

The impact of climate change on water resources and food security in Indonesia



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Article Info

Received: 20 January 2023

Revised: 25 February 2023

Accepted: 15 March 2023

Keywords:

Climate Change;

Water Resources;

Food Security;

Abstract

The agricultural industry in Indonesia is facing a significant challenge in the form of climate change, particularly with regards to its impact on water resources. Climate change has various consequences, such as diminished precipitation, compromised water quality, and alterations in water availability. These outcomes pose significant risks to both food security and the long-term viability of agricultural output. The vulnerability of the water sector on Java Island is further intensified by factors such as population growth, land use changes, excessive utilization of water resources, and the expansion of infrastructure. The phenomenon of diminishing water discharge and alterations in water quality has emerged, posing a risk to water resources and substantial reservoirs. There is a pressing need for enhanced comprehension and proactive measures to effectively mitigate the repercussions of climate change on Indonesia's water resources

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1. Introduction

Climate change seriously threatens the agricultural sector and can create new problems for maintaining food production and agricultural production systems. Climate change, according to the United States Global Climate, is defined as an extreme reaction to weather phenomena that causes negative impacts on air resources, agricultural resources, depletion of the ozone layer, human health, vegetation and soil, which causes a doubling of the concentration of carbon dioxide in the ecosystem.¹ The main cause of climate change is human activity (anthropogenic) related to increased emissions of greenhouse gases (GHG) such as CO₂, methane (CH₄), CO₂, NO₂ and CFCs (chlorofluorocarbons), which cause global warming and have lasted for almost the last 100 years.

The impact of climate change on the agricultural sector varies, from resources, farm infrastructure and production systems to food security and independence, as well as the welfare of farmers and society. The impact is divided into two indicators, namely

¹ Okoli, J. N. & Ifeakor, A. C. 2014. An overview of climate change and food security: Adaptation strategies and mitigation measures in Nigeria. *Journal of Education and Practice*, 5(32), 13–19.

<https://doi.org/10.62264/jlej.v1i1.2>

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vulnerability and consequence. Vulnerability to climate change is "a condition that limits the ability (of humans, plants and livestock) to adapt and perform physiology/biology, development/phenology, growth and production, and optimally (naturally) due to climate change". The impact of climate change is "a disturbance or situation that causes physical, social and economic losses and benefits due to the pressure of climate change".²

There have been many reports about the impact of climate change on air resources globally. Among other things, Bates created an official document for the Intergovernmental Panel on Climate Change (IPCC) with contributions from many countries and authors. Still, this document needs to discuss information regarding air resources in Indonesia.³ Jose and Cruz discussed assessing the readiness of the air sector in the Philippines to face the impacts of climate change, especially in identifying the vulnerability of reservoir systems to changes in rainfall and temperature in the future.⁴ Breke discusses how federal agencies in the United States prepare reports regarding water resource management strategies in dealing with the impacts of climate change.⁵ The report by Mall discussed the potential for sustainable development and the development of water resources to face the impact of climate change in India.⁶

Water resources in Indonesia, especially on the island of Java, are experiencing many changes with environmental degradation and a decline in water quality, and several studies state that the water resources sector on the island of Java is in a critical condition. Changes in air resources are caused by several factors, including population pressure with all the activities carried out, changes in land use, exploitation of air resources, and development of physical infrastructure.⁷ The air crisis in Indonesia is caused by the gap between air demand caused by population and the availability of water supply from the flow of main regional rivers. For this reason, it is necessary to identify air-critical areas (Sandi, 2019).⁸ The decrease in water discharge in most rivers on the island of Java, especially in the downstream section, occurs mainly in super-priority critical river basins

² BALITBANGTAN. 2011. *Pedoman Umum Adaptasi Perubahan Iklim Sektor Pertanian*. Badan Penelitian dan Pengembangan Pertanian, Kementerian Pertanian.

³ Bates, B.C., Z.W. Kundzewicz, S. Wu, and J.P. Palutikof. 2008. *Climate Change and Water*. IPCC Technical Paper.

⁴ Jose, A.M. and N.A. Cruz. 1999. Climate change impacts and responses in the Philippines: water resources. *Climate Research*, published August 27, 2009. Vol.12: 77–84, 1999.

