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Review

Climate Security and Its Implications for East Asia

Takashi Sekiyama

Graduate School of Advanced Integrated Studies in Human Survivability, Kyoto University, Kyoto 606-8306, Japan; sekiyama.takashi.2e@kyoto-u.ac.jp

Abstract: This study investigated the scientific progress of climate security studies through a literature review and discussed its risks in East Asia. Climate security refers to the protection of countries and societies from conflicts and riots caused by climate change. As climate change becomes more apparent, climate security has been vigorously debated in the international community. Climate security risks in East Asia, however, are not yet widely discussed. This literature review identified that climate change increases the risk of conflict not only through direct threats to people and societies from extreme weather events and natural disasters, but also indirectly through various pathways, such as shortages of water and other resources, outbreaks of climate migration, disruptions in food production, economic and social disturbances, and geopolitical changes. Considering the climate-conflict pathways identified by the literature review, East Asia may face (1) tensions caused by climate emigrants, (2) conflicts over loss of territories and fishery areas, (3) conflicts caused by water shortage, (4) instability caused by heavy rain and floods, and (5) geopolitical risks of rare earth sourcing, green industrial policies, and the Arctic. East Asian countries need to lower climate security risks in the region through cooperative international measures such as climate change mitigation, vulnerability reduction, and policy dialogue.

Keywords: climate security; climate change; conflicts; East Asia

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1. Introduction

It is becoming apparent that human impacts have warmed the atmosphere, oceans, and land. According to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), which summarizes the latest scientific findings on climate change, the global average temperature for the most recent decade (2011–2020) has already increased by 1.09 °C compared to the late 19th century (1850–1900). Abnormal weather events have also become increasingly severe around the world in recent years. The frequency and increase in intensity of extreme temperature events, heavy 1-day precipitation evemts, and droughts that occurred once in 10 years on average in a climate without human influence now likely occur 2.8 times, 1.3 times, and 1.7 times as often, respectively [1].

Such anthropogenic climate change has caused widespread adverse impacts and related losses and damages to nature and people beyond what would otherwise have occurred due to natural climate variability. Global warming, reaching 1.5 °C in the near-term, would cause unavoidable increases in multiple climate hazards and present multiple risks to ecosystems and humans such as impacts on water scarcity, food production, health, wellbeing, settlements, and infrastructure. According to the IPCC's simulations, Asia, for example, is expected to experience damage to urban infrastructure due to flooding, reduced fishery resources due to rising sea levels, reduced precipitation, rising temperatures, and risks to food and water security [2].

As climate change becomes more apparent, there is growing interest in its economic and social impacts. The risk of conflict and violence between groups or nations caused by climate change (climate security risk) has been vigorously debated in the international community for more than a decade. For example, the United Nations (UN) Security Council has been discussing the security implications of environmental issues such as climate change since 2007 [3]. The European Union (EU) has also recognized that climate change is a remote cause of many conflicts around the world in the European Commission's 2008 report on climate change to the European Parliament and, more recently, in its Common Foreign and Security Policy document [4]. In the United States, the Republican administration of George W. Bush in 2007 was the first to backtrack on the issue of climate change, but the Biden–Lugar Resolution, adopted by the Senate Foreign Relations Committee by future President Joe Biden and others, noted the potential impact of climate change on US national security interests [5]. Later, in 2010, when the Obama administration came to power, the Quadrennial Defense Review (QDR) also made a direct reference to the national security threat posed by climate change [6]. Against the backdrop of this growing debate on the policy side, the number of papers dealing with climate security in the academic community increased dramatically after 2007.

Discussions on climate security have also been conducted in East Asia. In Japan, the Ministry of the Environment published a report on climate security in 2007 [7]. The Ministry of Defense launched a new "Climate Change Task Force" in May 2021 and began to study the impact of climate change on security. In China, as early as 2015, Professor Zhang Haibin of Peking University published "The Impact of Climate Change on China's National Security: A Perspective of the Overall National Security Outlook" in the Journal of International Studies [8]. Subsequently, Liu Changsong and Xu Huaqing of the Climate Change Strategy Center of the Ministry of Ecology and Environment published a paper on insights and suggestions for climate change and national security in 2017 [9]. PLA-Daily, the official newspaper of the Central Military Commission of the Chinese Communist Party, carried an essay on climate security risks in 2020 [10].

Despite all of this, it cannot be said that climate security risks are widely discussed in East Asia. Although East Asian countries had officially acknowledged the importance of tackling climate change, discussion of climate security were almost nonexistent among governmental officials, politicians, and academics with very few exceptions, cited above, until recently. Taking Japan as an example, climate change had not been discussed in the context of "cause of conflict and violence", while "long-term irreversible planetary changes" and "short-term abrupt risks to individuals" of climate change had been considered previously [11].

