Climate Change and Undernutrition Challenge of Children Under Five Years of Age in East Nusa Tenggara-Indonesia: A Literature Review

Putu Sri Agung Paramita Kelakan

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KIT (Royal Tropical Institute)

Vrije Universiteit Amsterdam (VU)

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Master of Science in International Health

by

Putu Sri Agung Paramita Kelakan

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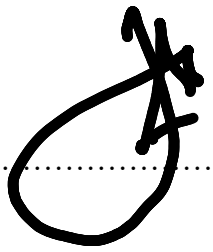
Signature: …… 

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Abstract

Introduction

undernutrition is still one of the world's most serious socioeconomic and health problems which can cause risk factors for health problems, decreased cognitive development, and poor educational outcomes. Climate change through climate events can potentially exacerbate the determinants of undernutrition. As the province with the highest level of stunting in Indonesia and one of the provinces that is prone to natural disasters, it is important to understand how climate change can affect undernutrition in NTT in order to strengthen the policy related to climate change and undernutrition including mitigation and adaptation efforts

Methods

This study is a descriptive study that is based on a literature review to address all the objectives. The framework used in this study is the climate change and nutrition meta-framework by Salm et al.

Findings

The determinants of undernutrition in NTT are the availability of nutrient-rich food, feeding practices, maternal education, maternal health, access to clean water and improved sanitation, socioeconomic, and health services and facilities. The increasing number of climate events is affecting the determinants which will exacerbate undernutrition through food, care, and health pathway. However, the mitigation and adaptation plans that are available are not specifically mentioning undernutrition.

Conclusion

Climate events tend to exacerbate the risk of undernutrition through the determinant of undernutrition in NTT. Therefore, mitigation and dynamic adaptation efforts are important to reduce the impact.

Keywords

Indonesia, Undernutrition, Climate, Adaptation, Mitigation

Word Count

13,086 words

List of Figures

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Abbreviation

COP	Conference of Parties
DALYs	disability-adjusted life years
FSVA	Food Security and Vulnerability Atlas
GHG	Greenhouse Gasses
IPCC	Intergovernmental Panel on Climate Change
IYCF	infant and young child feeding
MoH	Ministry of Health
NCDs	Non-Communicable Diseases
RISKESDAS	Riset Kesehatan Dasar (Basic Health Research)
SSGI	Studi Status Gizi Indonesia (Study of Indonesian Nutrition Status)
UNICEF	United Nations Children's Fund

Key Terms

Stunting	Low height-for-age (159)
Underweight	Low weight-for-age (159)
Wasting	Low weight-for-height (159)

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My dear daughter, now I can play with you again.

Chapter 1: Background Information on Nusa Tenggara Timur, Indonesia

1.1.Geographical, and socio-demographical

Indonesia is the largest archipelago country in the world as it accounts for more than 17,500 islands (1). The archipelago consists of five main islands which are Java, Kalimantan, Papua, Sulawesi, and Sumatera, also four smaller archipelagos which are Riau, Bangka Belitung, Nusa Tenggara, and Maluku (2). Until 2021, Indonesia had 34 provinces which were divided into 416 regencies and 98 municipalities and further divided into 7,230 districts, 8,488 sub-districts, and 74,953 villages (3). Indonesia is famous for its diversity of ethnic, cultures, and languages. There are more than 700 languages available in Indonesia and there are more than 300 ethnic groups living in this country (4). In the last decade, Indonesia has successfully recorded an average annual GDP growth of around 5% per year which resulted in reducing poverty from 14.1% in 2019 to 9.2% in 2019 (5). Indonesia's Human Development Index increased significantly from 0.67 in 2010 to 0.71 in 2018 (5). East Nusa Tenggara (NTT) is an archipelagic province of Indonesia which is a part of Nusa Tenggara Archipelago (2). NTT is also called Flobamorata because it consists of five islands which are Flores, Sumba, Timor, Alor, and Lembata (6). NTT is 47,931 km2 in land area, and the largest island is Timor at 14.732 km2 (6). Administratively, in 2020, NTT was divided into 21 regencies and 1 municipality. The largest area is Sumba Timur Regency at 7,005 Km2 and Kupang Regency at 5,525 km2 (6). The total population of NTT in 2020 was 5,325,566 people with 51.43% working in the agriculture, forestry, and fishery sectors (6). Based on the data of the human development index by province in Indonesia, NTT has experienced a significant rise from 63.13 in 2016 to 65.19 in 2020. However, NTT is placed 3rd as the province with the lowest human development index in Indonesia after Papua and Papua Barat (6).

1.2.Climate Profile

The climate in Indonesia is tropical where the highest rainfall is in the lowland, and the mountain areas have cooler weather. The wet season is from November until April, and the dry season is from May until October. El Niño Southern Oscillation (ENSO) influence the climate in Indonesia. Dry periods happen during El Nino and wetter periods happen during La Nina (1). The eastern part of Indonesia is dominated by a dry climate with annual rainfall of less than 2.000 mm per year where 24% of the areas are located in East Kalimantan, East Java, part of Sulawesi, North Maluku, Bali, West Nusa Tenggara, and NTT (1,7). In NTT, around 3.3 million hectares from the total of 4.6 million hectares of land are categorised as very dry regions or semiarid with annual rainfall less than 1,000mm and the other 0.3 million hectares have more than 2,000mm annual rainfall (7). The wet season in NTT only appears for four months while the rest 8 months are the dry season. The fewer rainy days are affected by the geographical location of NTT which is located near Australia, where the moist wind from Asia and the Pacific Ocean reaches NTT with reduced moisture (8,9). There is a large variety in temperatures across NTT. Based on the data from 10 meteorology and climatology stations in NTT, it has been documented that the highest temperature was in 2020 which was 32.9℃. NTT is categorized as hot areas with average temperatures between 27℃ and 28℃. The average rainfall that has been recorded in 2020 was 141.9mm.

1.3.Health System

Since the beginning of decentralisation in the 1990s, health control such as management, health facilities, human resources for health, policy, and budget were delegated to the provincial governments, then the provincial governments will delegate it to regencies. Since January 2014, the government of Indonesia launched a comprehensive Universal Health Coverage program which is managed by the Healthcare Social Security Management Agency (Badan Penyelenggara Jaminan Sosial Kesehatan/ BPJS Kesehatan) (4,10) which is known as one of the world's largest single-payer social health insurance programmes (11,12). By 2018, BPJS Kesehatan covered around 76% of the total population in Indonesia (11,12).

At the district level, health services are focused in Puskesmas which not only provides medical care but also has a role as a public health centre. The main curative service provider is hospitals which also accept referral cases which could not be handled in the Puskesmas. The responsibility of the health sector governance is tiered which includes the regency, provincial, and central governments where each governance is responsible for the hospital in their territory. The regency governance is also responsible for the Puskesmas. The Ministry of Health is responsible for the central hospital as the last referral, provides strategic direction for the health sector, establishes Health standards and regulations, and ensures the availability of financial and human resources for Health (4,10). NTT as a province also follow this pattern where all the Puskesmas located in the districts of NTT are under the regency governances, and the regency governances are also responsible for the hospital in their territory. Most of the Puskesmas also have subsidiary Puskesmas to help with the work of the main Puskesmas. As Puskesmas not only provide medical care but also has a role in public health, it has basic health programs such as health promotion, maternal and child care, nutrition program, and environmental health program (13). To provide healthcare and health promotion to mothers, pregnant women, caregivers, and children under five, Puskesmas own a program called Posyandu which recruits the communities to participate as cadres (14). The activities in Posyandu include vaccination, nutrition education, and prevention and treatment of diarrhoea (14). Posyandu plays an important role to screen undernutrition. Each child who visited Posyandu will get screened through their height, weight, vaccination status, and others (15). The cadres will refer those who are undernourished to the Puskesmas to get further care. The ideal ratio of the subsidiary Puskesmas is 1 subsidiary Puskesmas to serve maximum of 1,500 population. However, in 2017, the ratio was 1:4,979 which is far than the ideal ratio. The ideal ratio for the main Puskesmas is 1:16,000 and in 2017, the ratio was 1:13,420 which means it has fulfilled the ideal ratio. Nevertheless, according to the condition of NTT which is an archipelago province with uneven distribution of population, also considering the geography and topography of NTT, it seems that NTT still needs more Puskesmas (16).

1.4.Undernutrition of children under 5

With the continued high rate of stunting, underweight, and wasting rates of children under five in Indonesia, nutrition is a significant problem (17). According to Riskesdas in 2018, 17.7% of children under five in Indonesia are underweight, 30.8% of children under five in Indonesia experienced stunting, and 10.2% of children under five are experiencing wasting (3,18). In 2021, the result from SSGI mentioned, that the rate of stunting in Indonesia decreased to 24.4%, as well as wasting decreased to 7.1%, and underweight also decreased to 17% (figure 1) (19). In the same year, the number of stunted children under five in NTT was decreasing to

37.8% from 45% in 2018. However, both in 2018 and 2021, NTT still placed as the province in Indonesia with the highest number of stunting prevalence (figure 2, figure 3). (19,20).

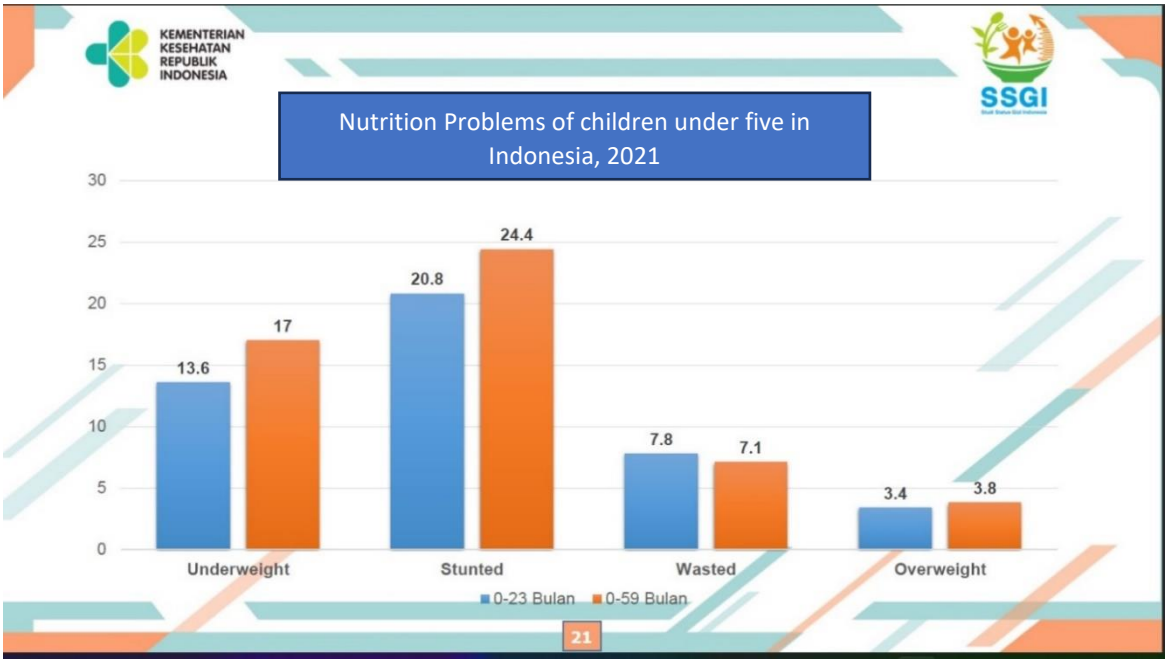

Figure 1. The percentage of nutrition problems of children under five in Indonesia, 2021. Blue shows the percentage of 0-23 months old, and orange shows the percentage of 0-59 months old. (19)