⁵ Brekke, L.D., J.E. Kiang, J.R. Olsen, R.S. Pulwarty, D.A. Raff, D.P. Turnipseed, R.S. Webb, and K.D. White. 2009. *Climate Change and Water Resources Management: A Federal Perspective*. USGS Circular 1331.

⁶ Mall, R.K., G. Akhilesh, S. Ranjeet, Singh, Rathore. 2006. Water Resources and Climate Change: An Indian Perspective. Review Article of *Current Science*. Current Science Association.

⁷ Mawardi, I. 2010. Kerusakan Daerah Aliran Sungai dan Penurunan Daya Dukung Sumber Daya Air di Pulau Jawa serta Upaya Penanganannya. *J. Hidrosfir Indonesia* 5(2).

⁸ Sandi, R. L. 2019. Pengaruh Krisis Air Bersih Terhadap Kualitas Air di Indonesia dalam https://www.researchgate.net/publication/333557597_Pengaruh_Krisis_Air_Bersih_Terhadap_Kualitas_Air_Di_Indonesia_oleh_Rizki_Sandi_Laksono accessed on 07 September 2023 pukul 14.15 WIB.

(DAS), and the impact of climate change does not necessarily cause this decreasing trend.⁹

Climate change in Indonesia is demonstrated by the impact on air availability, such as Pawitan, which shows a decrease in annual rainfall in the southern part of Java in 1931-1960 and 1968-1998, which reached 1000 mm.¹⁰ This also happened in the Citarum River Basin (DAS), where there was a decrease in local incoming water discharge (DAML) at a rate of 1.49% (3.14 m³ s⁻¹) and local incoming water volume (VAML) and 4.20% (275.26 million m³), an increase in the Q max-min ratio of 5.99% (average 131.94), an increase in the average sedimentation rate of 10.20 million m³-12.86 million m³ (total of three reservoirs) each dangerous year, especially the Saguling and Cirata Reservoirs, and a decrease in the chemical quality of the air in the Citarum River.¹¹

2. Research Method

In this writing, we use the literature study method or literature review, which is chosen, as Cooper and Taylor explained.¹² The data obtained in this paper comes from literature studies in the form of books, journals and other literature related to the topic. Library research or literature review (literature review, literature research) examines or critically reviews knowledge, ideas, or findings contained in a body of academic-oriented literature, as well as formulating theoretical and methodological contributions to a particular topic.¹³

3. Results and Discussion

Indonesian Climate Change

Indonesia has experienced an increase in temperature of around 0.50 C in the 20th century or 0.30 C since 1900.¹⁴ In 2020-2050, the average temperature in Indonesia is estimated to increase by 0.80 C to 10 C (BAPPENAS, 2010).¹⁵ World Bank Several regions in Indonesia are

⁹ Hatmoko, W. 2009. Tren perubahan debit andalan sungai di Jawa. Makalah Lokakarya Tren Perubahan Curah Hujan dan Debit Sungai-sungai di Indonesia, Program Penguatan IPTEK Adaptasi dan Mitigasi Perubahan Iklim - KNRT, 21 April 2009.

¹⁰ Pawitan, H. 2002. Hidrologi DAS Ciliwung dan Andilnya Terhadap Banjir di Jakarta. Lokakarya Pendekatan DAS dalam Menanggulangi Banjir Jakarta: Lembaga Penelitian IPB-Andersen Consult.

¹¹ Tampubolon, R., Sanim, B., Sri S.M. dan Boer. R. 2007. nalisis Perubahan Kualitas Lingkungan Daerah Aliran Sungai Citarum Jawa Barat dan Pengaruhnya Terhadap Biaya Produksi PLTA dan PDAM (Studi Kasus PLTA Saguling, PLTA Cirata, PLTA Jatiluhur, PDAM Purwakarta, dan PDAM DKI Jakarta). *Jurnal Tanah dan Iklim* No. 26/2007.

¹² Cooper dan Taylor dalam Mohammad Imam Farisi. 2010. Pengembangan Asesmen Diri Siswa (Student Self-Assessment) sebagai Model Penilaian dan Pengembangan Karakter. Artikel disampaikan pada Konferensi Ilmiah Nasional "Asesmen dan Pembangunan Karakter Bangsa" HEPI UNESA 2012.

