned of a potential famine.<sup>8</sup> Looking forward, climate-related disasters are expected to compound existing food insecurity, nutrition deficit and humanitarian conditions. Poor management of future agricultural and economic crises may increase migration or spark other small crises. The rice and maize breadbasket of North Korea is one region of high concern regarding these stressors.<sup>9</sup>

In both 2017 and 2019, North Korea experienced serious droughts that decimated major crops such as rice, soybean, and maize. This, combined with economic sanctions, led to devastating food shortages.<sup>10</sup> Climate projections indicate that areas of the South Hamgyong and North Pyongan provinces, which cultivate a combined 38% of

the country's rice and 30% of its soybeans, will experience up to an additional 3 months of severe drought each year by 2035.<sup>11</sup>

The majority of North Korea's rice and maize crops are grown in three provinces: South Hwanghae, South Pyongan, and North Pyongan. Changes in precipitation and temperature will shift favorable climate conditions for growing rice and maize away from coastal areas to more inland areas in the breadbasket provinces (Figure 1). Climate projections show rice and maize yield failures will become more likely along the Western coastline and less likely in inland areas by 2030.<sup>12</sup> Due to the mountainous topography of inland North Korea, it is unlikely the breadbasket will shift completely to inland provinces to adapt to climatic changes. Despite the coastal-inland variation, a rice yield failure across the breadbasket is projected to occur more often, from once every 7 years to once every 5 years. However, a maize yield failure across the breadbasket is projected to occur less often, from once every 6 years to once every 8 years. Though North Korea's breadbasket may struggle to supply historical quantities of rice, maize yields are likely to become more stable in the upcoming decades.

Change in Probability of Crop Yield Failures by 2030

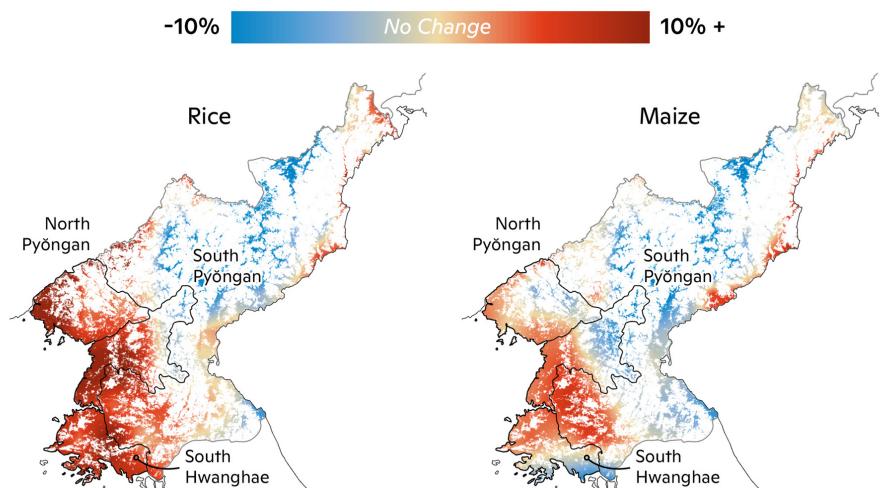


Figure 1: Change in the probability of rice (left) and maize (right) yield failures in 2021-2040 compared to 2001-2020.