If climate change causes conflicts, what mechanisms exist? What climate security risks might East Asia face in the coming decades? This study aims to answer these questions through a literature review on climate security in East Asia. First, a general literature review on the mechanisms linking climate change and conflict is provided. Then, the results and discussion sections consider climate security risks in East Asia in light of the predicted impacts of climate change in the region and the mechanisms linking climate change and conflict.

2. Materials and Methods

East Asia refers to the eastern part of the Eurasian continent, including Mongolia, China, Korea, and Japan. The eastern region of East Asia is characterized by a temperate monsoon climate, intensive rice and wheat cultivation, high population density, and advanced industrialization. Japan, Korea, and eastern China are included in this region. The western part of East Asia has an arid climate and is sparsely populated. The population in this region mainly engaged in cattle raising, while industry is largely limited to light industry. It includes the Mongolian plateau, the Jungar Basin, the Tarim Basin, and the Tibetan Plateau. [12]

Taking into consideration the mechanisms linking climate change and conflict identified in the literature review as well as the predicted impacts of climate change, this paper examined climate security risks in East Asia through further literature review. Southeast Asia, South Asia, and the Pacific are also included in the discussion, as necessary, to the extent that they are relevant to climate security risks in East Asia.

The Google Scholar and Web of Science databases, and the keywords "climate," "conflict," as well as "East Asia," or "Asia" were used to search for climate-conflict articles mentioning

East Asia. This study mainly reviewed articles published between 2012 through 2022 and papers cited in them. Statistical data were updated with the latest resources as necessary.

3. Literature Review: Pathways Connecting Climate Change and Conflicts

Climate change and extreme weather events should be understood as complex causal processes that may or may not lead to conflict. In the papers reviewed in this study, competition for resources, economic deterioration, and migration have been identified as the main factors linking climate change and extreme weather events to conflict. This section summarizes the causal processes by which these factors interact and sometimes lead to conflict.

3.1. Temperature and Precipitation Change

Changes in weather, such as temperature and precipitation, can have psychological or physiological effects on people such as discomfort, and can trigger violence [13]. For example, higher temperatures are more likely to cause urban riots [14] and political unrest [15] such as coups d'état. Changes in temperature also affect various forms of interpersonal violence such as murder, assault, rape, robbery, and sports brawls [16]. One study predicted a 6% increase in homicides worldwide for every 1 °C rise in the average global temperature [17].

Global conflicts have also been correlated with temperature. For example, Burke et al. of Stanford University found a strong correlation between temperature rise and the occurrence of civil war in sub-Saharan Africa between 1981 and 2002, and predicted that, if greenhouse gas emissions continue at the current rate, the incidence of civil war will increase by approximately 50% by 2030 [18].

However, some previous studies have rejected any direct correlation between temperature and conflict. Buhaug of the International Peace Research Institute in Oslo, for example, pointed out that the abovementioned study by Burke et al., which affirmed the correlation between rising temperatures and civil wars, was biased in its sample of periods and countries, and lacked consideration of social and geopolitical factors. His analysis found no correlation between temperature and civil wars in Africa [19]. In response to Buhaug's criticism, Burke et al. also modified their regression model and reanalyzed the results; while they still found a correlation between temperature rise and conflict occurrence, they reported that the correlation had disappeared since 2002 [20].

Similar to the analysis of temperature change, mixed positive and negative results have been reported on the relationship between changes in precipitation, such as extreme high or low rainfall, and conflict. With regard to precipitation, analysis has shown that civil wars of a relatively large scale are likely to occur in developing countries in years of high precipitation [21]. In Africa, the correlation of rainfall with conflicts and riots has been pointed out. For example, inter-group conflicts often occur during periods of extreme rainfall and extreme drought in East African countries, such as Ethiopia, Kenya, and Uganda [22].

While some of these analyses acknowledge the relationship between changes in precipitation and conflict, a few studies deny that any correlation exists. For example, studies that deny a correlation between drought and the start of civil wars can be found in Asia [23] and Africa [24]. Another study in East Africa suggested that extremely high rainfall might reduce the risk of violence [25].

3.2. Natural Disasters

Climate change will increase the frequency and severity of natural disasters such as storms and floods. Natural disasters damage infrastructure and harm crops and livestock. Existing empirical studies suggest that floods may prolong civil wars. Floods destroy public infrastructure and reduce government revenue, thereby reducing the government's security capacity, which in turn tends to prolong civil wars [26].