¹³ Nana Syaodih. 2009. *Metode Penelitian Pendidikan*. PT. Remaja Rosdakarya : Bandung. hlm.52.

¹⁴ BAPPENAS. 2009. *Indonesia Climate Change Sectoral Roadmap (ICCSR): Synthesis Report*. Jakarta: Badan Perencanaan Pembangunan Nasional, Republik Indonesia.

¹⁵ BAPPENAS. 2010. *Indonesia Climate Change Sectoral Roadmap (ICCSR): Water Resources Sector Report*. Jakarta: Badan Perencanaan Pembangunan Nasional, Republik Indonesia.

vulnerable to climate change. Climate change causes an increase in rainfall and a rise in sea levels. Increasing sea temperatures will also affect marine biodiversity and harm coral reef ecosystems.¹⁶ Climate change that occurs in Indonesia is characterized by changes in temperature, rainfall patterns, sea level heights and El Nino and La Nina phenomena. Climate change in Indonesia seriously impacts various sectors, including agriculture, health and the economy.

The UK Met Office estimates an overall temperature increase in Indonesia of 2.0 C-2.50 C in 2100 based on the IPCC's A1B emissions scenario, namely balanced energy use between non-fossil and fossil energy.¹⁷ An increase in daily average temperature affects rainfall patterns, generally determined by the Asian and Australian monsoon circulation. With monsoon circulation, Indonesia has two main seasons: dry and rainy. Changes in daily average temperature can influence extreme changes in rainfall patterns. One evidence of increasing temperatures in Indonesia is ice melting in Puncak Jayawijaya, Papua.¹⁸

Increasing atmospheric surface temperature can also increase seawater temperature, expanding seawater volume and melting polar ice. Rising sea levels risk decreasing the quality of life on the coast. The average rise in global sea levels in the 20th century was 1.7 mm per year. Indonesia is located between the Indian and Pacific Oceans, and the non-uniform increase of sea levels affects ocean current patterns. Studies conducted by The National Council for Climate Change show that storm surges, tides and extreme climate variability such as La Nina, modulated by rising sea levels, can exacerbate the danger of seawater inundation on the coast.¹⁹ Climate changes in Indonesia have a major impact on food production, such as corn and rice. Production of food originating from the marine sector, such as fish and other sea products, is estimated to experience a large decline due to changes in current patterns and high sea surface temperatures. Indonesia is one of the countries most vulnerable to food security threats from climate change in the fisheries sector.²⁰

The impact of climate change on water resources includes an increase in extreme weather and climate events, which have the potential to cause floods, landslides and droughts. This condition is also worsened by the decreasing land carrying capacity caused by increasing pressure on the ground. The National Disaster Management Agency shows that hydrometeorological factors and their interactions dominated the disasters in Indonesia from 1815-2011. The chance of flood disasters in Indonesia will increase as sea levels rise, extreme wave intensity, high rainfall and the La Nina phenomenon. Severe flood disasters occurred in the DKI Jakarta area. The flood disaster resulted in economic losses and threatened public

¹⁶ World Bank. 2013. *Turn Down the Heat: Climate Extremes, Regional Impacts, and the Case for Resilience*. Amerika: World Bank.

¹⁷ United Kingdom Met Office. 2011. *Climate: Observations, projections and impacts*. United Kingdom: United Kingdom Met Office.

¹⁸ BAPPENAS. 2009. *Indonesia Climate Change Sectoral Roadmap (ICCSR): Synthesis Report*. Jakarta: Badan Perencanaan Pembangunan Nasional, Republik Indonesia.

¹⁹ Dewan Nasional Perubahan Iklim (DNPI). 2012. *Rencana Aksi Nasional Adaptasi Perubahan Iklim Indonesia*. Dewan Nasional Perubahan Iklim.

²⁰ Huelsenbeck, M. 2012. *Ocean-Based Food Security Threatened in a High CO2 World. A Ranking of Nations' Vulnerability to Climate Change and Ocean Acidification*.

health.²¹ Climate change is not the sole cause of natural disasters, which occur frequently. However, climate change has an impact on making these hydrometeorological phenomena or natural disasters extreme.