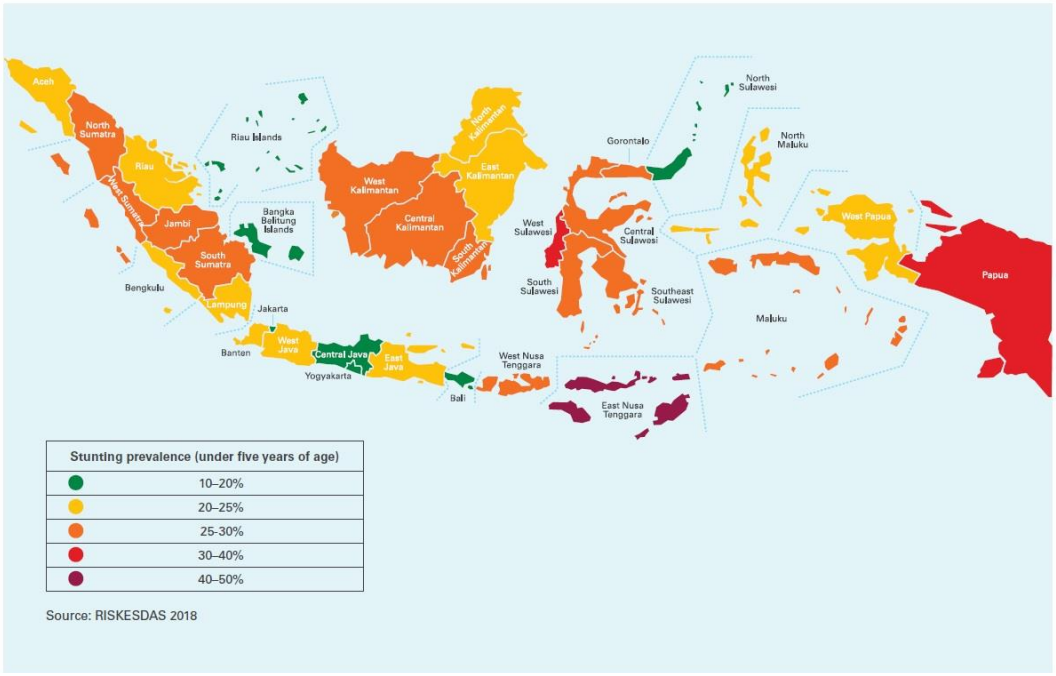

Figure 2. Stunting prevalence of children under five in Indonesia, 2021 (20)

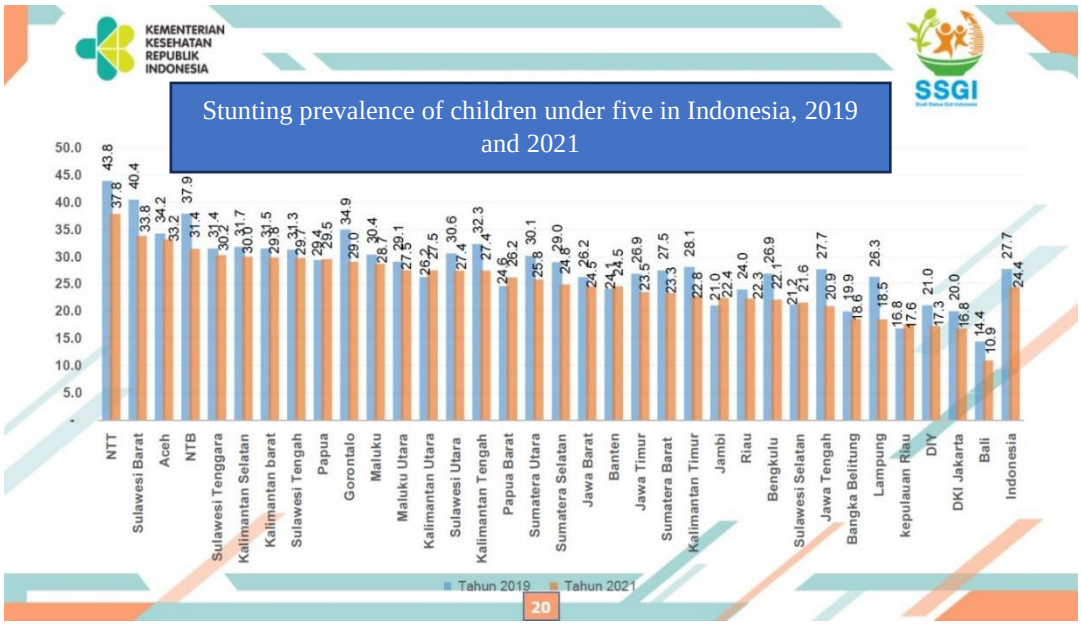

Figure 3. Stunting prevalence of children under five in Indonesia, 2019 and 2021 (19)

The region in NTT with the lowest rate for stunting was Flores Timur with 23.4% and the highest rate was Timor Tengah Selatan at 48.3% followed by Timor Tengah Utara with 46.7%. For Wasted, the lowest rate was in Manggarai Barat and the highest was in Rote Ndao. As for the underweight rate, the lowest was in Manggarai and the highest was in Kupang Regency. All the highest rates are located in Timor and Rote Island which are located next to each other. According to the map of food security of NTT in 2011, there were many areas in Timor and Rote Islands that were the priority of food insecurity, however, in 2015, there were many improvements related to food security and almost all of the areas changed into secure except for Kupang Regency and South Timor Tengah (Figure 4) (21,22).

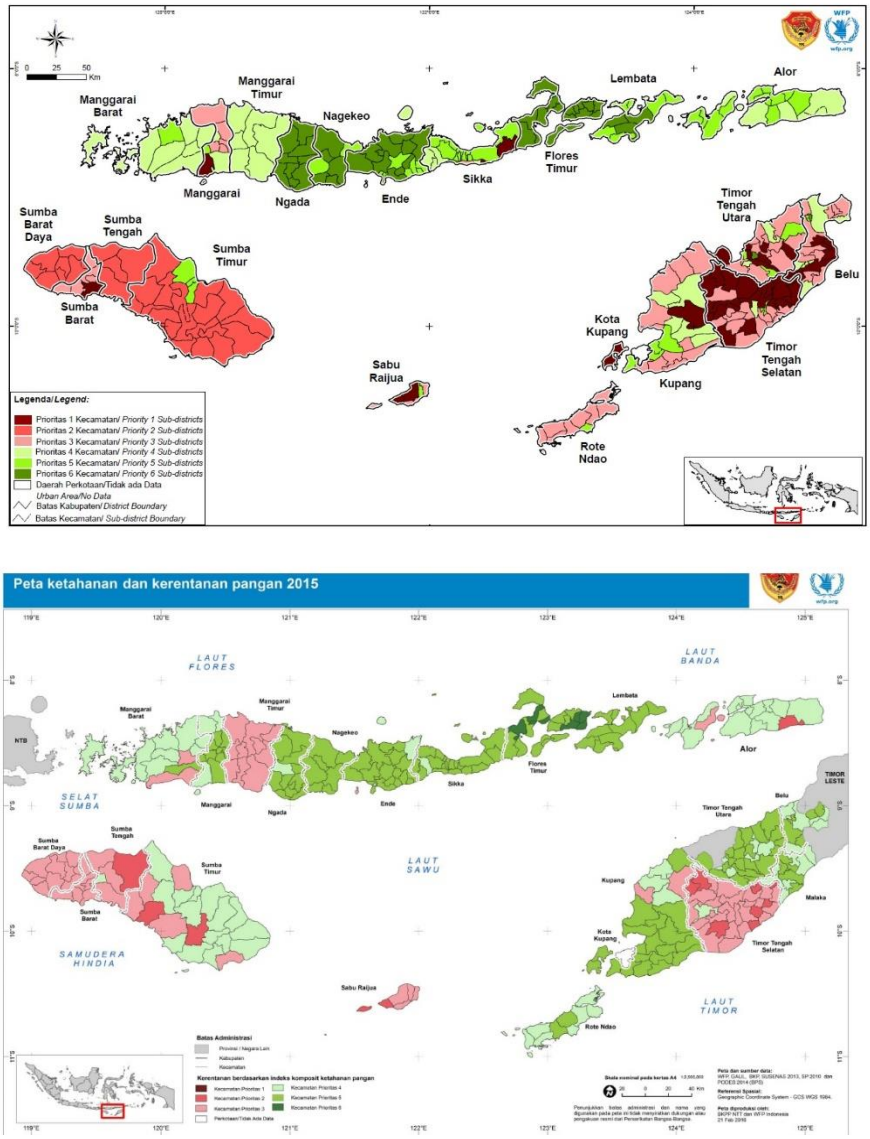

Figure 4 The Food Insecurity Map in NTT in 2011 (above) and 2015 (below). The green areas represent areas with less priority while red ones are the areas with high priority (21,22)

Chapter 2: Problem statement, justification, objectives, and methods

2.1. Problem Statement and Justification

As stated in the Conference of Parties 26 (COP 26) special report on climate change and health 2021, climate change can cause death and harmful effects on health through heat waves, storms and floods, food system disturbances, increasing cases of zoonosis, and mental health (23). Specific observations showed that some areas are being exposed to or experiencing new varieties or increased cases of food, water, and vector-borne diseases (23). It is projected that future health impacts such as injuries, diseases and deaths will be caused by intense heatwaves, food-, water-, and vector-borne diseases, and undernutrition (23). These impacts will mostly affect the most vulnerable and disadvantaged populations. Women, children, ethnic minorities, poor communities, migrants or displaced persons, older populations, and those with underlying health conditions are those who are included as the most vulnerable and disadvantaged populations (24,25).

Often overlooked, undernutrition is still one of the world's most serious socioeconomic and health problems (26). Inadequate intake of important nutrients for children's growth and development such as protein, vitamins, and minerals can result in undernutrition (27). Undernutrition also can cause risk factors for health problems, decreased cognitive development, and poor educational outcomes (28,29,30). In further, a person who has undernutrition in their childhood often has a limited ability to participate in social and economic activities. Moreover, their children also have this limitation(26,31). Undernutrition is caused by multiple factors such as limited access to food, poor feeding practices, infection, poverty, inadequate access to healthcare, poor sanitation, and food insecurity (26,30,32,33). In 2011, it has been reported that 45% of the total 3.1 million deaths of children under five worldwide are related to undernutrition (32), and in 2017, more than 150 million children in the world were stunted (34). This mostly happens in low and middle-income countries (35) where access to food and healthcare are limited (26,27).

There is an increasing amount of evidence showing that vulnerable populations like women, infants, and children who are undernourished are vulnerable to climate change as it indirectly affects nutrition through deteriorating problems related to food, care, and health in varied ways (26,31). Climate change will affect food security and disturb the ongoing hunger reduction effort (26). The changes in temperature, rainfall, and extreme weather conditions as a result of climate change can impact harvests, which can cause food insecurity. This can affect the nutrition status of children under five, where at this age, children are really sensitive to nutritional deficits which can disturb their cognitive development and their health (36,37). The Intergovernmental Panel on Climate Change (IPCC) mentioned in its fifth assessment report that climate change will have negative impacts on per capita calorie availability, childhood undernutrition (particularly stunting), undernutrition-related child deaths, and DALYs (disability-adjusted life years) in developing countries (38).