Studies dealing with the relationship between natural disasters and conflict point to the difficulty and uncertainty of predicting them. Agricultural societies have always coped with such unpredictable and uncertain disasters. As climate change increases these uncertainties to levels never before experienced by humans, however, coping strategies that have worked in the past may no longer function [27].

Some have suggested that sudden, short-term disasters such as cyclones and storms may be more likely to cause conflict than gradual changes such as sea level rise [28]. If the change is gradual, society has more time to cope with the new environment and it is relatively easier to avoid situations that could lead to outbreaks of violence and conflict. Sudden disasters, on the other hand, do not give people time to adapt [29].

Alternately, other studies report a negative relationship between natural disasters and conflict [30,31]. Some studies even suggest that disasters may promote peace rather than conflict. This may be the case in situations where disasters have made continued fighting impossible [32].

3.3. Sea Level Rise

Sea level rise poses an existential threat for some small islands and some low-lying coasts. Global mean sea level increased by 0.2 m between 1901 and 2018. The average rate of sea level rise was 1.3 mm per year between 1901 and 1971. It increased to 1.9 mm per year between 1971 and 2006, and further increased to 3.7 mm per year between 2006 and 2018 [1].

As sea levels rise due to climate change, many people will be forced to leave their familial lands. This displacement, called climate migration, may cause conflict, as explained below [30]. Globally, population change in low-lying cities and settlements will lead to approximately one billion people projected to be at risk from coastal-specific climate hazards in the mid-term beyond 2040. The population potentially exposed to a 100-year coastal flood is projected to increase by about 20% if global mean sea level rises by 0.15 m relative to 2020 levels. This exposed population doubles at a 0.75 m rise in mean sea level and triples at 1.4 m without additional adaptation. By 2100, the value of global assets that could be lost in a 1-in-100-year coastal flood is projected to range from US$7.9 trillion to US$14.2 trillion [2].

3.4. Insufficiency of Resources Such as Water

The effect of resource scarcity has long been a focus of attention as a mechanism by which climate change causes conflict. In other words, it is argued that when freshwater, arable land, forests, fisheries, and other resources become scarce due to climate change, competition and conflict over these increasingly scarce resources intensify [33]. In developing countries in particular, it has been pointed out that when water shortages occur due to reduced rainfall and rising temperatures, farmers and nomads may come into conflict over limited water resources [34]. It is also said that conflicts and disputes tend to occur between nations that jointly use water, such as rivers and lakes, especially between upstream and downstream nations, over their water resources [35].

However, the argument that resource scarcity causes conflict has been subject to no small amount of criticism, both theoretical and empirical [36–38]. To economists, for example, scarcity is a surmountable problem. They would say that investment, innovation, and trade would be made to conserve or replace scarce resources, as long as efficient markets are functioning [39]. However, markets cannot function without stable governance and institutions. In this regard, some political scientists point to poor governance, widespread corruption, and inefficient institutions as important factors that link resource scarcity and conflict [40].

3.5. Climate Migration

As sea levels rise, weather conditions change, and water and food shortages become more severe owing to climate change, many people may be forced to leave their familial lands. The resulting influx of large numbers of “climate immigrants” can be a burden to their host societies and can lead to conflicts with the indigenous population [41]. For example, migrants and indigenous people will compete for land, jobs, resources, healthcare, education, and other social services. Furthermore, if the influx of climate migrants disrupts the ethnic balance of the host region, it could increase political tensions between ethnic groups, resulting in conflicts [42]. The combination of extreme weather conditions that cause migration and the influx of migrants that create conflicts in receiving areas can already be seen in Bangladesh [43] and Kenya [44]. In the early days of the conflict in Darfur, people moved from villages with poor water resources and vegetation to those with abundant water resources, leading to competition for resources at the destination [36]. Similarly, it has been reported that riots are more likely to occur in India when the number of internally displaced people increases due to erratic rainfall [45].

3.6. Decline in Crop Harvest/Food and Price Crisis

Extreme weather and natural disasters can have a serious impact on crop yields and livestock rearing, causing farmers to lose income and food prices to rise. If they become destitute, some may even resort to violence to survive. This is because the loss of income and economic opportunity lowers the opportunity cost for participating in insurgency and riots [46]. Opportunity costs refer to the potential benefits that an individual misses out on when choosing one alternative over another. For example, when farmers participate in a riot or a war, they may lose the future agricultural income they would have gained. Reduced farmers' incomes due to extreme weather events and natural disasters lowers opportunity costs of leaving agriculture. Thus, the reduction in agricultural income due to climate change will provide the conditions for more farmers to participate in conflicts. This may affect the incidence, duration, and intensity of conflict. Similarly, for urban residents who do not have easy access to alternative food sources, destitution induced by higher food prices is likely to lower the opportunity costs for participating in demonstrations, protests, and riots [47,48].