The Impact of Climate Change on Water Resources

Changes in land use patterns impact decreasing regional air availability, resulting in increased seasonal peaks with increasingly extreme flood and drought disasters. The size of watersheds and the capacity of watershed storage systems, both on the surface (rice fields, crops, swamps/reservoirs and rivers) and below the surface (layers of the earth's soil and water), are factors that determine the vulnerability and carrying capacity of regional air resource systems to climate change.²² Based on several research results, there has been a decrease in water discharge in several main watersheds on the island of Java, which is strongly influenced by changes in watershed characteristics. The changes that occur are caused by changes in land function from forest to agricultural land, as well as in land function from agricultural land to non-agricultural land, as happened in the Citarum River, where there was shallowing in the downstream part caused by erosion and non-functioning of the river border. The decrease in air discharge in various watersheds is exacerbated by irregular rainfall patterns, especially those related to the duration of extreme dry months due to global warming. There is much evidence to show that the climate, including rain patterns in Indonesia and various countries, has changed. Global warming is also predicted to influence extreme climate changes such as prolonged droughts, floods and other extreme events.²³

The Impact of Climate Change on Food Security

The impact of climate change occurring in Indonesia is closely related to the increase in the frequency and intensity of extreme weather conditions. Research shows that in the last 100 years, the frequency and intensity of the El Nino phenomenon of which ten occurred after the 1940s. The flood and drought disasters in Indonesia have caused crop failure, and in the last ten years, there has been extreme drought. Rainfall fluctuations in Java as a production centre for the main food crops in Indonesia, especially rice, corn, soybeans and sugar cane, are greatly influenced by the El Nino and La Nina phenomena, where the accumulation of drought failure is around 250,000 hectares and floods are about 90,000. Thousand hectares.²⁴

Pests and diseases that attack food crops will tend to increase during periods of extreme weather. Research conducted by Boer in Karawang, Indramayu and Tasikmalaya Regencies,

²¹ Badan Nasional Penanggulangan Bencana (BNPB). 2016. *Risiko Bencana Indonesia*. Jakarta: Badan Nasional Penanggulangan Bencana

²² Pawitan, H. 1999 Penilaian kerentanan dan daya adaptasi sumber daya air terhadap perubahan iklim. Makalah Lokakarya Nasional-Kantor Menteri Negara Lingkungan Hidup, Jakarta, Februari 1999.

²³ IPCC. 2007. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press.

²⁴ Boer, R. 2010. The Threats of Global Climate Change on Food Security in Indonesia. *Agrimedia Journal*, Vol.15(2), pp: 16-21 Central Agency of Statistics (BPS). (Various Issues). Statistical Yearbook of Indonesia Jakarta: BPS.

West Java, shows that the frequency of floods in the last few years has resulted in attacks by golden snail pests in rice fields. Likewise, high rainfall during the change of seasons accelerates planthopper pest attacks. Climate change can affect the capacity of land resources in Java, and rice production will decline by 5 per cent from the current production capacity in 2025. It will continue to reduce by 10 per cent in 2050.²⁵ Indonesia needs to expand its fertile land to produce more food, especially outside Java, to offset the decreasing production capacity in Java. Delays in developing and reconstructing agricultural infrastructure will severely impact crop failure, reduce production, and threaten Indonesia's food sovereignty.

Laws and plans in facing climate change related to water resources and food security

The laws and plans pertaining to the management of climate change in relation to water resources and food security can be outlined as follows: The initial legislation in question is Law number 18 of the year 2012. According to Law no. 18 of 2012, the objective of food administration is to fulfill fundamental human requirements in a manner that is just, impartial, and environmentally sustainable, guided by the principles of Food Sovereignty, Food Independence, and Food Security. In order to achieve this objective, it is imperative to establish a food institution that possesses the necessary authorities to foster coordination, integration, and synergy across various sectors. This agency is entrusted with the execution of governmental responsibilities in the food sector, operating under the direct authority and accountability of the President.²⁶

The community can actively engage in various aspects of food security, such as production, distribution, trade, and consumption. Additionally, they can contribute to the organization of community food reserves, as well as efforts to prevent and address food and nutrition insecurity. Furthermore, community members can play a role in disseminating information and knowledge about food and nutrition, and monitoring the effective implementation of food security measures, including affordability, diversity, and safety. Lastly, they can work towards enhancing household food independence. The community has the ability to communicate issues and provide input to the government and regional authorities in order to address food-related challenges.²⁷