Climate change may also impact the physical environment, which can further result in undernutrition. Through long-term warming and changes to precipitation, the increased greenhouse gases in the atmosphere will impact agricultural production and livelihood assets, and increase irrigation water requirements (31). The increased level of carbon dioxide in the atmosphere can reduce the nutrient levels such as protein, iron, and zinc in plant foods, especially cereals, and legumes (39). Atmospheric carbon dioxide also displaces nitrogen which is necessary for protein synthesis and reduces mineral content in the plants. In further, this will affect calories

and nutrition intake (31). The household that relies on fish or marine production will also be affected due to the increase in ocean acidification.

Stored plants and grains can be stressed by variability in precipitation and temperature as well as increased humidity. Plants can also be spoiled before and after harvesting due to the shifted range of aflatoxin-producing fungi which is also caused by variability in precipitation, temperature, and increased humidity. In further, all these climate change impacts will also affect food prices which will reduce access to food and will affect food and nutrient intake (31,39). High temperatures and extreme weather conditions can affect appropriate care and feeding practices (31,39). Women's availability to give adequate feeding and care can be affected by changes in rainfall patterns that may result in increased labour migration and female workloads (39).

Climate change can also affect breastfeeding practice as the recommended source of nutrition for newborns and infants (31). Dehydration and other climate-related impacts on the maternal diet can affect the quality of breast milk (39). Climate shocks and stresses are exacerbating poor early childcare practices such as inadequate breastfeeding practices, inappropriate complementary feeding, poor access to food, and inadequate micronutrient intake that contribute to poor growth and malnutrition of children. Climate change also affects the health of pregnant women and foetuses which are vulnerable to extreme temperatures (31). Warmer climates and heatwaves can prolong drought and increase the risk of diarrhoea and dehydration which also affects fetal growth and the breastfeeding ability of a mother (31). Warmer climates and heatwaves also can cause maternal stress, lack of appropriate mother-child spaces, and decreasing access to clean water, sanitation and hygiene (31,39,40).

The risk of water and food borne diseases are also increased which further, as a consequence of warmer temperatures, extreme weather, and change in rainfall patterns can affect nutrition (31,39). Extreme weather can destroy facilities, infrastructure, and health commodities such as medicines, nutritional, supplemental and therapeutic foods which can cause unavailability of regular maternal and childcare health services. Family can also lose economic access to health services or transportation to access healthcare which can fasten the undesirable interactions of diseases and undernutrition (31,39,41). Crops, livestock, fish, and humans will be exposed to new pests and disease vectors by the warmer ambient temperatures, which also cause microbial growth and increase the transmission of food-borne illnesses (31,39,41).

Although it is difficult to isolate and identify direct evidence of climate change impacts because it relates to the pattern and intensity of climate factors in an average of a 30 years timespan, there are several indicators that can provide insight into climate change in Indonesia. These indicators are changes in land temperatures, changes in extreme rainfall patterns, shifting of seasons, and changes in rainfall volume (42). These indicators are related to climate events such as floods, drought, storms, fires, and heat waves which can cause physical environment impacts that indirectly affect nutrition.

Indonesia is one of the countries that is most prone to climate change (1) and the number of undernutrition rates is also high. The latest data showed that 17% of children under five were underweight, 24.4% were stunted, and 7.1% were wasted (19). NTT is one of the provinces that have the highest level of undernutrition in Indonesia, particularly stunting (3,19). Additionally, NTT is known for its natural disasters. Every year, NTT experienced several natural disasters such as landslides, floods, and droughts (43). Climate change can exacerbate the incidents of natural disasters which may further worsen undernutrition in NTT.

Compared to 2018, the number of undernutrition rate in Indonesia has been reduced in 2021, as well as in NTT. Even so, with the threat of climate change, it is important to keep an awareness of it (19). Therefore, it is important to understand how climate change can affect undernutrition in NTT in order to strengthen the policy related to climate change and undernutrition including mitigation and adaptation efforts (37).

2.2. Objectives

Main Objective:

The objective of this thesis is to analyze the link between climate change and undernutrition in NTT - Indonesia, in order to help the Indonesian government strengthen the mitigation and adaptation strategy regarding undernutrition and climate change.

Sub Objectives:

1. To describe the determinants of undernutrition in NTT
2. To describe the impacts of climate change in NTT and its potential impacts on undernutrition
3. To describe the adaptation and mitigation efforts related to climate change in Indonesia.
4. To provide recommendations for the Indonesian government related to the link between undernutrition and climate change.

2.3. Methods

2.3.1. Conceptual Framework

This study is a descriptive study that is based on a literature review to address all the objectives. The framework used in this study is the climate change and nutrition meta-framework by Salm et al (Figure 5) (46), which is a development from the nutrition framework by UNICEF (44), 2018 Lancet Countdown on Health and Climate Change report (41) and an article by Karlsson, Naess, Nightingale, and Thompson (45,46). This framework is considered related to all the objectives of this study.

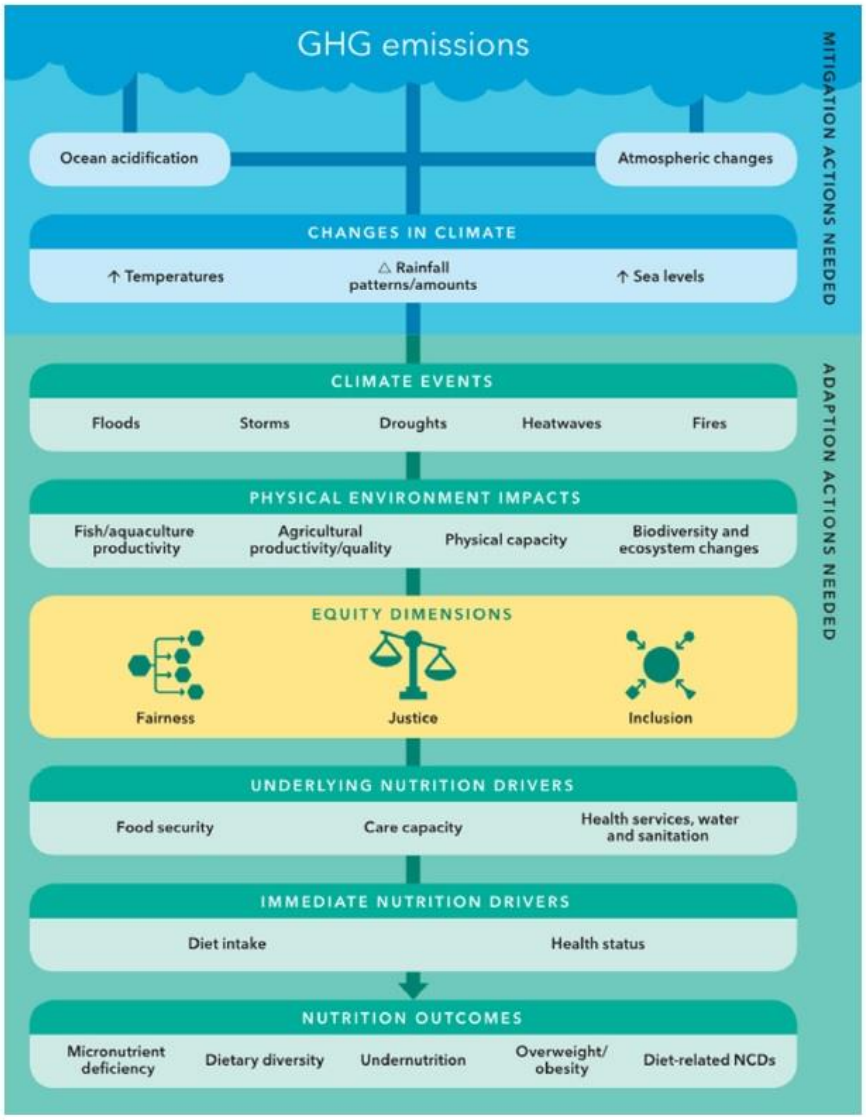

Figure 5. The Climate Change and Nutrition Meta-framework by Salm et al (46)

The determinants of undernutrition are shown in the framework within the underlying nutrition drivers and immediate nutrition drivers which resulted in nutrition outcomes such as micronutrient deficiency, dietary diversity, undernutrition, overweight/obesity, and diet-related Non-Communicable Diseases (NCDs). However, this study will only focus on one nutrition outcome which is undernutrition. The two nutrition drivers are based on the underlying and immediate causes from the nutrition framework by UNICEF, 2018 (44). The situation of these determinants of undernutrition in NTT will be described in the findings to answer the first sub-objective. There are three elements in the underlying nutrition drivers that determine undernutrition. They are food security; care capacity; health services, water and sanitation.

According to the framework, from the particular level where the equity dimension is placed, the outcomes of climate change for various communities are more likely to be influenced by inequity. Climate change is one threatening issue for reaching optimal nutritional status as it can affect food production and alter social and economic influences in life. Salm et al had seen from many existing papers mentioned that climate change can affect nutrition because of inequity that the vulnerable populations are the most impacted by the effect of climate change on nutrition. However, from the existing literature, they have not seen any research mentioning why, so they develop this framework. Salm et al made a conclusion during their development of this framework, that it is important to find the cause of inequity (how it can happen) in order to find solutions behind the impact of climate change on undernutrition (46). Salm et al developed three equity dimensions (fairness, justice, and inclusion) to widen the focus on equity. If there are some socioeconomic groups that get the most impact, where these groups do not have proper access to get goods and services because of several reasons such as poverty, or because they are living in an ecologically geographically marginal area, this means that it is against fairness. Furthermore, there are some situations that are against justice such as gender or racism where there is an assumption that specific genders or minority ethnicities are less favoured. The last equity dimension is inclusion. This dimension means that all people whether they are minorities, poor or live in the rural, they need to be included in all decision-making. This inclusion is important to make sure all people will experience fairness and justice (45,46).

2.3.1.1. Underlying nutrition drivers

2.3.1.1.1. Food security

Food security consists of three elements which are availability, access, utilization and stability. Availability means that supply must meet the needs of the whole population in quality, quantity, and variety (47). The availability of food can be from national production, food reserves, and food income which includes import and food aid (21). Access means the capability of households to have enough nutritious food. It can be from self-production, market, barter, gift, and aid (21). Food might be available in some areas, but some households might not be able to access it if they are not capable to access due to physical, economic, or social situations (21). If there are many varieties of food with huge quality and quantity but many households cannot afford it, then it cannot be stated as secure (44). Food utilization includes the utilization of food that can be accessed by households and the individual's ability to absorb nutrients. It also includes how the food is being stored, processed, and prepared, the safety of the water that is used to drink and cook, hygiene conditions, feeding habits, and distribution of food within the household according to individual needs (growth, pregnancy and lactation), and the health status of each household member (21). Adequate energy and nutrient intake by individuals is the result of good feeding practices, food preparation, dietary diversity and food distribution within the household (11,21,48). Stability means that a "secure situation" needs to be sustainable. If the food intake is adequate at present, but there are several moments of inadequate access to food that risks the nutritional status, it cannot be stated as stable. This situation can be affected by weather conditions, unemployment, food prices, or political instability (11).