It has been reported that temperature extremes during the high season for maize cultivation in sub-Saharan Africa reduce the yields of those crops and increase the incidence of civil conflict [49]. Similarly, another study analyzing data from 1997 to 2011 for 46 African countries found that extreme weather events during the growing season of a region's major crops were more likely to lead to conflict than extreme weather events at other times of the year [50]. An analysis of the Syrian Civil War also indicated that droughts during the growing season of major crops are more likely to trigger riot outbreaks [51]. In addition, higher food prices due to extreme weather events and natural disasters have also been correlated with urban riots in African countries [52] and global social unrest [53].

3.7. Widening Disparities

Reduced crop yields, rising prices, and damaged infrastructure induced by extreme weather events and natural disasters can lead to recession and widening inequality in not only the agricultural sector, but also the economy as a whole, which can be a remote cause of conflict. The key link between widening inequality and conflict is the concept of relative deprivation. This concept refers to the gap between the quality of one's expected and actual life. Widening inequality exacerbates relative deprivation for many people and drives them to demand the redistribution of wealth, even to the point of participating in riots and conflicts. In other words, when recession and widening inequality are exacerbated by extreme weather events or natural disasters, this can lead to riots and conflicts [54]. The area around Lake Chad, which borders the Sahara Desert and spans four countries (Nigeria, Chad, Niger, and Cameroon), is a typical example of a region where water shortages, food shortages, and the accompanying widening gap have been distant causes of conflict. Lake Chad lost more than 90% of its area between 1963 and 2001 due to the effects of large-scale irrigation, overgrazing, and desertification associated with the growth of the surrounding population. As a result, severe shortages of water and food became endemic in the region, depriving the local people—who depended on the lake for agriculture, fishing, and grazing—of their livelihood. In northern Nigeria in particular, the lack of water and food due to the drying up of Lake Chad has exacerbated existing inequalities, poverty, and political instability. This has given rise to the rise of the Islamic terrorist group Boko Haram, which was formed in 2002. For many jobless youth, joining terrorist organizations has become a way to improve their lives [55].

3.8. Geopolitical Changes

Another important pathway through which climate change may indirectly lead to conflict could point to geopolitical changes brought about by climate change itself or by measures taken in response. In particular, the declining dependence on fossil fuels and the spread of renewable energy sources are likely to have a significant impact on the global geopolitical power structure [56].

Oil, natural gas, and coal reserves are geographically unevenly distributed, and, therefore, over the past two centuries fossil-fuel energy has been central to geopolitics. The relationship between western Europe and China changed decisively in 1839, when Britain deployed coal-fired steam ships in the First Opium War. The turn to oil in the twentieth century made the United States the world's dominant power. For the last decade, the United States and Russia have competed with each other to sell gas to Europe, as they did oil at the start of the past century. Renewable energy sources, in contrast, potentially exist almost everywhere in the world in varying degrees and types. Thus, as the shift from fossil fuels to renewable energy sources gains momentum, we can expect a rewriting of the geopolitical balance of power and a reshaping of international relations [57].

Also, as renewable energy becomes more widespread, and related technologies such as solar panels, wind turbines, electric vehicles, and energy storage become more widely used, the demand for the various rare metals and rare earths needed to produce them will increase. Rare metals and rare earths are strategic resources that are essential in a decarbonized society. For example, the widespread use of photovoltaics has increased the demand for silver and silicon, while the proliferation of lithium batteries has increased the importance of lithium and cobalt. In addition, many other rare earths are essential for improving the performance of electronics products such as light-emitting diodes and super-strong magnets, and rare metals and rare earths are essential for decarbonization and the spread of renewable energy. Countries with large reserves of such metals and minerals would benefit from energy transformation. In addition, countries that gain an advantage in new renewable energy technologies may increase their influence on the international community [58].

Since countries that can gain an advantage in the technologies needed to promote new renewable energies will increase their influence in the international community, the international political implications of each country's green industrial policies have increased [59]. An economy that aims for sustainable development that balances the environment and economic growth is called a green economy. Industrial policy for this purpose is green industrial policy. It includes public investments, incentives, regulations, and other policy support to stimulate and promote the development of environmental technologies [60]. What distinguishes green industrial policy from other industrial policies is its objective of transforming and restructuring the economy into a green economy. As green industrial policy becomes more central to climate change mitigation, it is shifting its character from environmental policy in the narrow sense to economic and industrial policy [61].