# Inland Flooding

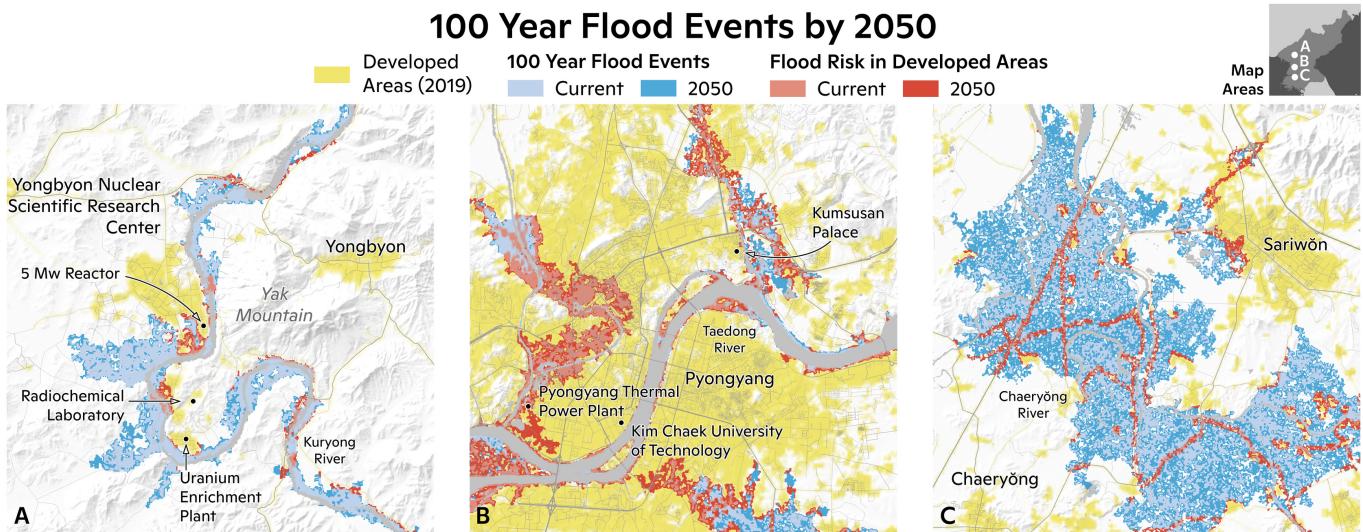
North Korea will experience significant intensification of extreme rainfall due to climate change. Military installations, residential, commercial and transportation infrastructure, and agricultural facilities located in flood-prone areas are increasingly at risk. Mitigating these impacts will require already scarce resources and could precipitate internal conflicts over how to allocate such resources. Although seasonal flooding is already common, the increased precipitation will translate into larger floods that happen more frequently. Deforestation, a process which amplifies flood risk by depleting the intercepting tree canopy and soil-anchoring root systems,<sup>13</sup> is a perennial problem in North Korea.<sup>14</sup> In 2020 North Korea announced several initiatives to bolster flood defenses, including a campaign for preventing damage in rural communities by overhauling hundreds of reservoirs and drainage facilities.<sup>15</sup>

This study models inland flooding at three locations of interest: the Yongbyon Nuclear Scientific Research Center; Pyongyang, the country's capital; and North Hwanghae Province, a largely agricultural region that experienced severe floods in 2020 (Figure 2).<sup>16</sup> These locations serve as a survey of potential climate impacts at strategic facilities, population centers, and agricultural areas in North Korea, providing a basis for assessing security implications.

## Yongbyon Nuclear Scientific Research Center

The Yongbyon Nuclear Complex is a primary location for fissile material production. The facility, situated on the Kuryong River, houses key components of the North Korean nuclear weapons program, including an intermittently operated 5-megawatt (5MWe) electrical nuclear reactor for plutonium production; an experimental light water reactor (ELWR) under construction; a radiochemical laboratory for reprocessing spent reactor fuel; a uranium enrichment plant; as well as many other ancillary functions necessary for a nuclear weapons program. The 5MWe reactor and the ELWR are the most proximate to the Kuryong River, in part because the river serves as a water source for cooling. Seasonal flooding has occurred along the Kuryong River near the cooling systems for the 5MWe and ELWR reactors, and climate change increases the potential for severe flooding.<sup>17</sup> If not properly

**Figure 2:** The current (light blue) vs 2050 (dark blue) extent for the 1-in-100 year flood for (A) the Yongbyon Nuclear Scientific Research Center, (B) Pyongyang, and (C) North Hwanghae Province. Developed areas (yellow) indicate land covered predominantly by buildings and other man-made structures.



anticipated, such flooding could damage the coolant pumps and their associated power systems, or the pipes that transfer water from the Kuryong River, potentially affecting reactor operations.

Floods that were historically considered a 1-in-100 year event (a flood event that has a 1% chance of occurring each year) in the 1971-2000 time period will become a 1-in-68 year event by 2050. Without more accurate digital elevation models it is difficult to model the precise impacts to the facility, but flooding likely presents a threat to both consistent production of fissile materials and the safe functioning of the reactors.