2.3.1.1.2. Care Capacity

Care capacity includes feeding for children and the ability to give care. According to the infant and young child feeding by WHO and UNICEF, in the first 1 hour of birth, the early initiation of breastfeeding is recommended, as well as 6 months of exclusive breastfeeding which needs to be continued until 2 years of age and combined with safe complementary foods starts from 6 months of age (49). Mothers and children have linked health and nutritional status, which means, ensuring the health and nutritional status of mothers is important in order to improve infant and young child feeding (50,51). Therefore, it is important for mothers to have access to information and skilled support. This is related to the other underlying cause "inadequate health services" where mothers can get adequate access to information and skilled support from the resources of the health services (50). Furthermore, women's literacy, especially mothers and caregivers of toddlers, is known to be a very important determining factor in food utilization and greatly influences the health and nutritional status of each family member. Studies in various countries show that the level of education and knowledge of mothers about nutrition is highly correlated with the nutritional status of their children (21,48).

2.3.1.1.3. WASH/Health

Water is one of the most important things to the food system and health. The quality of the water used for drinking can affect the effectiveness of the absorption of nutrients in the human body (48). With access to a safe water supply and proper sanitation, the risk of diarrhoea and the spread of infectious diseases can be prevented. The health centre also plays an important role in supporting good nutrition because it can provide access to curative and preventive health services (21,44).

2.3.1.2. Immediate Nutrition Drivers

Underlying nutrition drivers will affect the diet intake and health status in immediate nutrition drivers. Both diet intake and health status such as infection in immediate nutrition drivers are affecting each other. Infection can cause loss of appetite, malabsorption, disturbing metabolism, also behaviour change. The same condition will also happen to children with undernutrition. Their immunity is weak and it is easy to get sick, which further can worsen their undernutrition state (44).

2.3.1.3. Climate Events, Physical Environmental Impacts, and Their Potential Impact on Undernutrition

Climate events can cause physical environmental impact which further can affect the nutrition drivers through three pathways which are food pathway, care pathway, and health pathway and then resulting in consequences for human health and nutrition (31). Several possible impacts of climate change through climate events that can affect undernutrition are shown in Appendix 1. The impacts of climate change in NTT will be described in the 2nd sub-objective.

2.3.1.4. Mitigation and Adaptation

Mitigation and adaptation are two strategies that are used to address climate change. Mitigation focused on human intervention in preventing or reducing Greenhouse Gasses (GHG) emissions (41,52). In this context, humans can refer to individuals, organizations, and governments. Adaptation focused on preventing the damage caused by climate change (52). In Indonesia, the

mitigation and adaptation efforts are at the national level and each region is responsible to apply it in their region based on their development priority, regional budget and the community (53).

2.3.1.5. Equity Dimensions

As the part of equity dimension is quite complex, it will be only briefly explained about the status of who gets the most impact related to climate change and undernutrition. This part will be placed after answering the second sub-objective about the impacts of climate change in NTT and its potential impacts on undernutrition.

2.3.2. Literature Review

To find literature related to the study, a systematic literature search was done through PubMed, Google Scholar, and the VU library database. Organizational, governmental, and other websites were also accessed to find grey literature. The keywords used for the search are shown in Appendix 2. The inclusion criteria were studies conducted from 2000 onwards, except for the source of UNICEF's framework and agreements that have not been renewed. Literature in both English and Bahasa Indonesia was included, as well as, unpublished literature and reports. The exclusion criteria included studies about overnutrition or overweight.

Chapter 3: Findings.

3.1. Determinants of Undernutrition in NTT

3.1.1. Underlying Nutrition Drivers

3.1.1.1. Food Security

According to the map of the provincial food index 2021 (figure 9), in 2020, NTT was placed in the "secure' state with a score of 67.35 (the scores are between 0-100. The cut-off point of the food security index are shown in table 1) (54). This score was compiled by the Indonesian Food Security Agency-Ministry of Agriculture based on nine indicators; Normative consumption to production ratio, Percentage of population living below the poverty line, Percentage of households where the proportion of expenditure on food is more than 65 per cent of total expenditure, Percentage of households without access to electricity, Average years of schooling for women above 15 years, Percentage of households without access to clean water, Ratio of population per health worker to population density level, Percentage of children under five with stunting, and Life expectancy at birth (54). NTT was placed in the 28th position within 34 provinces with Papua in the last place with a score of 35.48. Even though NTT is in a secure state, it is still ranked poorly in Indonesia as there are half provinces of Indonesia scored above 75 (54). Appendix 3 shows the details of the food security and its elements scores of each Regency and Municipality in NTT (54). Kupang City as the only municipality in NTT, does not have an availability score because a city is considered unable to provide its own food (54). The scores of availability are relatively high except for Sabu Raijua Regency with 41.31. This score is far below the score of other districts. However, even though the scores of availability elements are relatively high, the scores of access and utilization and stability scores for each district are much lower.

Table 1. The cut off point of the food security index (54)

Food Security Classification	Regency	City	Province
1 (Very Insecure)	<= 41.52	<= 28.84	<= 37.61
2 (Insecure)	> 41.52 – 51.42	>28.84 – 41.44	>37.61 – 48.27
3 (Quite Insecure)	>51.42 – 59.58	>41.44 – 51.29	>48.27 – 57.11
4 (Quite Secure)	>59.58 – 67.75	>51.29 – 61.13	>57.11-65.96
5 (Secure)	>67.75 – 75.68	>61.13 – 70.64	>65.96 – 74.40
6 (Very Secure)	>75.68	>70.64	>74.40

For example, South Timor Tengah (Timor Tengah Selatan) owned a food security score as high as 59.21 while the availability score was quite high (89.09) but the score to access, and utilization and stability are really low (41.01 and 51.20). According to Appendix 3, from the 11 regencies that owned the lowest scores of food security, 72% of the regencies were in the top 10 regencies with the highest number of stunting.

3.1.1.1.1. Availability

In NTT, the main food commodities are mostly corn, rice, tubers, and cereal crops, as they are the primary food for most people of NTT. Fisheries and livestock also contribute as one of the sources of food in NTT. Vegetables and fruits are also the main sources of vitamins and minerals in NTT (21). The rice production in NTT increased by 49% from 2010-2014; in 2019, it increased by 2% from the production in 2018 (48). Meanwhile, the production of fruits and vegetables was decreasing from 651 thousand tons to 472 thousand tons (21). Fish production was also decreasing by 15.06% from 2013 to 2014. The latest food security report (48) did not include the production of fruit, vegetables, and livestock production. According to the availability rates, the scores of food availability in NTT are relatively high, which means that the food in NTT should be enough to fulfil the needs of the whole population. However, the indicator that is used to calculate the availability scores is only used to calculate the availability of high energy plants and not considering food sources from animals, fruits, vegetables, and other commodities (21,48) which are rich in nutrients (55,56). This means that the food availability in NTT is not considering the variety of the food and can cause undernutrition due to a lack of nutrients from animals, fruits and other commodities (55,56).

3.1.1.1.2. Access

The access scores in NTT are low compared to the availability scores. Of 21 regencies and 1 city in NTT, only six of them had access scores above the provincial food security index. As it is mentioned in the method section, food might be available in some areas, but some households might not be able to access it if they are not capable to access due to physical, economic, or social situations (21,48). Physical access is related to infrastructure and transportation (21,48). The infrastructures to connect islands need more attention. For example, transportation to connect Sabu Raijua and other regencies is through water transportation meanwhile the availability of the modes of transportation itself is limited. The schedule of a ship to come to Sabu Raijua is once per two weeks (57) and when there are bad weather or high tides, no ship can be operated (58,59). Water transportation is crucial because NTT also buy food from other provinces and the commodities are delivered to NTT through water transportation (21). The infrastructure for land transportation also needs attention. The road became impassable due to the damage caused by the flood, and the lack of investment to fix it. It is important to do the improvement of port infrastructure to avoid the long late and high cost of transportation between islands to provide proper food commodities (21). Economic access is related to the affordability to buy nutritious food. Food might

be available in the market, but not every household can afford a variety of food. Those who are unable to afford will only buy cheaper food for their family which is probably enough to fill their stomach but not their nutrition (21,48), and some people tend to reduce the quantity of the food they are buying (60). Thus, it will affect the nutrition of all family members, especially those who are vulnerable like pregnant women and children (21). Social access means how people get access to food through social programmes (21,48). The government has provided rice to help 421,799 households in NTT. This programme aims to help people get food, especially during the "hunger period" in October – December 2015 and 2016 due to the shift in planting (21). Even though the literature mentioned three situations related to access (physical, economic, and social), to count access scores, it is not included physical access.

Table 2. Poverty Line, Number, and Percentage of Poor People by Regency/Municipality in NTT (6)

Kabupaten/Kota *Regency/Municipality*	Garis Kemiskinan (rupiah/kapita/bulan) *Poverty Line (rupiah/capita/month)*		Jumlah Penduduk Miskin (ribu) *Number of Poor People (thousand)*		Persentase Penduduk Miskin *Percentage of Poor People*	
	2019	2020	2019	2020	2019	2020
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Kabupaten / *Regency*						
1. Sumba Barat	331 713	358 252	36,56	36,95	28,29	28,17
2. Sumba Timur	343 589	370 487	77,39	77,3	30,02	29,65
3. Kupang	356 463	379 600	92,02	94,94	23,03	22,77
4. Timor Tengah Selatan	318 986	338 099	130,31	128,98	27,87	27,49
5. Timor Tengah Utara	363 162	386 990	56,94	56,98	22,45	22,28
6. Belu	349 414	372 087	34,08	34,18	15,54	15,37
7. Alor	311 560	336 402	44,32	43,55	21,59	21,09
8. Lembata	359 792	388 577	37,46	37,92	26,30	26,14
9. Flores Timur	279 268	301 611	27,83	27,89	10,90	10,84
10. Sikka	301 994	324 775	43,32	42,18	13,53	13,12
11. Ende	363 508	392 591	63,45	65,22	23,18	23,76
12. Ngada	336 601	363 531	20,31	20,62	12,48	12,51
13. Manggarai	316 910	340 633	69,33	69,52	20,55	20,34
14. Rote Ndao	305 166	322 619	47,66	48,77	27,95	27,54
15. Manggarai Barat	318 546	340 094	49,23	49,4	18,01	17,71
16. Sumba Tengah	285 048	307 853	25,12	25,37	34,62	34,49
17. Sumba Barat Daya	355 252	383 674	96,30	97,81	28,06	28
18. Nagekeo	328 646	353 481	18,70	18,51	12,85	12,61
19. Manggarai Timur	318 762	344 642	75,83	76,69	26,49	26,52
20. Sabu Raijua	374 256	403 846	29,49	30,14	30,52	30,18
21. Malaka	348 919	371 812	30,83	31,12	16,12	16,04
Kota / *Municipality*						
1. Kota Kupang	545 219	587 921	39,86	39,72	9,22	8,96
Nusa Tenggara Timur	**373 922**	**403 005**	**1 146,32**	**1 153,76**	**21,09**	**20,9**

The indicators that are used are those that represent economic access which are the percentage of the population living below the poverty line, the percentage of households where the proportion of expenditure on food is more than 65 per cent of total expenditure and the percentage of households without access to electricity (48). The regencies with access scores above 66 (Appendix 3) are the regencies with a percentage of poor people below 20% (Table 2).
Physical, Economic, and Social are related. NTT also buy commodities from other provinces which require water transportation to deliver the commodities (21). Bad weather, dry season, and longer-term environmental conditions can affect the market price because of the change in agricultural production, and hard access which can cause scarcity of commodities (44,60). The government also send rice through water transportation (61) where bad weather can cause a delay in the delivery and distribution (62).