Furthermore, it is worth noting that Law no. 17 of 2019 is of significant importance in the context under discussion. Law no. 17 of 2019 addresses the issue of water resources management in response to the growing disparity between diminishing water availability and increasing water demand. The legislation emphasizes the importance of managing water resources in a manner that considers the social, environmental, and economic dimensions,

²⁵ Boer, R. 2010. The Threats of Global Climate Change on Food Security in Indonesia. *Agrimedia Journal*, Vol.15(2), pp: 16-21 Central Agency of Statistics (BPS). (Various Issues). Statistical Yearbook of Indonesia Jakarta: BPS.

²⁶ Sudharto P Hadi, Rizkiana S Hamdani, and Ali Roziqin, 'A Sustainability Review on the Indonesian Job Creation Law', *Heliyon*, 9.2 (2023), e13431 <<https://doi.org/https://doi.org/10.1016/j.heliyon.2023.e13431>>.

²⁷ I Gede Yusa and Bagus Hermanto, 'Implementasi Green Constitution Di Indonesia: Jaminan Hak Konstitusional Pembangunan Lingkungan Hidup Berkelanjutan', *Jurnal Konstitusi*, 15.2 (2018), 306 <<https://doi.org/10.31078/jk1524>>.

aiming to achieve a harmonious balance.²⁸ This approach seeks to foster synergy and integration across regions, sectors, and generations, ultimately ensuring the fulfillment of society's water requirements. Water, as a constituent of water resources, holds significant importance in various aspects of production and plays a crucial role in sustaining the lifestyles of numerous individuals. In accordance with the provisions outlined in the 1945 Constitution of the Republic of Indonesia, the state assumes ownership of water resources with the objective of utilizing them for the utmost benefit and prosperity of the populace.

Thirdly, the strategies for addressing the challenges posed by climate change in relation to water resources. The incorporation of the environmental paradigm is necessary across multiple domains of development, including but not limited to the energy sector, forest and natural resource management, agriculture, plantations, spatial planning, and infrastructure. There is a need for rigorous coordination across various entities involved in endeavors aimed at mitigating the effects of climate change. Sustainable development patterns are necessary. The evaluation, updating, and improvement of the National Action Plan for Climate Change Adaptation is necessary in response to the evolving dynamics of climate change. There is an expectation that the national action plan on climate change may be effectively executed, serving as a guiding framework for pertinent authorities at both the central and regional levels in their pursuit of sustainable development in the present and future.²⁹

The National Action Plan for Climate Change Adaptation in the water resources sector aims to support the achievement of Indonesia's water vision, namely "Towards the Realization of Steady, Efficient, Effective and Sustainable Water Utilities for all Indonesian People."³⁰ The phenomenon of seawater intrusion onto land, resulting from climate change, drought, declining groundwater levels, and rising sea levels, leads to the contamination of water sources utilized for clean water and irrigation. The National Action Plan for Climate Change Adaptation in the water resources sector aims to enhance the effectiveness of current programs and initiatives in order to adequately address the challenges posed by climate change. a. Enhancing the management of water resource infrastructure to facilitate water supply involves several key measures: the advancement of management and restoration practices for weirs, bungs, and dams, as well as the enhancement of their management quality; the regulation of water consumption at water sources; and the development, maintenance, and rehabilitation of raw water supply infrastructure to adequately cater to the daily demands of urban and industrial sectors. b. developing disaster risk management for floods (rivers, tidal waves, rain lava), landslides and drought, included: construction and maintenance of coastal buildings to overcome floods/tidal waves in large cities in coastal and other strategic areas; implement structuring and controlling river borders for locations experiencing flooding/causes of flooding; developed, operated, and maintained flood and

²⁸ M. Alvi Syahrin, 'The Immigration Crime and Policy: Implementation of PPNS Authorities on Investigation', *Journal of Indonesian Legal Studies*, 3.2 (2018), 175–94 <<https://doi.org/10.15294/jils.v3i02.27512>>.