Although Yongbyon personnel have reportedly installed mitigation measures, the construction histories of and the safety practices at North Korean nuclear facilities are difficult to assess.<sup>18</sup> Planning for future events is also not well understood. An extreme flood may pose a risk to infrastructure that houses sensitive nuclear and other toxic materials and introduce into the environment radiation and other health hazards if not properly contained. A genuine nuclear emergency at Yongbyon would likely lead to panic among North Korean citizens. Yongbyon is monitored closely by North Korean specialists, and international attention would reverberate globally, likely sparking a crisis among citizens and governments in neighboring countries.<sup>19</sup>

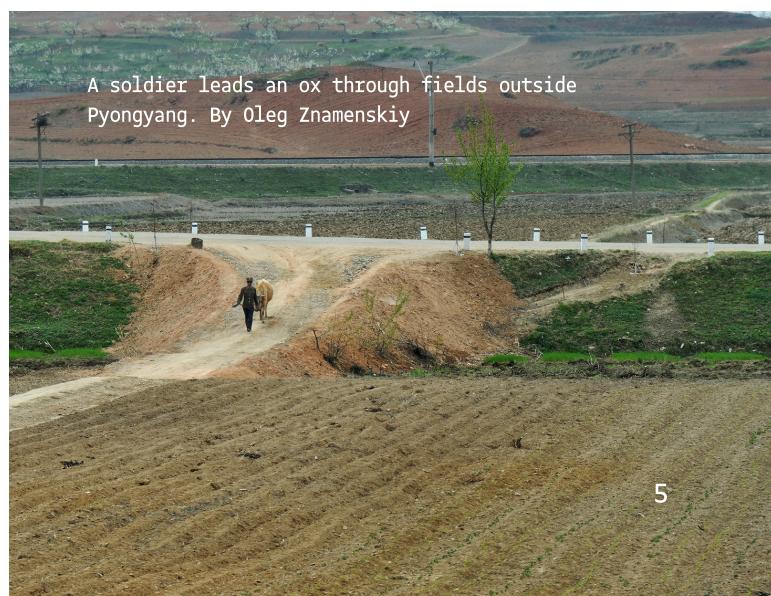
In addition to the environmental and health risks, damage to sensitive facilities may be a catalyst for broader disruption—potentially influencing the regime’s risk calculation for weapons production and deployment. The regime might have an incentive to increase weapons production or to alter weapons deployment plans and locations, introducing additional uncertainty as to their posture.

The regime also may decide to divert resources from civilian projects, with an adverse spillover on national security. This and other nuclear, missile, and general military facilities that face climate risk would profit from more granular modelling and study.

### *Pyongyang*

As the country’s capital and most populous city, Pyongyang is an important political, economic, and cultural center for the Kim regime. Much of the critical infrastructure it houses is under Korean People’s Army control, and it performs both civilian and military functions for the entirety of the country. Thus, flooding in Pyongyang has strategic implications, and North Korea’s experience of and response to these effects would certainly inform security analyses by other nations. Those changing perceptions and calculations could contribute to major changes in actions if flooding or other climate impacts were to occur during a crisis or when tensions are higher than normal.

Flood control options for the Taedong River, which runs through the city, are limited. During the 2020 rainy season, bridge traffic in Pyongyang was halted twice out of concern for the stability of bridges over the Taedong River in high waters.<sup>20</sup> Current 1-in-100 year flood events will become 1-in-34 year events, almost tripling in probability, by 2050.



A soldier leads an ox through fields outside Pyongyang. By Oleg Znamenskiy



### North Hwanghae Province

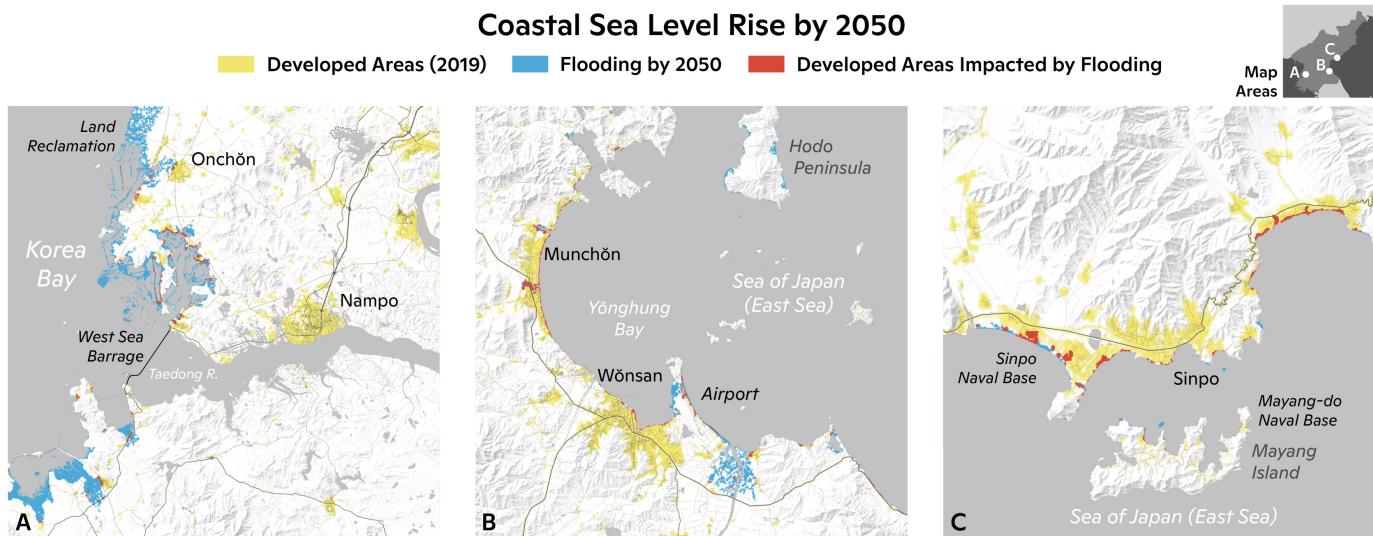
Several of North Korea's primary agricultural regions will be susceptible to increased inland flooding. In August 2020, devastating floods occurred in North Hwanghae Province near the city of Sariwon. The flooding was so severe as to merit multiple visits from Kim Jong Un, first to inspect the damage to croplands and residential neighborhoods, and then to inspect residences that had been rebuilt.<sup>21</sup> Indeed, in 2020 the North Korean regime publicly warned of potential crop failures stemming from this unusually wet summer and agricultural monitors noted affected rice-producing areas.<sup>22</sup> Extreme flood risk is projected to almost double in this area—a 1-in-100 year flood will become a 1-in-57 year flood event—by 2050.