3.1.1.1.3. Utilization

The Food Security and Vulnerability Atlas (FSVA) of NTT stated that utilization consists of the ability the utilization of food accessible to households and the ability of individuals to absorb nutrients-efficient utilization of food by the body. These aspects depend on food storage and processing facilities, the knowledge and practices related to food preparation, and feeding practice for children under five and other family members. All these elements can be influenced by the level of knowledge of mothers or caregivers and customs or beliefs. Additional aspects are the distribution of food within family members and the state of health of each individual which may be declining due to disease, poor hygiene and water and sanitation (21,48). A study in NTT shows that there is a strong relation between food processing, feeding practice, and stunting (63). The study also mentioned that 53% of children under five who eat from improper food processing and 48% of children who got improper feeding practice processing were stunted (63). The study also mentioned that a history of diarrhoea is also related to stunting, where 41% of children under five with a history of diarrhoea are stunted. Low access to clean water can cause water-borne diseases such as diarrhoea which can affect nutrient absorption (48). In 2019, the number of households without clean water access in NTT is 34.52% which is higher than the national percentage (26.35%). Usually, women are responsible to prepare, cook, preserve and store food for their families (44,48), therefore, women with high education are likely to serve more various and nutritious food which contributes to increasing the consumption patterns in their household (48). The average schooling duration of women above 15 years of old in NTT is still below the target (12 years of duration) (48).

3.1.1.2. Care Capacity

3.1.1.2.1. Breastfeeding

Breastfeeding and stunting are correlated. Infants who are exclusively breastfed until 6 months of age are unlikely to have stunting (12). According to a study by Rosita et al, the chance of stunting in toddlers who are exclusively breastfed is 5 times lower than in those who are not (12,64). National data also shows that in 2021, NTT has good rates of exclusive breastfeeding which are 72.4% for 0-5 months of age infants and 67.2% for 6-23 months of age infants. Both are above the national average which are 52.5% and 52% (19).

3.1.1.2.2. Complementary Feeding

The nutrition and energy from breastfeeding alone are not enough when infants reach 6 months of age, therefore, infants at this age need complementary feeding (65). The guidelines of infant and young child feeding (IYCF) (Table 3) state that to ensure children get all the nutrient needed, the food needs to be nutrient-rich (65). In NTT, only 39.9% of children eat nutrient-rich food and only 71.4% of children meet the minimum frequency of eating according to the recommendation of IYCF (65,66).

Table 3. IYCF Practical Guideline (65)

AGE	ENERGY NEEDED PER DAY IN ADDITION TO BREAST MILK	TEXTURE	FREQUENCY	AMOUNT OF FOOD AN AVERAGE CHILD WILL USUALLY EAT AT EACH MEAL[a]
6–8 months	200 kcal per day	Start with thick porridge, well mashed foods Continue with mashed family foods	2–3 meals per day Depending on the child's appetite, 1–2 snacks may be offered	Start with 2–3 tablespoonfuls per feed, increasing gradually to ½ of a 250 ml cup
9–11 months	300 kcal per day	Finely chopped or mashed foods, and foods that baby can pick up	3–4 meals per day Depending on the child's appetite, 1–2 snacks may be offered	½ of a 250 ml cup/bowl
12–23 months	550 kcal per day	Family foods, chopped or mashed if necessary	3–4 meals per day Depending on the child's appetite, 1–2 snacks may be offered	¾ to full 250 ml cup/bowl

Further information

The amounts of food included in the table are recommended when the energy density of the meals is about 0.8 to 1.0 kcal/g.

If the energy density of the meals is about 0.6 kcal/g, the mother should increase the energy density of the meal (adding special foods) or increase the amount of food per meal. For example:

- for 6 to 8 months, increase gradually to two thirds cup
- for 9 to 11 months, give three quarters cup
- for 12 to 23 months, give a full cup.

The table should be adapted based on the energy content of local complementary foods.

The mother or caregiver should feed the child using the principles of responsive feeding, recognizing the signs of hunger and satiety. These signs should guide the amount of food given at each meal and the need for snacks.

[a] If baby is not breastfed, give in addition: 1–2 cups of milk per day, and 1–2 extra meals per day (*18*).

A study in NTT found that the results of children that eat nutrient-rich food and children that meet the minimum frequency of eating according to the recommendation of IYCF are different in urban and rural areas of NTT (66). In urban areas, 37.7% of children under two years of age did not meet the recommendations of IYCF (Table 3), meanwhile, in rural areas, the result was 57.1%. The study also found that 55.2% of children under five years of age in urban areas of NTT and 65.8% of children under five years of age in rural areas of NTT did not meet the recommendation of food diversity and eating frequency by IYCF (66).

3.1.1.2.3. Health and Nutritional Status of The Mother

Maternal Undernutrition will cause low birth weight which is more likely to be stunted. Therefore, nutrition intake such as supplementation of micronutrients in pregnant women is important for fetal growth (67). The nutritional status of pregnant women in Indonesia is usually measured by upper arm circumference (LILA), and haemoglobin level (68,69). The measure of LILA can be used to identify chronic energy deficiency, while haemoglobin levels are used to know whether pregnant women are suffering from anaemia or not (69). According to the available data, in 2018, 17.3 % of pregnant women in Indonesia are suffering from chronic energy deficiency, and 36.8% of them are from NTT (20,70). Further data mention that the prevalence of pregnant women with chronic energy deficiency is 33.5% of those aged 15-19 years old and 23.3% of those aged 20-24 years old, while the prevalence of pregnant women in NTT with anaemia is 46.2% (71). Chronic energy deficiency is related to protein intake, and anaemia is related to the intake of micronutrients such as iron, folic acid, and vitamins (70,71).

3.1.1.2.4. Women's Literacy

Children whose mothers are with low education are more likely to have stunting 1.6 times more than those whose mothers are with high education. The education of the mothers is affecting the parenting methods including the children's nutrition (72). According to the research by Hagos et al, children under 5 whose mothers did not finish elementary education or higher are having stunting risk 20% higher than the mother who finish elementary education or higher (72,138). The local government of NTT made a report about the education and knowledge level of female residents aged 15 years and over based on their schooling duration. 15 years is chosen because according to the statistic in 2017, 25.71% of women aged 20-24 years old were married when they aged below 18 years old. The data stated that 74.11% of areas in NTT were in three red categories: Very bad, Bad, and Slightly bad, which means many of the women in the areas have not met the minimum requirements for 12 years of study (Table 4) (48). The details of the areas can be seen in Figure 6.

Table 4. Average Schooling Duration of Women > 15 Years Old in NTT (48)

Table Priority	Average Schooling Duration of Women >15 years old	Category	Total	Percentage
Priority 1	≤ 6.0	Very Bad	79	25.57%
Priority 2	>6.0 – 6.5	Bad	44	14.24%
Priority 3	>6.5 – 7.5	Slightly Bad	106	34.30%
Priority 4	>7.5 – 8.5	Slightly Good	38	12.30%
Priority 5	>8.5 – 9.0	Good	12	3.88%
Priority 6	>9.0	Very Good	30	9.71%
Total Number of Districts			309	100%

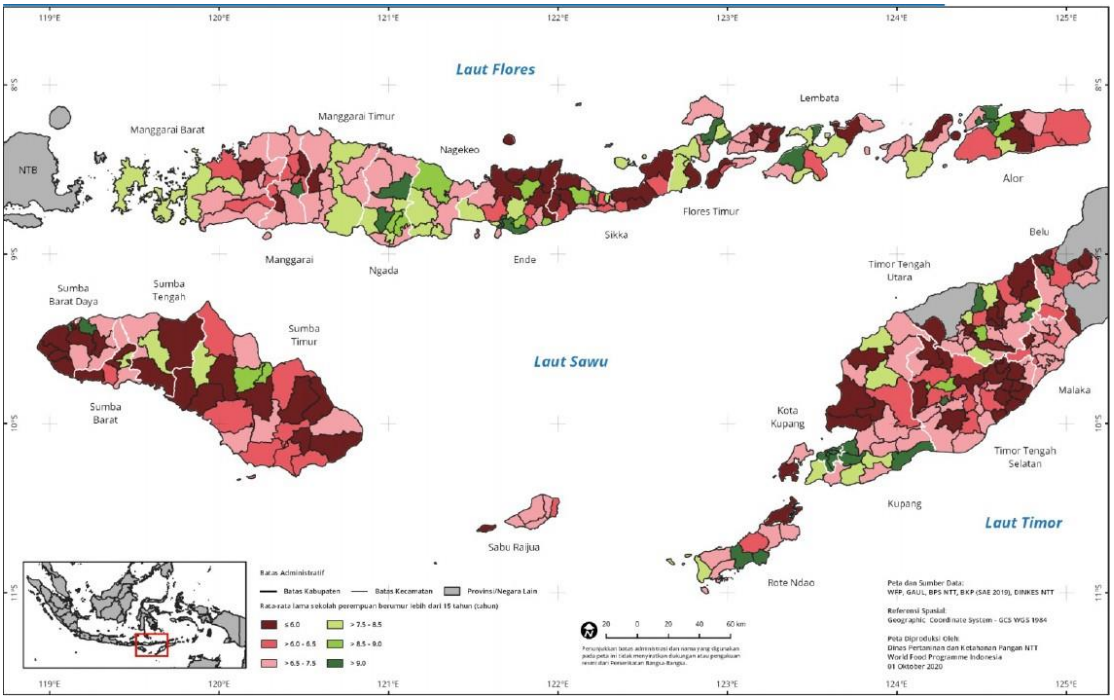

Figure 6. Area mapping for average schooling duration of women above 15 year old (ZV)

3.1.1.3. Health Services, Water and Sanitation

3.1.1.3.1. Water and Sanitation

The source of drinking water for the majority of households in NTT province is included in the criteria for clean drinking water sources, namely 31.65% from protected springs, 17.47% from protected wells, and 15.20% from tap water. Even so, there are still areas in NTT where households do not have access to clean water (water from improved drinking water sources and the minimum distance to the nearest septic tank is 10m) such as Sumba Barat Daya (Southwest Sumba) with 77.51%, Sumba Tengah (Central Sumba) with 62.87%, and Sabu Raijua with 57.28% of households without access to clean water (more details are shown in figure 7) (48). Sumba Barat Daya is in the 4th position of the regency with the highest stunting rate in NTT, meanwhile, Sabu Raijua is in the 4th position of the regency with the highest rate of wasted in NTT and 3rd position of the regency with the highest rate of underweight in NTT (Appendix 3). The data from the local government showed that only 64% of the households in NTT have access to improved sanitation (6)(Appendix 4). As it is shown in Appendix 4, there are some regencies that only less than 60% of their household has access to improved sanitation (6). Timor Tengah Selatan which ranked 1st of the regency with the highest stunting rate in NTT, only 35% of its household have access to improved sanitation. The data in Table 8 also shows that of the 10 regencies with less access to improved sanitation, 70% of them are the top 10 regencies with the highest number of stunting.