Geopolitically speaking, green industrial policies would reposition countries in global supply chains and reconfigure the balance of power. Demands for environmental technologies are likely to increase in the coming decades. International competition for intellectual property rights in green technologies is expected to be fierce. Green industry policy is an important approach to ensure a country's dominance in this competition. By fostering domestic green industries, countries would be competing for industrial competitiveness and economic growth [62].

3.9. Vulnerability/Adaptability of Each Country/Region

The extent to which climate change increases the risk of conflict, whether directly or indirectly through causal pathways, can depend on the level of economic development, administrative capacity, and various other social conditions in a country or region. Climate change is likely to trigger conflicts among people vulnerable to the effects of extreme weather events and natural disasters. Countries with high rates of poverty and high dependence on agriculture and other industries that are sensitive to natural conditions are particularly vulnerable to the effects of climate change; as a result, these countries are also at a higher risk of climate change-related conflict [63]. It has also been pointed out that developing countries that lack the capacity to absorb population in cities due to underdeveloped infrastructure and social services are more prone to conflict when the influx of people from rural to urban areas increases due to climate change [64]. It is not only developing countries that face the risks of climate change. Reducing the use of fossil fuels, which is a pressing issue as a measure against climate change, will impose greater conversion costs on the richer countries with more developed economies and societies [65].

On the other hand, in countries and regions with high administrative capacity and low corruption, political leaders have incentives to gain political support by providing citizens with the necessary economic assistance, infrastructure development, and social services in the event of extreme weather events and natural disasters [66]. Conversely, it has been pointed out that in non-democratic countries, economic shocks associated with extreme weather events and natural disasters are more likely to lead to civil wars [67].

3.10. Summary of General Literature Review on Climate Change

Figure 1 summarizes the causal processes by which these factors interact and sometimes lead to conflict. As stated above, climate change seems to interact with other political, economic, and social factors in a complex causal process leading to conflict. Of these, security risks induced by extreme weather events, disasters, and sea level rise can be counted among those directly brought about by natural phenomena associated with climate change. Alternately, security risks triggered by local resource competition, livelihood insecurity, migration, volatile food provision, transboundary water management, and unintended effects of climate policies can be counted among those indirectly caused by climate change [68].

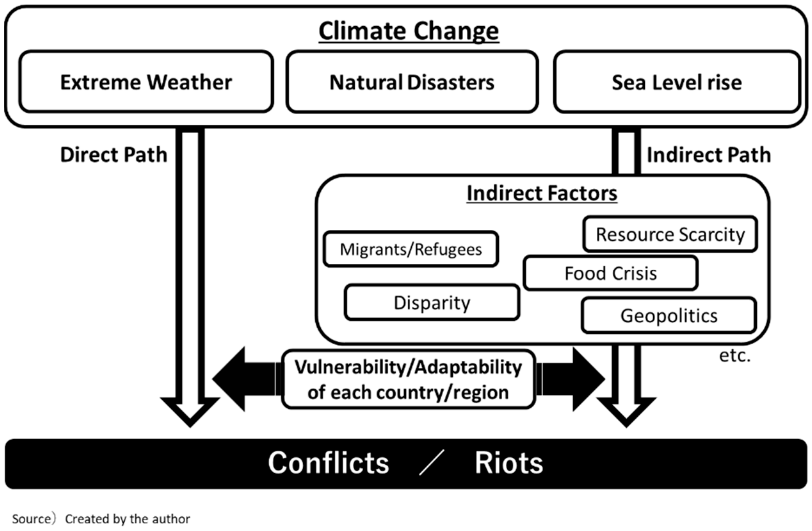

Figure 1. Pathways Connecting Climate Change with Conflict.

4. Results: Climate Security Risks in East Asia

According to the IPCC's simulations, Asia is subject to many impacts associated with climate change, including climate migration, damages in coastal areas, decrease in fishery yields and crop production, and water scarcity. In addition, the demand for water and food is growing in the region owing to population growth, urbanization, and industrialization. This has increased the vulnerability to water and food shortages associated with climate change. Furthermore, attention should be also paid to the impact of climate change on the governance and geopolitical balance of East Asian countries, as pointed out above [2].

What climate security risks might East Asia face in the coming decades? This section examines the future climate security risks that East Asia may face in light of the predicted impacts of climate change and the mechanism linking climate change and conflict outlined in the previous section.