By Shota Tokuda (2017)

## Sea Level Rise

Coastal North Korea is also experiencing sea level rise. Under a business-as-usual scenario, North Korean sea levels will rise by 0.3 meters (0.98 feet) by 2050.<sup>23</sup> Approximately 553,000 people are expected to be impacted by annual floods exacerbated by sea level rise by 2050. Intense storm surge in coastal areas is already occurring.

This study modeled projected sea level rise for three coastal locations in North Korea to serve as examples of the scale of impact and assess potential security interactions: Nampo, a major port on the west coast located at the mouth of the Taedong River; Wonsan, a large port on the east coast<sup>24</sup> and a city vital to tourist interests in North Korea; and Sinpo, a major naval base (Figure 3).<sup>24</sup>



**Figure 3:** The extent of projected inundation from present annual floods plus sea level rise by 2050 at (A) Nampo, (B) Wonsan, and (C) Sinpo.

As with inland flooding, North Korea has indicated some concern for sea level rise—the 2020 campaign to overhaul reservoirs and drainage facilities also included a push to reinforce sea walls.<sup>25</sup>

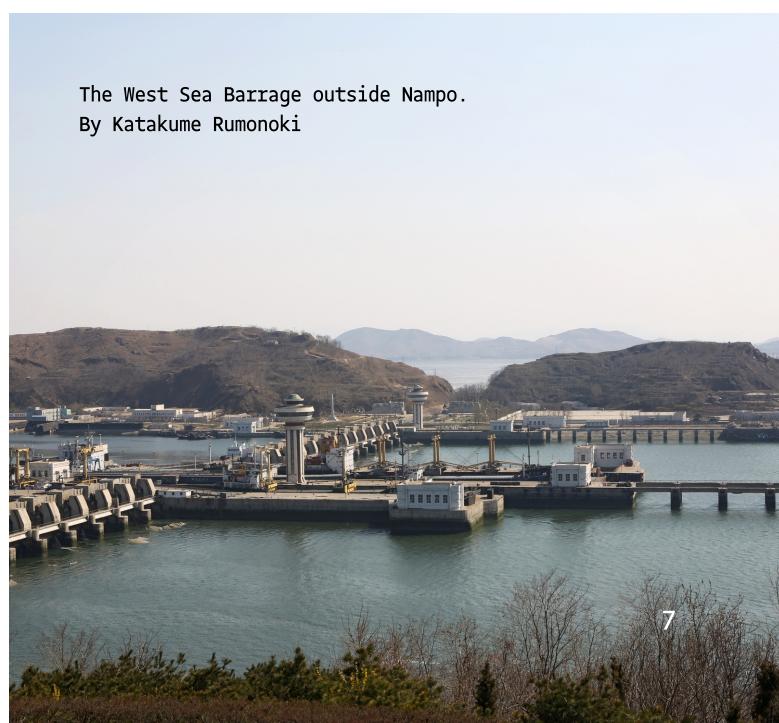
Existing flood barriers constructed in the 1980s near Nampo at the West Sea Barrage (located by the mouth of the Taedong river) protect against flooding and create a large freshwater reservoir and additional arable land. The sea level rise risk is minimal for the Nampo port and city. As with many dams, sediment buildup from silt and stones carried downstream by the Taedong River requires dredging. However, hardening the coastline diminishes the ecosystem services provided by wetlands and other coastal systems. Natural and man-made flood defences should be configured to work in tandem to mitigate flood risk but also provide long-term ecological resources.<sup>26</sup> Nonetheless, the regime's infrastructure at Nampo serves as an example of how to mitigate risks to other coastal areas.