²⁹ Anis Widyawati and others, 'Urgency of the Legal Structure Reformation for Law in Execution of Criminal Sanctions', *Lex Scientia Law Review*, 6.2 (2022), 327–58 <<https://doi.org/10.15294/lesrev.v6i2.58131>>.

³⁰ BAPPENAS. 2014. *Rencana Aksi Nasional Adaptasi Perubahan Iklim (RAN-API)*. Jakarta: Badan Perencanaan Pembangunan Nasional, Republik Indonesia.

drought control infrastructure and facilities for cities and districts that are vulnerable to disasters; capacity building in disaster risk management; development of early warning system infrastructure to anticipate disasters (disasters and drought); preparation and updating of NSPK for disaster risk management of water resources; preparation of reliable planting management plans and implementation of socialization to anticipate drought; carrying out improvements to the irrigation management system by integrating climate change risk management; implementing re-evaluation of irrigation operation and maintenance arrangements to accommodate the impact of climate change in terms of increasing or decreasing rainfall intensity.³¹

Plans for Facing Climate Change Related to Food Security

The general target of food security is the realization of food security that is sustainable and good in the aspects of supply, distribution and accessibility, as well as in the context of independence, sovereignty and food security.³² The general goal of food security will be difficult to achieve if the agri-food development system does not have resilience to climate diversity and change. Therefore, the main targets of the National Action Plan for Climate Change Adaptation in the field of food security are: a. reducing the rate of loss of food production due to climate change; b. development of new growth source areas for food production in areas with low climate risk and minimum environmental impact (low emissions); c. develop a food security system for farmers and communities (micro) with healthy, nutritious, and balanced food patterns and realize food diversification to an optimum level.³³

These three targets were developed by considering farmers' economic aspects and welfare and their contribution to climate change mitigation and environmental sustainability (Climate Smart Agriculture).³⁴ The main strategy to achieve the targets of the National Action Plan for Climate Change Adaptation in the Field of Food Security is carried out through (a) Adapting and developing farming systems to climate change, (b) developing and applying adaptive technology to climate stress, (c) developing and optimizing land and water resources and genetics. The strategies in handling the National Action Plan for Climate Change Adaptation in the field of food security are realized through 7 Main Programs, namely:

To mitigate the adverse effects of climate variability and change on food production, it is

³¹ Zsazsa Dordia Arinanda and Aminah Aminah, 'Sentralisasi Kewenangan Pengelolaan Dan Perizinan Dalam Revisi Undang-Undang Mineral Dan Batu Bara', *Jurnal Ilmu Hukum*, 10.1 (2021), 167–82.

³² Simone Athayde and others, 'Viewpoint: The Far-Reaching Dangers of Rolling Back Environmental Licensing and Impact Assessment Legislation in Brazil', *Environmental Impact Assessment Review*, 94.August 2021 (2022) <<https://doi.org/10.1016/j.eiar.2022.106742>>.

³³ BAPPENAS. 2014. *Rencana Aksi Nasional Adaptasi Perubahan Iklim (RAN-API)*. Jakarta: Badan Perencanaan Pembangunan Nasional, Republik Indonesia.

³⁴ Luciana Gomes Barbosa, Maria Alice Santos Alves, and Carlos Eduardo Viveiros Grelle, 'Actions against Sustainability: Dismantling of the Environmental Policies in Brazil', *Land Use Policy*, 104.October 2020 (2021), 105384 <<https://doi.org/10.1016/j.landusepol.2021.105384>>.

imperative to make adjustments to existing food production systems.³⁵ These adjustments should encompass various aspects such as cropping patterns, technology utilization, and farming system and aquaculture business models. The primary objective of these adjustments is to minimize the potential risks and losses associated with climate-related factors, including reduced productivity and diminished planting areas. The implementation of this action plan involves making modifications to agricultural and fishery practices and technologies, with the assistance of other interconnected industries. Furthermore, the extension of food agriculture and fisheries cultivation areas serves a crucial purpose beyond mere compensation for land conversion and production losses. However, it is imperative to address the pressing issue of meeting the escalating need for food, particularly in light of population expansion. The expansion of agricultural and fish farming areas is being undertaken with careful consideration of potential climate risks and the environmental carrying capacity. These expansion clusters are designed to ensure that the conservation function of regions and habitats is not compromised. The implementation of this program should be grounded in climate-resilient spatial planning, in accordance with Law no. 32/2009 on Strategic Environmental Studies (KLHS). It is particularly important to prioritize the usage and simultaneous enhancement of degraded and neglected land.³⁶