4.1. Tension Brought by Climate Migrants

In the Asia–Pacific region, including East Asia, there are a number of countries where a high percentage or total number of people are displaced by sea level rise and other climate change impacts. Many low-lying countries in the region, where the entire land mass is only a few meters above sea level, are at risk of sea-level rise. More than 40% of the population will be affected in the Maldives, Marshall Islands, and Kiribati. In terms of total numbers, 107 million people in China, 53 million in Bangladesh, 44 million in India, 38 million in Vietnam, and 26 million in Indonesia are threatened by climate change [69]. It has been suggested that sea level rise and flooding could result in up to 20 million people migrating from Bangladesh by 2050 [70].

These climate migrants from Asia-Pacific countries could become a source of conflict in East Asia. Even a fraction of them surging into neighboring countries as migrants and refugees could be a major destabilizing factor in the region. The combination of extreme weather conditions that cause migration and the influx of migrants that create conflicts in receiving areas can already be seen in Bangladesh [43].

4.2. Tension over Losing Terittories and Fishery Area

Sea level rise and coastal erosion can lead to a partial loss of territory, territorial waters, and exclusive economic zones (EEZs) for maritime nations. One of the hotspots in East Asian waters likely to be affected by sea level rise is Okinotorishima Island, Japan's southernmost island. Okinotorishima Island supports an EEZ of approximately 400,000 km^2, which is larger than the total land area of Japan. However, at the time of the 2004 survey, the island was already only 16 cm above sea level at high tide [71]. In this regard, UN Convention on the Law of the Sea prescribes that a low-tide elevation, a naturally formed area of land which is surrounded by and above water at low tide but submerged at high tide, has no territorial sea of its own [72]. If Okinotorishima Island sinks below the sea surface during high tides, Japan will lose its surrounding territorial waters and EEZ.

If the island sinks below sea level in the future, conflicts could be intensified among Japan, China, South Korea, and North Korea. The reason why this small island is important is that the area around Okinotorishima is rich in fishery resources, and its seabed has undersea mineral resources such as cobalt and nickel. Even today China, South Korea, and North Korea do not recognize Okinotorishima as an "island" and claim that it is a "rock" that does not have an EEZ under the UN Convention on the Law of the Sea. China, in particular, has been conducting frequent oceanographic surveys around Okinotorishima since around 2001, and is already in conflict with Japan over this area [73].

Also, East Asia may face intensifying conflicts over fishery resources. Climate change causes the redistribution of marine fish stocks, increasing risk of transboundary management conflicts among fisheries countries. It is negatively affecting the equitable distribution of food provisioning services as fish stocks shift from lower to higher latitude regions [2]. Many countries in the region depend on fisheries and marine tourism resources for food and income. Rising sea temperature and ocean acidification have life-or-death impacts on fishery resources and coral reefs. Rising sea temperature has already reduced fishery productivity by 15–35% in East Asian waters [74].

If climate change causes fish to move their habitats to waters with lower temperatures, this could affect conflicts in existing disputed areas, such as the South China Sea and East China Sea, and could lead to new conflicts over territorial waters and exclusive economic zones in other areas in the Sea of Japan.

4.3. Instabilities Caused by Extrema Weather Events and Water Shortages

East Asia could also face social instability owing to an increase in heavy rainfall and flooding. The tropical monsoon regions in East Asia are more prone to extreme downpours [2]. In addition, climate change will also affect the path and intensity of typhoons, which may cause flooding in areas that have traditionally suffered little damage from typhoons [75]. As a result of these effects, more countries in the Asia–Pacific region are expected to face permanent water shortages, while more countries will be exposed to severe damage from heavy rains and storms caused by global warming.

Existing empirical studies suggest that floods may prolong civil wars [26]. As floods destroy public infrastructure and reduce government revenues, they appear to reduce the government's security capacity, which in turn tends to prolong civil wars [26]. Studies in the Philippines have also indicated that erratic rainfall increases repression, civil war, and terrorism, which in turn increase discontent [76].

Extreme weather events during the growing season of a region's major crops were also more likely to lead to conflict than extreme weather events at other times of the year [50]. It has been reported that temperature extremes during the high season for rice cultivation in Indonesia reduce the yields of those crops and increase the incidence of civil conflict [77].

While heavy rainfall and flooding are concerns, East Asia is also likely to face a climate security risk triggered by water scarcity. In particular, glaciers in the Hindu Kush–Himalayan region are an important source of freshwater for people in mainland China and the Indian subcontinent, but they are rapidly disappearing owing to warming in recent decades. If glaciers continue to melt in the future, at least one-third of the glaciers in the region are expected to disappear by the end of this century [78].