Of more concern are a port and airport located on the Eastern coast of North Korea at Wonsan. Wonsan lacks significant flood barriers, and thus faces a higher flooding risk than Nampo. Wonsan is a favored location of the Kim regime, and has been important for attempts to grow the tourism industry in North Korea. It also provides a retreat for the Kim regime, and on many occasions the airport and adjacent beach have served as a location for missile and artillery testing, including that of short-range ballistic missiles, multiple rocket launcher systems, and other tactical systems. Flooding at key ports and airports, many of which serve as hubs for exports that provide a crucial source of revenue for the regime, could disrupt supply chains in North Korea if the infrastructure needed for normal port operations is threatened.

Flooding of coastal military infrastructure in North Korea could disrupt normal military

operations and weapons deployments. The Sinpo Naval Base, a major installation on the country's east coast that also houses parts of the submarine ballistic missile program, faces a coastal flooding risk by 2050. The production, testing, maintenance, and deployment infrastructure of key naval assets faces higher inundation, which would necessitate rebuilding or moving these functions to other areas. Moving or adding resilience to coastal military assets can be expensive for any military. Any amphibious training elements at such a base could become useless for certain activities with even minimal sea level rise. Maintaining hard infrastructure, in particular that related to submarines, would also be costly.

In fact, many military installations, strategic manufacturing facilities, and other locations important to the Kim regime in coastal areas merit closer scrutiny. Adverse impacts at military installations may necessitate changes to, as well as a diversion of resources from, civilian infrastructure. In a worst-case scenario, disruptions could induce adversaries to misinterpret climate mitigation efforts as a genuine change in military strategy. This is especially concerning for this region, in which risks stemming from potential misinterpretation and miscommunication actively shape military plans and force postures.



The West Sea Barrage outside Nampo.  
By Katakume Rumonoki



# Regional Instability

Although climate impacts in North Korea pose the most immediate threats to internal domestic control and regime stability, they may also exacerbate underlying tensions in the region and introduce points of escalation with other actors.

Increased flooding risk in particular may drive instability in North Korea-Republic of Korea (ROK) bilateral relations by introducing shared downstream effects and opportunities for destabilizing actions. Several rivers in North Korea discharge into the sea along South Korea's west coast as well as into the Imjin River along the DPRK-ROK border, and large discharges of excess water by North Korea during heavy rains can adversely affect South Korea.<sup>28</sup> Hwanggang Dam, near the DPRK-ROK border, is of particular concern. In September 2009, a flash flood in South Korea along the Imjin River killed several people after a release through the Hwanggang Dam in the North. After this incident, the two countries signed a dam release notification agreement, but North Korea still engages in unannounced dam releases, including at least three during the 2020 rainy season.<sup>29</sup> Additionally, North Korea reportedly has used flooding as a cover for military provocations. These types of events serve as escalatory stressors in DPRK-ROK relations.

If living conditions for North Korean citizens become more dire and the regime cannot meet the basic needs of citizens, mass migration could occur from the country to its neighbors. While it is difficult to assess what the breaking points might be, a conservative estimate of 30,000-50,000 migrants have left since the 1990s famine, predominantly to China and South Korea (Figure 4).<sup>30</sup> A mass migration has never been realized, but an increase in migration or defection attempts in the form of genuine climate refugees will likely put political pressure on both North Korea and its neighbors. Given that China receives the most defections, the relatively stable relationship between Beijing and Pyongyang may face new strains. Degradation in this bilateral relationship may have implications for broader regional dynamics, as North Korea could feel marginalized and seek to provoke additional tensions among neighbors with increased nuclear and conventional weapons buildup and testing.