Thirdly, the enhancement and advancement of climate-resilient agricultural facilities and infrastructure. The primary foundation of food agriculture consists of rice fields and cultivated area for fisheries, both of which are susceptible to and capable of adapting to the effects of climate change.³⁷ The degree of susceptibility and adaptability is intricately linked to the capacity for irrigation. At present, a significant number of irrigation networks within food production and aquaculture facilities are undergoing degradation and damage, resulting in a potential reduction of planting areas and heightened susceptibility to climate change, particularly in the face of extreme climatic events. Furthermore, the pursuit of enhanced food production growth through the extension of agricultural areas necessitates the concurrent establishment and maintenance of irrigation networks to provide the necessary water resources. The program aimed at enhancing and advancing agricultural facilities and infrastructure will also prioritize the examination of potential alterations in climate and environmental circumstances, particularly in relation to vegetation coverage within rain catchment regions.³⁸

The topic of discussion pertains to the phenomenon of food diversification, specifically focusing on its acceleration. The process of enhancing food diversification, encompassing crops, livestock, and fish, involves the creation of a range of nutritious food items derived from alternative food commodities. These commodities exhibit greater resilience to climate-

³⁵ Prakrit Silal and Debashis Saha, 'Impact of National E-Participation Levels on Inclusive Human Development and Environmental Performance: The Mediating Role of Corruption Control', *Government Information Quarterly*, 38.4 (2021), 101615 <<https://doi.org/https://doi.org/10.1016/j.giq.2021.101615>>.

³⁶ Suwari Akhmaddhian, 'Discourse on Creating a Special Environmental Court in Indonesia to Resolve Environmental Disputes', *Bestuur*, 8.2 (2020), 129 <<https://doi.org/10.20961/bestuur.v8i2.42774>>.

³⁷ Miriam Matejova, 'Silver Linings: Environmental Disasters as Critical Junctures in Global Governance', *Environment*, 65.1 (2023), 4–14 <<https://doi.org/10.1080/00139157.2023.2146943>>.

³⁸ L. Aldieri and others, 'Waste Recycling Patents and Environmental Innovations: An Economic Analysis of Policy Instruments in the USA, Japan and Europe', *Waste Management*, 95 (2019), 612–19 <<https://doi.org/10.1016/j.wasman.2019.06.045>>.

related pressures and offer advantages in terms of land and water resource conservation when compared to rice crops.³⁹ Examples of such commodities include corn, green beans, as well as various indigenous food sources like sago, canna, tubers, nuts, and other locally available foods. In order to bolster this cluster, it is imperative to implement a comprehensive food policy tailored to the specific locality or region, while simultaneously enhancing the consumption of fish within the community.⁴⁰

The development of technology that is both innovative and adaptive is a topic of great interest and importance.⁴¹ The focus of technological advancements lies in the integration of diverse technologies that may effectively respond to climate-induced challenges, enhance genetic resources for agricultural and aquatic purposes, and optimize the utilization of land and water resources while minimizing greenhouse gas emissions. In addition to pioneering and cutting-edge technology, this action program also aims to investigate and cultivate native technology, encompassing traditional knowledge and practices.⁴² The primary objectives of this action plan encompass three key areas: (a) the exploitation and manipulation of genetic resources pertaining to cultivated plants and fish, (b) the enhancement of land and water resources through the advancement of adaptable cultivation techniques, and (c) the utilization and maximization of carbon, biomass, and organic waste in an efficient manner.