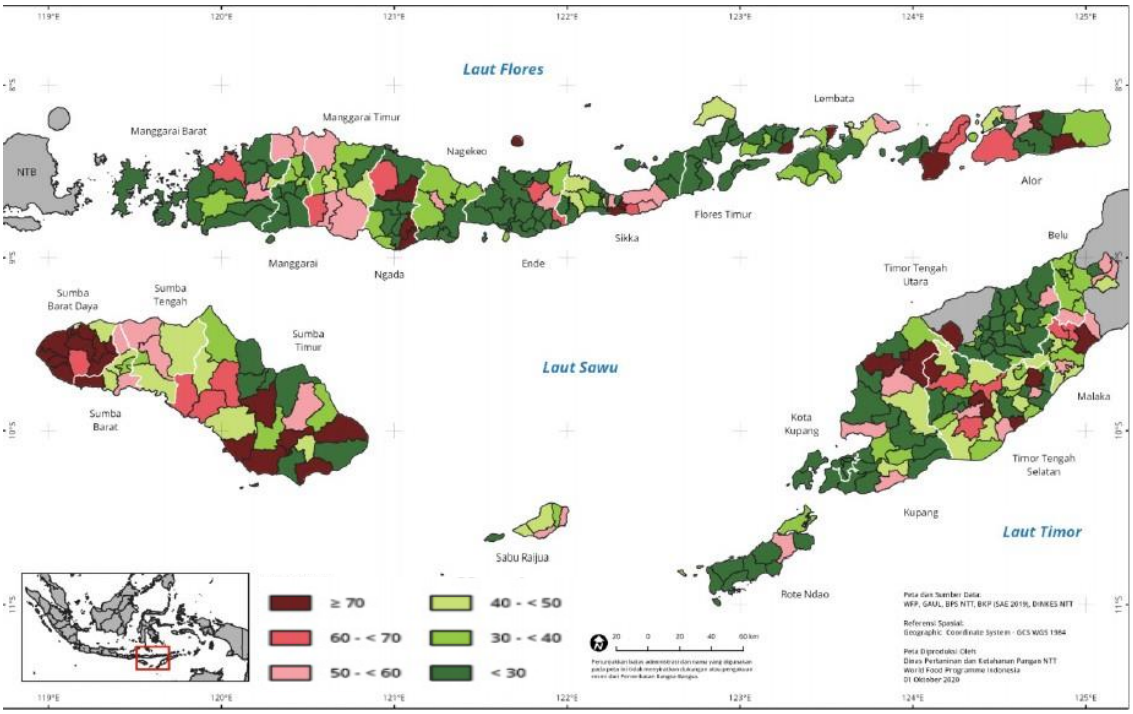

Figure 7. Percentage of households in NTT without access to clean water (ZV)

According to a study by Badriyah et al, stunting in children is significantly associated with water sources, the use of toilets, and sewage and waste management (73). Among 33.3% of children under two years of age in Indonesia who are suffered from stunting, only 1.2% of the families had the main water source located far from the source of contamination. Most of the families of the children had poor sewage and waste management, and 33.1% of the families had no septic tank or using unimproved sanitation, while open defecation was still being practised by 12.9% (73). Poor hygiene and sanitation can cause diarrhoea which can affect nutrition absorption, and up to 50% of undernutrition is predicted related to diarrhoea or infection caused by water, sanitation, and hygiene (73).

3.1.1.3.2. Health Services

About 96% of villages had access to the nearest health facility within a reach of about 5 km. The 2 highest percentages of regency where its villages have very limited access to health facilities (more than 5 Km of distance) are Timor Tengah Selatan (14.75% of villages) and Alor (10.86% of villages). Timor Tengah Selatan is the regency with the highest rate of Stunting in NTT, meanwhile, Alor is in the 3rd place. Ideally, there are nine types of health workers in Puskemas which are: Doctors, Dentists, Nurses, Midwives, Public Health Officers, Sanitation and Environmental Health Officers, Laboratory Officers, Nutrition Officers, and pharmacists. If a Puskesmas has at least one of the 9 health workers, then it is considered enough (3). From 414 Puskesmas in NTT, only 22.9% meet the minimum requirement (at least 1 health worker) (3). Proper access and utilization of healthcare (such as institutional deliveries, distance, presence of skilled birth attendants, and access to prenatal care) are inversely correlated with the occurrence of childhood stunting (74).

3.1.2. Immediate Nutrition Drivers

Immediate nutrition drivers are directly affected by the underlying nutrition drivers. The underlying nutrition drivers affect undernutrition through household and community levels which further will affect children under five at the individual level through individual dietary intake and infection. Both dietary intake and infection are affecting each other. Infection can cause loss of appetite, malabsorption, and disturbing metabolism. The same condition will also happen to children with undernutrition. Their immunity is weak and it is easy to get sick, which further can worsen their undernutrition state (44). If comparing the children who did not suffer from diseases with the children who got an acute respiratory infection and/or diarrhoea in the past six months, the risk of malnourished from those who never get sick is less than those who experienced infections. A study reported that children who have been experiencing more than four episodes of

sickness in the past six months are more vulnerable to malnutrition (75) and a study in Kupang-NTT showed that from 171 children under five, 63.1% of them are stunted and have infections. Children who had a history of infections are 3.7 times more at risk of stunting (76).

Diarrhoea is known as the most common cause of death in children under five years of age in Indonesia (3). In 2020, there were 27 children under five in NTT died caused by diarrhoea (3). Children with stunting are easily exposed to diarrhoea. The episode can be more frequent and longer as well as the risk of hospitalisation (77,78).

In NTT, 52,878 cases of diarrhoea were reported in 2020, and it was the most common infection in NTT followed by Malaria with 14,850 cases (6). NTT is one of 4 provinces in Indonesia with the highest rate of Malaria, and the highest case in NTT was found in Sumba (79,80,81). West Sumba reported that Malaria is one of the 10 major public health problems, and it is responsible for the children mortality in the area (80).

3.2. Climate Events, Physical Environmental Impacts, and Their Potential Impacts on Undernutrition

3.2.1. Climate Events and Physical Environmental Impacts in NTT

According to the World Bank, Indonesia is placed 3rd on the list of countries for natural hazard risk (1). The available data from the National Agency for Disaster Countermeasures of Indonesia showed that during the last 2 decades, the number of climate-related natural disasters such as forest and land fires, landslides, tidal waves/abrasions, floods, drought, and tornados is increasing (figure 8)(82). In 2021, NTT experienced a flash flood caused by the 1st Seroja tropical cyclone which affect 20 districts and 1 city (83). According to BMKG, before 2021, this cyclone was only in the ocean and never reach the land. One of the analyses was the change in this cyclone is affected by global warming (84). During cyclone events like this, NTT can experience multiple days of heavy rains together with strong winds and high sea waves (85).

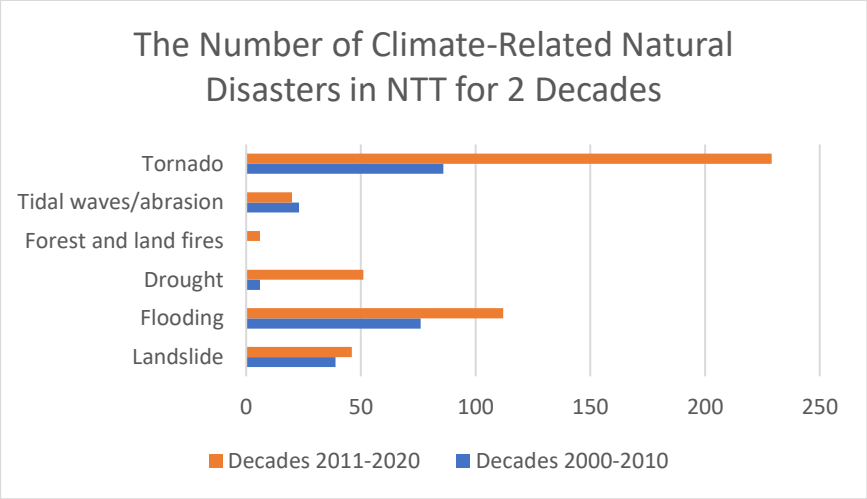

Figure 8. The Number of Climate-Related Natural Disasters in NTT for 2 Decades (2000-2020) (82).

3.2.2. Impacts of Climate Change Through Food Pathway

3.2.2.1. Food Availability

Despite the increasing climate events in the last 2 decades, rice production in NTT in the last 2 decades shows a trend of increasing as well as the production of fruit and vegetables in the last 1 decade (Figure 9, 10, 11). However, climate events still cause damage to food commodities. The unofficial data stated that the Seroja Tropical Cyclone in 2021 caused damage to agricultural land in NTT (86,87). It is also reported that NTT has lost 23.5 thousand hectares of rice production which are spread in 15 regencies and city. These losses were 7.2% of the total target harvest area of rice (87). There was also a high risk of harvest failure after the cyclone, as there were several consecutive days of heat with caused the land to dry (88). In further, it is reported that there were more than 45 thousand livestock were missing because of the cyclone (87). In 2019-2020, NTT only experienced 2 months of rainy seasons which are during December and January. This situation leads to harvest failure due to drought and water deficit so the farmer was having trouble irrigating their land (89). The data on rice production (figure 9) shows that the production of rice was decreasing from 2019 to 2020. The details about the cause of this loss are unclear. It could be due to climate events, or another cause. However, the damage caused by climate events still threatened the availability of food. The drought in 2019 also causes the death of more than one hundred cows and more than 20 lambs due to a lack of food and water (90).

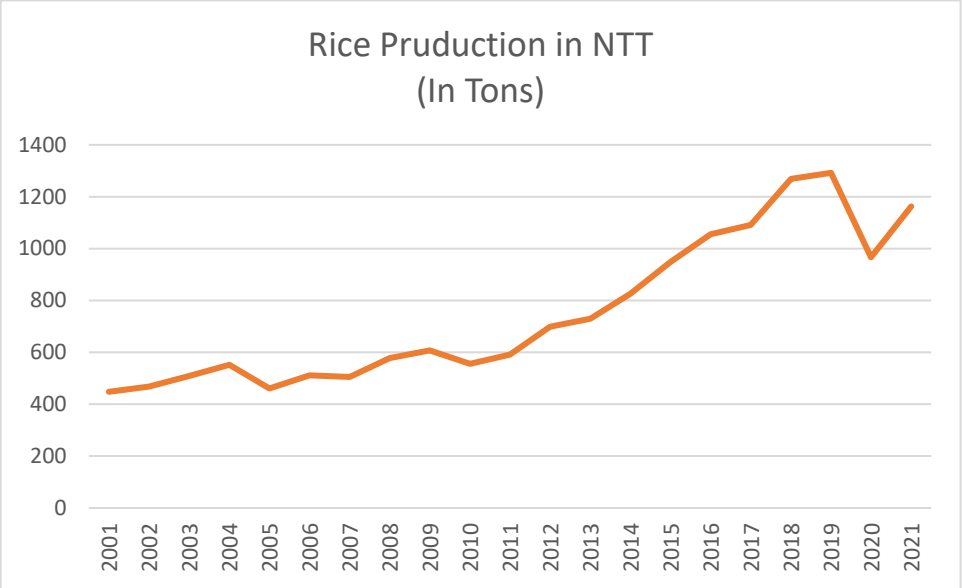

Figure 9. Total rice production in NTT from 2001-2021 (6,91-94)