Soldiers clap at a parade in Pyongyang. By Shutterstock user Astrellok

Climate impacts may induce North Korea to alter weapons deployment or production, introducing ambiguity into regional expectations. If established production and deployment sites become unusable due to climate impacts, mitigation attempts for such infrastructure might be misperceived. If the regime feels particularly vulnerable to climate impacts, especially in comparison to South Korea or Japan, there might be a perverse incentive to increase the production of strategic weapons systems to demonstrate relative strength and resolve. Changes in the regime's risk calculus also may prompt provocations. North Korea routinely has tested conventional and nuclear-equipped weapons systems over the past decade, both for a domestic audience and in response to perceived foreign criticisms and threats. At times North Korea has initiated attacks against neighbors. In 2010, after the collapse of the six-party nuclear talks, tensions were particularly high after North Korea sank a South Korean naval vessel, the Cheonan, and fired artillery shells at Yeonpyeong island in South Korea.<sup>31</sup> Tensions abated without further serious incidents at the time, but the escalatory potential after North Korean provocations remains high. In such murky times, a neighbor also could take advantage of North Korean weakness and instability. North Korea is not alone in building up military capabilities. South Korea's own growing short range ballistic missile systems and missile defense infrastructure is at play, increasing the incentive for a preemptive strike by either side targeting national leadership and strategic sites.<sup>32</sup>



Conversely, climate change impacts may open up new avenues of negotiation and cooperation among North Korea and regional allies on broader security issues. Food aid has served as a major lever during past nuclear negotiations, and assistance in building resilience and mitigating adverse climate impacts may also be an important carrot going forward. Engaging with North Korea on climate change on its own merits also may open a path for negotiations on other more sensitive issues.<sup>33</sup>

**Figure 4:** Historic migration patterns from North Korea to neighboring states.

# Conclusion and Recommendations

Much work in understanding and mapping the climate impacts that North Korea will face in the coming decades remains to be done. Opportunities for the United States and allies in the Indo-Pacific region are currently limited, but more options may be illuminated by granular research. Additional research on climate impacts to critical crops, major military sites, nuclear facilities, and commercial hubs in North Korea is also needed. Specific variables to research further include: existing flood defenses at Yongbyon and other facilities handling nuclear materials; disaster response plans at missile deployment sites; projected impacts to all major agricultural-producing regions; flooding disruptions to worker housing units and agricultural production areas at key military facilities; and sea level rise impacts to coastal military and commercial infrastructure.

A near-term opportunity is to work to restore NGO access, which has been severely curtailed since the coronavirus pandemic in 2020.<sup>34</sup> NGOs likely will play a crucial role both in providing local observations and in coordinating relief efforts.

Supporting global initiatives to increase climate resiliency in North Korea should also be a priority.<sup>35</sup> The DPRK appears to be open to international support for mitigation and adaptation. The United Nations Green Climate Fund approved a project to be implemented through the UN Food and Agriculture Organization with the North Korean Ministry of Land and Environment Protection to develop a package of training and capacity building exercises.<sup>36</sup> While success is not guaranteed, this type of support could also increase transparency with North Korea more generally while providing valuable support to North Korea as well.

A longer-term proposal could center on building a regional climate forum to address climate impacts on the Korean Peninsula. A forum dedicated to this issue could provide an opportunity for joint future research and cooperative monitoring of climate impacts as well as a venue for differentiating climate-related disruptions from intentional military actions in times of heightened tensions.

Climate change has the capacity to further compromise North Korea's already precarious ability to provide public goods for its population and thus maintain regime stability, multiplying threats for the Korean peninsula and the entire region. North Korea will bear significant risks from climate change, and in the interest of its citizens and regional stability, more research needs to be done to better understand the granular climate impacts the country will face. In tandem, the United States and its allies should develop strategies for climate mitigation and adaptation as a means to increase overall stability and security in the Indo-Pacific region.