The topic of discussion pertains to the development of information and communication systems in relation to climate and technology. The efficacy of the climate change adaptation action program will be contingent upon the implementation of a proficient climate information system, a robust climate information transmission system, and advanced agricultural and fisheries technology for production and capture purposes.⁴³ Therefore, the primary objective of this cluster is to enhance the precision and comprehensiveness of climate data, as well as improve the accessibility of technology and dissemination platforms, thereby expediting the transmission of information. The Support Program, denoted as "Seven," is the subject of discussion. The successful execution of the aforementioned action programs necessitates the backing of comprehensive analysis and scientific research pertaining to vulnerability and the ramifications of climate change on food security. Additionally, it requires the examination and consolidation of policies concerning the utilization of land and water resources, the establishment of robust food institutions and

³⁹ Indah Nur Shanty Saleh and Bitu Gadsia Spaltani, 'Environmental Judge Certification in an Effort to Realize the Green Legislation Concept in Indonesia', *Law and Justice*, 6.1 (2021), 1–18 <<https://doi.org/10.23917/laj.v6i1.13695>>.

⁴⁰ Laurence L. Delina, 'Indigenous Environmental Defenders and the Legacy of Macli-Ing Dulag: Anti-Dam Dissent, Assassinations, and Protests in the Making of Philippine Energyscape', *Energy Research and Social Science*, 65.September 2019 (2020), 101463 <<https://doi.org/10.1016/j.erss.2020.101463>>.

⁴¹ Vinicius B.F. Costa and others, 'Socioeconomic and Environmental Consequences of a New Law for Regulating Distributed Generation in Brazil: A Holistic Assessment', *Energy Policy*, 169.July (2022) <<https://doi.org/10.1016/j.enpol.2022.113176>>.

⁴² Daniel Balsalobre-Lorente and others, 'Tourism, Urbanization and Natural Resources Rents Matter for Environmental Sustainability: The Leading Role of AI and ICT on Sustainable Development Goals in the Digital Era', *Resources Policy*, 82 (2023), 103445 <<https://doi.org/10.1016/j.RESOURPOL.2023.103445>>.

⁴³ Kleber Isaac Silva de Souza and others, 'Environmental Damage of Urbanized Stream Corridors in a Coastal Plain in Southern Brazil', *Ocean and Coastal Management*, 211.April (2021) <<https://doi.org/10.1016/j.ocecoaman.2021.105739>>.

production systems (specifically in agriculture and fisheries), and a conscientious consideration of socio-economic and cultural factors, gender dynamics, and unique environmental circumstances.⁴⁴

4. Conclusion

Climate change is characterized by the escalation of global temperatures, the elevation of sea levels in coastal regions, alterations in precipitation patterns, and the occurrence of severe weather events. The effects of climate change on water resources and food security can be assessed through key indicators such as changes in river flow, the biophysical characteristics of watersheds, the hydrological responses of watersheds (which determine regional water availability for different purposes and contribute to the assessment of the ecological, social, and economic value of existing water resources), heightened intensity and frequency of extreme climate events (such as floods and droughts), and the emergence of pests and diseases that impact food crops during periods of severe weather. The legal framework pertaining to water resource management and food security in the context of global climate change can be found in Law No. 18 of 2012 on Food Security and Law No. 17 of 2019 on Water Resources. The National Action Plan is a policy tool that requires ongoing evaluation, updating, and improvement in response to the evolving dynamics of climate change. The present document outlines the National Action Plan for Climate Change Adaptation specifically tailored to the water resources sector. There are several key areas that require attention in order to address water resource management effectively. Firstly, it is crucial to enhance the management of water resource infrastructure to ensure a reliable water supply. Secondly, there is a need to develop robust disaster risk management strategies specifically tailored to address floods (including rivers, tidal waves, and rain lava), landslides, and drought. Thirdly, efforts should be made to improve the management of water resources infrastructure in order to mitigate the destructive potential of water. Fourthly, it is important to raise awareness and encourage community participation in water conservation practices. Lastly, there is a need to enhance the availability and accessibility of data and information pertaining to the impacts of climate change on water resources. The National Action Plan for Climate Change Adaptation in the domain of food security is outlined as follows: The three key areas of focus in addressing climate change in farming systems are: (1) the adaptation and development of farming systems to effectively respond to climate change, (2) the development and deployment of adaptive technology to mitigate the impacts of climate stress on agricultural practices, and (3) the development and optimization of resources such as land, water, and genetics to enhance agricultural productivity and resilience in the face of climate change.

⁴⁴ BAPPENAS. 2014. *Rencana Aksi Nasional Adaptasi Perubahan Iklim (RAN-API)*. Jakarta: Badan Perencanaan Pembangunan Nasional, Republik Indonesia.

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