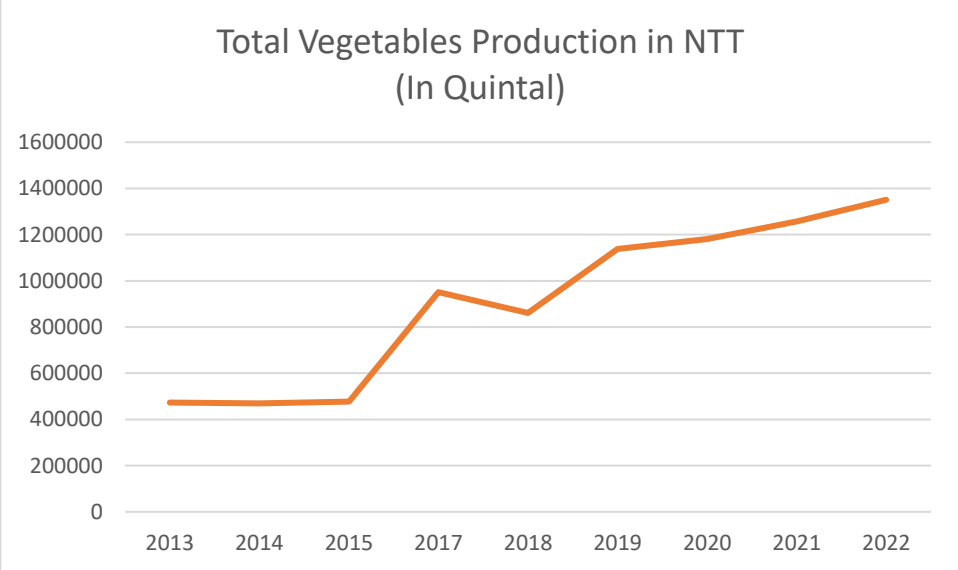

Figure 10. Total Vegetables Production in NTT from 2013-2022 (Site 36)

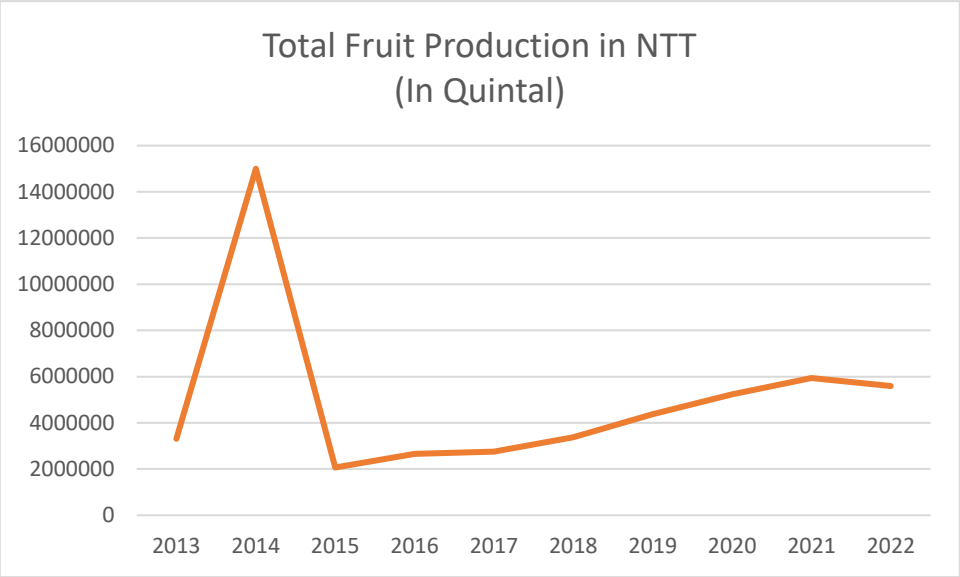

Figure 11. Total Fruit Production in NTT from 2013-2022 (100)

3.2.2.2. Food Accessibility

As it is mentioned in the first finding that access is related to infrastructure and transportation as they are important elements related to the living standard of the people in NTT. While NTT is actually own proper transportation to connect NTT with the other provinces (21), during certain seasons when the wind is quite fast, high tides, and during the rainy season, sea transportation cannot be operated due to the weather, affecting the supply of the basic needs of the society, especially those who live in the small islands (21). The infrastructure for land transportation also needs attention, as the road usually became impassable due to the damage caused by floods (21,95). The flash flood in 2021 caused damage to several roads that connect districts and regencies in NTT (96,97). Several harbours that connect islands in NTT also cannot be accessed due to the tidal wave and damage (98). Due to the loss of access, the price of basic necessities including food was rising (99). According to the report from Indonesian Bank, due to the Seroja cyclone, the inflation pressure in NTT increased by 1.54% which was higher than the national rate (1.42%) (87). This situation affects the communities that are living below the poverty line the most as it is harder for them to fulfil their basic necessities.

3.2.2.3. Food Utilization

In 2017, drought caused damage to over 70,000 ha of agricultural land in NTT (95). Drought, flood, and other climate-related disasters can exacerbate the clean water crisis in NTT (101) where this situation can affect food utilization due to the increased risk of pathogenic bacteria, parasites, or mycotoxins (102). This situation is also related to the health pathway, because the increased bacteria and others may cause diseases such as diarrhoea (102,103).

3.2.3. Impacts of Climate Change Through Care Pathway

Climate change through extreme weather, temperature changes, and change in rainfall patterns can affect care and feeding as they can increase female workloads, increase maternal stress, and limit access to WASH (39). Women's or caregivers' availability to give care and feeding practices including breastfeeding their children could decrease and one of the causes is the limited access to get water, where the caregivers will spend more time and effort to get water (39). NTT is known as one of the provinces that have low water availability (104), and this situation became harder due to drought. During drought, people need to walk about 4 km or more to get water and the primary water collector in NTT are mostly women (104). Increasing temperature can influence breastfeeding patterns and frequency. Research on dairy animals showed results that heat stress can affect the production, quality and quantity of breastmilk due to the lack of food intake and hormonal change (39,105), however, data related to the influence of increasing temperature and breastfeeding are lacking.

3.2.4. Impacts of Climate Change Through Health Pathway

Other than food, climate change can affect undernutrition through disease infection. According to IPCC, climate change will increase the risk of food-borne, water-borne, and vector-borne diseases through increasing temperature, extreme weather, and shifting rainfall patterns (40,106). The temperature in NTT has been increasing by an average rate of 0.07℃ per decade from 1880 to 2019, and the latest research mentioned that over a century, from 1920 to 2020, the temperature has been increasing by 0.09℃ per decade (107). A systematic literature review by Marina et al recaps several studies about climate and vector-borne diseases in Indonesia and found that Studies about dengue, malaria, and climate showed inconsistent relationships (108). Some studies find that rainfall and the incidence of dengue are positively correlated, some studies also find a non-linear association between climate and dengue, where dengue cases would be increased if there are increasing rainfall between 1500-3500mm, temperature around 22-27℃, and relative humidity below 70%. Another study stated differently that there is no significant correlation between rainfall, humidity, and dengue case, but there is a moderate association between temperature and dengue cases. Generally, there were two climatic factors that are the most important for dengue which are rainfall and temperature (108). As for Malaria, a positive relationship between rainfall,

temperature, and humidity was mostly demonstrated, but there were limited evidence about the relation between climate, vector density, and incidence of Malaria (108). A study conducted in Southwest Sumba-NTT mentioned the temperature rise and incidence of Malaria were not correlated (108,109), meanwhile, a study in Ende-NTT mentioned that there is a correlation between temperature and malaria in a negative pattern (110). On the contrary, a study in South Kalimantan mentions that increases in mean temperature are correlated with the rise of Malaria cases (108,111). However, South Kalimantan and NTT are having different climate types. Even though it seems that the temperature rise in NTT is not affecting malaria cases, there is one study conducted in West Sumba-NTT mentioned that malaria cases tend to rise when the rainfall pattern is decreasing (112), and the rainfall pattern in NTT is steadily decreasing -2.7 mm/year (107). High rainfall and flooding can increase the risk of water-borne diseases such as diarrhoea due to the water quality (25), on the other side, low rainfall, high temperatures, and drought can also increase the risk of diarrhoea. High temperatures will potentially increase the ability of Escherichia coli to survive, and it is also can increase the multiplication of pathogens, especially those found in food and water (103). In 2018, NTT experienced extreme drought for 60 days without rain (8,113). The number of diarrhoea cases in 2018 was relatively high with 89,689 cases (114,115) compared to the number of cases in 2020 (no data available for 2019) with 52,878 cases (114,115). The regency with the highest number of diarrhoea cases in 2018 was Sumba Barat Daya with 8764 cases (114,115). In 2018, the number of households that have access to improved sanitation in Sumba Barat Daya was only around 18%, while the regional rate was 50%. Only 52% of households in Sumba Barat Daya have access to improved drinking water, and this number was still lower than the regional one with 65.2% (42).

Access to health facilities can also be limited because of extreme weather which can damage the infrastructure, and the health facilities itself. In further, it will be harder to get medicine, food supplements, and other needs. The increasing temperature will also affect the quality of the medicine or vaccines (31). With limited access to health facilities, maternal and childcare services will also be disturbed (31). 46 health facilities in Sabu NTT were destroyed by the 1st Seroja Cyclone in 2021, including their pharmacy storage room (116,117). This cyclone also caused infrastructure damage which limits access to healthcare facilities (118).

3.3. Equity Dimensions

Aside from Children under five who are vulnerable related to climate-exacerbated undernutrition as they are physiologically susceptible to undernutrition, women, the poor, and rural communities are vulnerable related to climate-exacerbated undernutrition (31,39). These people will be affected more by the physical impact of climate change. Most poor people cannot afford to buy nutritious food (21), further, when climate events happen and the price of food is increasing, it will add more burden to them. In NTT, most women and children are the ones who will be responsible to fetch water during drought or if they live in areas with limited access to water. This will double the workload of the women. Children in rural areas tend to do not to meet the recommendation of food diversity by IYCF (66) and this could be because of the hard access to food causing the price of

the food in rural are more expensive than in the urban areas, and when climate events happen, the food will become more unaffordable.

3.4. Adaptation and Mitigation

3.4.1. Mitigation Efforts

In 2010, Indonesia made a voluntary pledge to reduce 26% of its emissions (and up to 41% with international support) against the business as usual scenario by 2020) (119). Later on, Indonesia changed its voluntary pledge to 29% by 2030 (119,120). To fulfil the pledge, Indonesia focusing on reducing emissions from the land and forestry sector, energy sector, and waste management sector. In the land and forestry sector, the government of Indonesia is banning the conversion of forests in Indonesia to decrease deforestation and forest degradation. The government of Indonesia also targeting to restore 2 million hectares of peat land and to rehab 12 million hectares of degraded land. These targets should be fulfilled in 2030 (119,120). In the energy sector, fossil fuel subsidies have been cancelled and diverted to support other sectors such as education, health, and infrastructure including renewable energy projects and public transportation (120). Indonesian government made several regulations to fulfil the pledged target such as regulations about reducing the emission of greenhouse gasses, greenhouse gasses inventory, mixed energy, and national energy policy (119,120). In the waste management sector, the government of Indonesia is trying to improve wastewater management capacity in urban areas, reduce landfill waste by promoting a "reduce, reuse, recycle" approach and convert waste into energy (119). Following the mitigation effort of Indonesia, the government of NTT announced a mitigation policy in the NTT governor regulation Number 40/2012. This policy mentions several action plans on greenhouse gases including evaluating agricultural policies, developing livestock, forestry, industry, energy, transportation, and water waste management (121). One of the plans from the NTT government was a strategy to increase the utilisation of renewable energy in order to increase the accessibility of energy supply (122). The government of NTT stated that by 2025, a minimum of 23% of the total primary energy need to be supplied by renewable energy (123). NTT is one of the provinces in Indonesia that owned a low electrification ratio of 61.06%; however, NTT has great potential for renewable energy sources. Sumba is one of the areas in NTT that own great potential for renewable energy resources. In 2018, renewable energy has been supported 29% of electricity needs in Sumba. Following this fact, the Ministry of Energy and Mineral Resources of Indonesia made a program called "Iconic Island of Renewable Energy" which targets 100% use of renewable energy to supply 95% of electrification by 2025 (124-127). However, there is no further information about this project, as well as other mitigation plans by the NTT government.