## Endnotes

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- [<sup>1</sup>] Silberstein, Benjamin Katzeff, “[North Korea’s Disaster Management: Getting Better, but a Long Way to Go](#),” 38North, 14 September 2020, and Hoare, James E., “[North Korea’s Disaster Management: A Comment About Perspective](#),” 38North, 3 November 2020.
- [<sup>2</sup>] Jung, I.-W., Bae, D.-H., & Kim, G. (2011). [Recent trends of mean and extreme precipitation in Korea](#). *International Journal of Climatology*, 31(3), 359-370.
- [<sup>3</sup>] Kim, J.-S., & Jain, S. (2011). [Precipitation trends over the Korean peninsula: Typhoon-induced changes and a typology for characterizing climate-related risk](#). *Environmental Research Letters*, 6(3), 034033.
- [<sup>4</sup>] Zwirko, Colin, “[North Korea’s east coast hit with damaging typhoon and floods, state TV shows](#),” NK News, 3 September 2020, and Zwirko, Colin, “[North Korean leader visits site of major flood damage after days of storms](#),” NK News, 6 August 2020.
- [<sup>5</sup>] Im, E.-S., Lee, B.-J., Kwon, J.-H., In, S.-R., & Han, S.-O. (2012). [Potential increase of flood hazards in Korea due to global warming from a high-resolution regional climate simulation](#). *Asia-Pacific Journal of Atmospheric Sciences*, 48(1), 107-113.
- [<sup>6</sup>] Chemnick, Jean, “[With Widespread Deforestation, North Korea Faces an Environmental Crisis](#),” *Scientific American*, 19 April 2019, and World Food Programme, “DPR Korea Country Brief,” January 2020.
- [<sup>7</sup>] Baquedano, F., Christensen, C., Ajewole, K., and Beckman, J. “[International Food Security Assessment, 2020-30](#),” U.S. Department of Agriculture, Economic Research Service, August 2020.
- [<sup>8</sup>] Bicker, L., “[Kim Jong-un warns of North Korea crisis similar to deadly 90s famine](#),” BBC News, 9 April 2021.
- [<sup>9</sup>] Mita, D., “[North Korea 2020/21 Rice and Corn Outlook](#),” United States Department of Agriculture, August 2020.
- [<sup>10</sup>] BBC News, “[North Korea Suffers Worst Drought in Decades](#),” May 16, 2019.
- [<sup>11</sup>] We calculate the number of severe drought months with [self-calibrated PDSI](#) less than -3 for a historical period, 1991-2020, and a future period, 2021-2050 (i.e., 2035), under RCP8.5 using output from a CMIP5-era high-resolution regional climate model, REMO2015.
- [<sup>12</sup>] A crop yield failure is defined as a 10% decline in yield in 2021-2040 (i.e., 2030) compared to average yield in 2001-2020. The probability of a crop yield failure is projected using an ensemble of agricultural models driven by CMIP5 global circulation models from the Agricultural Model Intercomparison and Improvement Project (AgMIP) under scenario RCP8.5. Effects of CO<sub>2</sub> fertilization are not included in the projections considering the short-term time horizon. Nitrogen limitations are accounted for.
- [<sup>13</sup>] Bradshaw, Corey JA., Sodhi, N., Peh, K., Brook, B. (2007). [Global evidence that deforestation amplifies flood risk and severity in the developing world](#). *Global Change Biology*, 13(11), 2379-2395.
- [<sup>14</sup>] Global Forest Watch, “[Tree Cover Loss in North Korea](#),” 2000.
- [<sup>15</sup>] KCNA, “Campaign for Preventing Heavy Rain Damage Launched in DPRK”, 11 July 2020 and Rodong Sinmun, “Level of Scientification of Flood Control Raised,” 15 July 2020.
- [<sup>16</sup>] The LISFLOOD-FP model was used to simulate flooding. The NASADEM was used as the digital elevation model. The Global Reach-Level Flood Reanalysis (GRFR) was used to estimate the 100-year streamflow values. The future probabilities of the present 100-year streamflow were calculated using the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP).
- [<sup>17</sup>] Makowsky, P., Pabian, F., Liu, J., Town, J. “[North Korea’s Yongbyon Nuclear Center: Significant Flooding of the Kuryong River](#),” 38North, 21 August 2020, and Makowsky, P., Pabian, F., Liu, J., Town, J. “[North Korea’s Yongbyon Nuclear Center: Drying Off](#),” 38North, 25 September 2020.
- [<sup>18</sup>] Makowsky, P., Pabian, F., Liu, J. “[North Korea’s Yongbyon Nuclear Center: Flood Damage Repairs Underway](#),” 38North, 22 October 2020.

## Endnotes

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[<sup>19</sup>] For example, Chinese citizens have expressed concern about potential radiation exposure after past North Korean nuclear tests. See Gao, Charlotte, “[Earthquake in North Korea Sparks Worry in China](#),” The Diplomat, 25 September 2017, and Henochowicz, Anne, “[Netizen Voices: Fear of Radiation from North Korea](#),” China Digital Times, 13 February 2013.

[<sup>20</sup>] Green, Christopher, “[Why heavy rain and border water pose a chronic political risk for South Korea](#),” NK Pro, 11 August 2020.

[<sup>21</sup>] Cha, Sangmi, “[North Korea’s Kim inspects flood relief; worry grows about crops](#),” Reuters, 6 August 2020.