If this occurs, the water flow of the Yellow River, Yangtze River, Mekong River, Indus River, and Ganges River will decrease, and a wide area from China to India will be severely affected. In particular, a decrease in the flow of international rivers, such as the Mekong, Indus, and Ganges, could lead to conflicts between upstream and downstream countries. The construction of dams and water flow adjustments upstream of the Mekong River has already caused conflicts between upstream and downstream countries [79].

4.4. Geopolitical Impacts of Climate Change

As pointed out earlier, countries that can gain an advantage in the technologies and resources needed to promote new renewable energies will increase their influence in the international community. In this respect, China has great potential. As Arctic Sea ice melts, geopolitical tensions between China, Japan, South Korea, Russia, the US, Canada, and other nations over the region's marine resources and shipping routes may increase.

4.4.1. Geopolitics of Rare Earth

Just as the 19th century was the era of coal and Britain, and the 20th century was the era of oil and the United States, some believe that the 21st century will be the era of rare earths and China [58]. Deng Xiaoping, China's former supreme leader, stated that "the Middle East has oil and China has rare earths," and he proposed that rare earths should be strategically used to China's advantage [80].

Although rare earth deposits themselves are distributed across the continents of Eurasia, Australia, North America, and South America, the U.S. Geological Survey (USGS) estimated that China accounted for 60% of global rare earth production in 2021, while the United States and Australia accounted for only 15% and 8%, respectively [81].

In fact, China sometimes uses rare earths as a diplomatic card. In 2010, Beijing stopped rare earth exports to Japan due to the conflict over the Senkaku Islands in the East China Sea [82]. In 2019, Chinese President Xi Jinping visited a rare earth plant in Jiangxi Province in the middle of the U.S.-China conflict, leading to widespread speculation that Beijing would restrict rare earth exports to the United States [83]. Countries are increasingly concerned about such Chinese rare-earth diplomacy from an economic security perspective, as they would not be able to mass-produce renewable energy equipment or electric vehicles if it could not import rare earths [57,58].

4.4.2. Geopolitics of Green Industrial Policies

Japan, East Asia's technological superpower, launched its green industry policy in December, 2020. Following Prime Minister Suga's declaration of intent to achieve carbon neutrality by 2050 in the same year, the "Green Growth Strategy" was compiled as the industrial policy to realize this goal. In addition to promoting the spread of renewable energies such as solar power and biofuels, the strategy also outlines a policy of creating 18 million jobs by 2050 by mobilizing fiscal expenditures, tax incentives, regulatory reform, standardization, international collaboration, and other policies centered on 14 priority sectors including transportation, manufacturing, housing, and others [84].

China, the largest economy in East Asia, launched its green industrial policy more than a decade earlier than Japan. China has set a goal of "raising the ratio of renewable energy to 10% of primary energy" in its "National Plan for Coping with Climate Change" in 2007. Since then, the realization of a low-carbon economy through the improvement of energy efficiency and the spread of renewable energy has been one of the key pillars of its industrial policy. In addition, since 2007, the Chinese Communist Party has incorporated not only economic growth but also the achievement of energy conservation and decarbonization goals into its personnel evaluations of local government leaders and executives of leading state-owned enterprises. This has strongly promoted the industrial development and introduction of renewable energy [85]. As a result, China has rapidly increased its manufacturing capacity for solar panels and wind power generation equipment. Now China has the largest market share in the world. In 2021, six among the top ten global wind turbine makers were Chinese companies, and their market share in total was 44.5% [86]. China also dominated the top four companies in the global PV module market by shipment volume in 2021, with six of the top ten companies being Chinese [87].

Green industrial policies can attract national conflicts over technologies and industries that are key to the green economy. In fact, exports of Chinese solar cells and modules, which have surged as a result of Beijing's green industry policies, have sparked a trade dispute between the United States and China. As early as 2012 under the Obama administration, anti-dumping measures were invoked, and then in 2018, the Trump administration invoked safeguard measures under Section 201 of the US Trade Act. In addition, the Trump administration included large magnets for wind turbines in the list of its trade sanctions against China. In fact, these measures have significantly reduced exports of Chinese-made renewable energy-related products to the United States [85].

4.4.3. Geopolitics in the Arctic

It has been noted that Arctic resources and new shipping routes attract East Asian non-Arctic nations to the region [88]. The Arctic is warming twice as fast as the rest of the planet. Within the next decade, the Arctic will begin to experience ice-free summers, and by mid-century, it will be completely free of sea ice during the summer months [89]. As a result, new shipping routes and resource extraction opportunities will open up in the Arctic. Thus there are some who worry that tensions could rise among East Asian countries including China, Japan, and South Korea, as well as some Arctic nations such as Russia and the US over newly available marine resources and routes as the sea ice melts [90,91].

Scientific research in the Arctic is also becoming increasingly important as a policy tool for exerting influence in the region [92]. Non-Arctic countries in East Asia, such as China, Japan, and South Korea, are using scientific research as an excuse to become more involved in the Arctic [93]. Additionally, China has proposed a series of infrastructure projects across northern Eurasia [94]. Some observers see this as a manifestation of economic opportunity and geopolitical ambition through shorter shipping routes [95].

5. Discussion

5.1. Reduction of Climate Security Risks in East Asia

As stated above, the literature review identified that East Asia may face several climate security risks in the coming decades. This section discusses how East Asian countries could deal with such risks. Based on the implications from this study, three measures can be proposed to reduce climate security risks in East Asia.

The first possible way to reduce climate security risks in East Asia is to promote climate change mitigation. Many natural and human systems are near the limits of their adaptation capacity, and additional systems will reach limits with increasing global warming [2]. As identified in this study, worsening climate change is likely to create various security risks in East Asia. If the impact of climate change can be reduced, climate security risks can be also reduced. Conversely, the more serious climate change becomes, the greater climate security risks become. Therefore, climate change mitigation is important from the perspective of climate security as well. The effects of climate change cannot be reduced without reductions in China, the world's largest emitter of greenhouse gases. The emissions embodied in Chinese exports, which are larger than the annual emissions of Japan, are primarily the result of China's coal-based energy mix and the very high emissions intensity [96]. International trade has become the fastest growing driver of global carbon emissions, with large quantities of emissions embodied in exports from emerging economies. If carbon-intensive manufacturing in emerging countries such as China entails drastically more CO_2 emissions than making the same product in developed countries, then trade can be assumed to increase global CO_2 emissions. To prevent such climate-trade dilemmas among East Asian countries, developed countries in the region, such as Japan and South Korea, should help China and other emerging Asian countries such as India reduce their greenhouse gas emissions.

Second, in order to enhance developing Asian countries' climate change preparedness and reduce regional climate security risks, major regional donors such as Japan, China, the Asian Development Bank (ADB), and the Asian Infrastructure Investment Bank (AIIB) should more actively support those countries' economic and social development through financial aid, technical assistance, and capacity building. Adaptation, in response to current climate change, reduces climate risks and vulnerability [2]. As pointed out in Section 3.9, the extent to which climate change increases the risk of conflict depends on the vulnerability and adaptive capacity of a country, including their level of economic development, administrative capacity, and various other political and social conditions. Climate resilient development integrates adaptation measures and their enabling conditions with mitigation to advance sustainable development for all [2]. As demonstrated in Africa [97], it could be effective to assist Asian developing countries with a co-benefit approach that integrates climate change mitigation with adaptation through public-private partnerships.

Third, in order to discuss concerns associated with climate change, and to deepen cooperation in support of Asian neighboring countries as mentioned above, a high-level policy dialogue framework between East Asian countries should be established. It may be practical to set this dialogue within an existing framework such as the East Asia Summit. Since climate security risks affect various sectors, it is necessary to involve not only environmental authorities, but also a wide range of relevant government agencies, including defense authorities, industrial policy authorities, and infrastructure authorities. It would be good to establish subcommittees for each issue, such as avoiding climate change-related conflicts, cooperation in climate change mitigation, and support for improving the adaptive capacity of developing countries in the region.

5.2. Limitations of This Study

This study purported to discuss climate security risks in East Asia. Since this topic has not been well covered in previous studies, this can be a significant contribution to the literature. This paper, however, only discussed future climate security risks facing East Asia based on a literature review. The risks presented in this paper need to be verified empirically and quantitatively through future research. Also, this paper could not cover all the related issues of climate security. The environmental implications of security and military activity in East Asia are one such issue. It is hoped that this study will stimulate research on various issues related to climate security in East Asia.

6. Conclusions

This paper investigated the scientific progress in the field of climate security through a literature review, and discussed climate security risks in East Asia. Climate change increases the risk of conflict not only through direct threats to people and societies from extreme weather events and natural disasters, but also indirectly through various pathways, such as shortages of water and other resources, outbreaks of climate migration, disruptions in food production, economic and social disturbances, and geopolitical changes. The literature review on climate security risks in East Asia identified that this region may face (1) tensions caused by climate emigrants, (2) conflicts over loss of territories and fishery areas, (3) conflicts caused by water shortage, (4) instability caused by heavy rain and floods, and (5) geopolitical risks of rare earth sourcing, green industrial policies, and the Arctic. East Asian countries could deal with such risks through cooperation for climate change mitigation, vulnerability reduction, and policy dialogue.

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