[<sup>22</sup>] Zwirko, Colin, “[Food shortages expected after wettest summer in North Korea for decades](#),” NK News, 11 September 2020, and GEOGLAM, “[Heavy rains and flooding in August affect primary rice producing areas in the Democratic People’s Republic of Korea](#),” 9 September 2020.

[<sup>23</sup>] The RCP8.5 scenario: the most aggressive of the UN IPCC carbon emissions scenarios and the one that best matches cumulative historical emissions. Schwalm, Christopher R., Glendon, S., Duffy, P. (2020). [RCP8.5 tracks cumulative CO<sub>2</sub> emissions](#). *Proceedings of the National Academy of Sciences*. (117)33, 19656-19657.

[<sup>24</sup>] For this study the 50th percentile sea level rise values from Kopp et al. (2017) were used. The annual flood refers to the water level with a 1-year return period. The annual flood was calculated from the Coastal Dataset for the Evaluation of Climate Impact (CoDEC). An improved version of NASADEM, generated from a machine learning model, was used as the digital elevation model and a bathtub model in addition to a connected components analysis was used to generate the inundation extents. Improved digital elevation models would enable better modeling of the most vulnerable coastal areas in North Korea to sea level rise. See Kopp, Robert E., et al. (2017). [Evolving understanding of Antarctic ice-sheet physics and ambiguity in probabilistic sea-level projections](#). *Earth's Future*. 5.12, 1217-1233.

[<sup>25</sup>] KCNA, “Campaign for Preventing Heavy Rain Damage Launched in DPRK”, 11 July 2020.

[<sup>26</sup>] Zhu, Zhenchang, et al. (2020). [Historic storms and the hidden value of coastal wetlands for nature-based flood defence](#). *Nature Sustainability* (3)10, 853-862.

[<sup>27</sup>] Park, Ju-min and Pearson, J., “[In Kim Jong Un’s Summer Retreat, Fun Meets Guns](#),” Retuers, 10 October 2017.

[<sup>28</sup>] Green, Christopher, “[Why heavy rain and border water pose a chronic political risk for South Korea](#),” NK Pro, 11 August 2020.

[<sup>29</sup>] Kim, Jeongmin, “[North Korea issues warnings on potential flood at the basin of Taedong River](#),” NK News, 5 August 2020.

[<sup>30</sup>] Tanaka, Hyroyuki, “[North Korea: Understanding Migration to and from a Closed Country](#),” Migration Information Source, 7 January 2008.

[<sup>31</sup>] McDonald, Mark, “[‘Crisis Status’ in South Korea After North Shells Island](#),” New York Times, 23 November 2010.

[<sup>32</sup>] Choe Sang-Hun, “[South Korea Plans ‘Decapitation Unit’ to Try to Scare North’s Leaders](#),” New York Times, 12 September 2017.

[<sup>33</sup>] Habib, Benjamin, “[North Korea and the Global Fight Against Climate Change](#),” The Diplomat, 28 October 2016.

[<sup>34</sup>] Everard, John, “[North Korea faces uncertain future after mass exodus of UN and foreign NGO staff](#),” NK Pro, 12 April 2021.

[<sup>35</sup>] One model would be grants for regional partnerships, see as an example European Union, “[EU provides 500,000 Euro to strengthen disaster preparedness capacities in the Democratic People’s Republic of Korea](#),” 29 March 2021.

[<sup>36</sup>] Food and Agriculture Organization of the United Nations (FAO) for Democratic People’s Republic of Korea, “[Readiness Proposal](#),” 30 August 2019.

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Woodwell Climate Research Center (“Woodwell”) is an organization of researchers who work with a worldwide network of partners to understand and combat climate change. We bring together hands-on experience and 35 years of policy impact to find societal-scale solutions to address the climate crisis.

Founded in 1985 as the “Woods Hole Research Center,” we work around the globe, conducting research in collaboration with policymakers and decision makers in more than 20 countries.

THE  
CONVERGING  
RISKS LAB

*an institute of*

COUNCIL ON  
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The Converging Risks Lab (“CRL”), an institute of the Council on Strategic Risks (“CSR”), is a research and policy development-oriented program designed to study converging, cross-sectoral risks in a rapidly-changing world. The CRL brings together experts from within the CSR’s distinct institutes, and from multiple sectors of the security community, to ask forward-thinking questions about these converging risks, and to develop anticipatory solutions.

**To learn more about this work, or other climate and security analyses by Woodwell and the Council on Strategic Risks, please contact:**

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