3.4.2. Adaptation Efforts

The Government of Indonesia established the National Action Plan on Climate Change Adaptation (RAN-API) which is a translation of the Indonesia Climate Change Sectoral

Roadmap to implement climate change adaptation efforts so that development in Indonesia becomes resilient to climate change. RAN-API is coordinated with all relevant stakeholders such as government, organizations, communities, business entities, and others (53,128). RAN-API applies nationally and each region is responsible for coordinating with the Ministry of Home Affairs in its implementation in their respective regions in accordance with regional development priorities, regional budgets and communities. The RAN-API is then evaluated and updated into "dokumen pembangunan berketahanan iklim" (climate resilient development document) (53,128). The first climate change adaptation in Indonesia has 4 priority sectors, namely the marine and fisheries sector, water sector, agriculture sector, and health sector because these four sectors contribute greatly to the gross domestic product sector (53,128,129). Appendix 5 shows the summary of the assessment of each sector. The latest RAN-API published by the Indonesian Government is Climate Resilience Development Policy for 2020-2045 which was published in 2021 with several changes in the assessment (128)(Table 5). Climate Resilience Development Policy also set a new way of monitoring and evaluating adaptation efforts using Development Action Planning and Monitoring Application Low Carbon and Climate Resilience Indonesia (AKSARA) which will make a resume of the evaluation and later the result will be reported in the local and international reports (128). The International report will be published by the ministry of Environment and forestry to the UNFCCC and the local report will be included in the yearly report of the President of the Republic of Indonesia (128)

Table 5 Assessment of Each Sector from Climate Resilience Development Policy for 2020-2045 (128)

Sector	Projection
Marine and Coastal	- High tide potential that can affect the sailing safety - Vulnerability of Coastal Areas
Water	- Potential of droughts - Potential of water shortage
Agriculture	- Potential of decreasing rice production
Health	- Potential of increasing cases of Malaria, Dengue and Pneumonia.

Several regions in NTT, such as Kupang City (2015) and Sabu Raijua Regency (2019), have published the Regional Action Plan for Climate Change Adaptation (RAD API). In preparing the RAD API in NTT, the government conducted a vulnerability study to see the socioeconomic factors that need to be prioritized in development programs as input in the preparation of adaptation measures (131,132). In addition, current and future climate risks or climate-induced disaster events are also taken into consideration in the preparation of adaptation efforts (131,132). The Kupang city's RAD API, developed in 2015, aims to guide the city's Vision and Strategy for climate change

adaptation and disaster risk reduction (API-PRB). It aligns government programs, creates a reference for synergy between agencies and stakeholders, and coordinates efforts related to climate change and disaster risk reduction. The adaptation program of Kupang city is divided into 3 groups: Disaster Mitigation and Climate Change Adaptation Program Group; Emergency and Post-Disaster Program Group; Data and Monitoring Program Group (131). The Disaster Mitigation and Climate Change Adaptation Program Group covers spatial planning, forestry, environment, flood control, water resources, community welfare, and food security. The Emergency and Post-Disaster Program Group includes health services for disaster victims, public kitchens and direct assistance to disaster victims, repair of public facilities affected by disasters, repair of post-disaster settlements, and others. Data and Monitoring Program Group assembles various programs related to data and information documents that become materials and references for the preparation of programs to reduce climate change vulnerability. The RAD API of Kupang City mentioned all the sectors stated in RAN API, however, in the health sector, even though RAD API of Kupang mentioned disaster-related communicable diseases and post-disaster nutrition improvement (131), it did not mention the effect on the health sector related to climate change as it is mentioned in RAN API (Appendix 5, table 5). Sabu Raijua Regency prioritizes its RAD API on 3 sectors: water resources, coastal industry resources, and the agriculture sector (133). Sabu Raijua Regency does not include the health sector at all. In the water resources sector, one of the things done is the rainwater harvesting system (Picture 12) which is also done in agriculture. Harvesting rainwater is an effort to overcome water shortages during droughts. In addition to harvesting rainwater, another effort from the water resources sector is to treat wastewater to be reused in agricultural and industrial areas (picture 12). In the coastal industry resource sector, Sabu Raijua focuses on seaweed cultivation because seaweed is the main source of income for Sabu Raijua people in coastal areas (134).

In the agricultural resource sector, some of the things that are applied are “mulsa” technology (Picture 12) where with the use of this technology, farmers will be able to save more water use because water only evaporates as much as 10%. To minimize crop failure, an integrated cropping calendar which helps to utilize climate information in the agriculture sector (Picture 12) is used that can help determine planting time (133).

Figure 12. Adaptation effortrs of Sabu Raijua. Left side: Harvesting rainwater; Middle: “Mulsa” technology; Right side: Integrated cropping calendar (133

Chapter 4: Discussions.

4.1. Determinants of Undernutrition in NTT

In this study, the determinants of undernutrition are divided into two phases which are immediate nutrition drivers which directly affect individual nutrition status through dietary intake and health status such as infection. These two aspects of immediate nutrition drivers are affecting each other. When children are infected with diseases, they could experience loss of appetite, malabsorption, and disruption of metabolism which can lead to undernutrition. Conversely, when a child is undernourished due to a lack of good nutrition, their immunity becomes weak and susceptible to diseases (44).

Immediate nutrition drivers are influenced by underlying nutrition drivers that consist of food security, care capacity, and the health and nutritional status of the mother. This study found that some of the determinants of undernutrition in the underlying nutrition drivers are lack of variety of nutrient-rich foods, feeding practices, maternal education, maternal health, access to clean water and improved sanitation, socioeconomic factors, and health services and facilities.

The data found shows that only 39% of children under five in NTT eat a diet with a sufficient variety of nutrients. The status of food availability in NTT shows that 95% of 21 regencies and 1 municipality have a very good food availability score, with a score above 75 (ratio 0-100). However, this food availability score only counts foods with high calories without taking into account other food sources such as meat, fruits, vegetables, and other commodities that are rich in nutrients (21,48). Good nutrition will help the body to avoid infection, reduce the severity of infection, and speeds recovery (44). Studies in Ghana and Malawi suggest that providing nutrition with the right composition is proven to reduce the incidence of stunting in children aged 6-18 months. A study in Pakistan also found that adequate nutrition reduced the risk of stunting by 9% and wasting by 22% in children aged 6 to 23 months (135).

Apart from the availability of food, feeding practices also affect nutrition intake. Feeding practices include exclusive breastfeeding for the first 6 months and complementary feeding (65). For complementary feeding, in addition to the lack of variety of nutrients, only 71% of children met the recommended meal frequency from IYCF. The data also showed that the achievement of complementary feeding in urban and rural areas in NTT showed different numbers, whereas in rural areas more children did not meet the IYCF recommendations for complementary feeding (66). One of the factors influencing this difference is the socioeconomic status of the family where people in urban areas have better economic status, so they have the better purchasing power to obtain food (66). NTT has a fairly good rate for exclusive breastfeeding which is higher than the national rate. A study in Eastern Indonesia which includes the provinces of NTT, Maluku, North Maluku, West Papua, and Papua stated that living in rural areas is one of the risk factors for children not getting exclusive breastfeeding because in urban areas it is easier to access health facilities and get health information (136). In addition, maternal education also plays a role as mothers in urban areas have a higher level of education so they are more aware of health information (66,136). However, the employment status of mothers showed different results, where working mothers, who were mostly found in urban areas, had less time for breastfeeding (136). A study in West Nusa Tenggara also concluded the same regarding

working mothers and exclusive breastfeeding (137). Therefore, feeding practice is more influenced by factors such as socioeconomics, education, and maternal employment than urban or rural residence.

The educational status of women, especially mothers, influences undernutrition where this study mentioned that children under five whose mothers did not complete elementary education or higher had a 20% higher risk of stunting than mothers who completed elementary education or higher (72,138). Generally in Indonesia, a mother plays a role in household food provision, so mothers with higher education will tend to provide nutritious food (44,48,139). In addition to education, maternal health status is very important. Mothers who experience undernutrition during pregnancy will tend to give birth to children with low birth weight, putting them at greater risk of stunting. Data found in this study states that of the 17% of pregnant women in Indonesia who experience chronic energy deficiency, 36% of them are from NTT (20,70). Aside of chronic energy deficiency, the prevalence of pregnant women with anaemia in NTT is also quite high at 46% (71). Several studies in Indonesia showed that both chronic energy deficiency and anaemia in pregnant women are associated with the lack of nutrients during pregnancy, as the need for nutrients in pregnant women is increasing (93,140). Therefore, it is also related to the other determinants of undernutrition which is the lack of nutrient-rich food.

Stunting in children is significantly associated with water sources, the use of toilets, and sewage and waste management (73). Therefore, access to proper hygiene and improved sanitation are important as improper access can cause diarrhoea or other infections caused by water, sanitation, and hygiene (73). The data in this study show that among the 10 regencies in NTT with less access to improved sanitation, 70% of them are the top 10 regencies with the highest number of stunting. This trend shows that there is a relation between stunting and sanitation as it is also mentioned in a study located in Indonesia by Rah et al which stated that children who have access to improved sanitation are 29% less likely to be stunted (94).

A study in Pakistan mentioned that the distance to health facilities is related to undernutrition (141). If the distance is increasing, the risk of undernutrition is also increasing. In NTT 96% of villages had access to health facilities (health facilities located a maximum of 5 Km away), but only 22.9% of the health facilities (Puskesmas) in NTT met the minimum requirement of having at least 1 health worker. According to a study by Palapessy, health workers have an important role to prevent stunting such as providing education and increasing awareness about nutrients, providing programs to monitor growth and nutritional status, providing support and counselling, and also providing nutritional supplements (142). In conclusion, Puskesmas is not only serving curative care but also promotive care including nutrition, so the availability of Puskesmas with complete services is highly needed.

4.2. Climate Events, Physical Environmental Impacts, and Their Potential Impact on Undernutrition

There are several meteorological and hydrological impacts that are anticipated as a result of climate change in Indonesia, including changes in land temperatures, changes in extreme rainfall patterns, shifting of seasons, and changes in rainfall volume (143). These changes are indicated by increased climate-related disaster events such as floods, drought, storms, fires, and heat waves that can cause physical environment impacts which indirectly affect nutrition. In the past 2 decades, the number of climate-related natural disasters in NTT has been increasing. The physical environment impacts of climate events will affect undernutrition through 3 pathways; Food, Care, and Health (39,46).

- Food Pathway
  This study found that climate events caused damage to food commodities through damage to agricultural land, livestock, and harvest failure. Climate events also increased inflation pressure that affects food prices which makes it harder for those who live below the poverty line to get food.. The study about drought by Verschuur et al found that drought can cause decreasing food availability and increase food prices which causes food insecurity (144,145). During harvest failure caused by climate events, farmers could not sell their harvest, so it impacted their economic stability (146). Between 2003 and 2013, climate-related disaster has been impacted around 1.9 billion people in developing countries and caused damage as high as approximately half a trillion US dollars (146). A study by Yan S. et al predicted that the harvest for cereal crops in four countries of South Asia (Bangladesh, Pakistan, India, and Sri Lanka) will be decreased in 2050 due to climate change. The highest loss is predicted will happen to Bangladesh and Pakistan with 16.4% and 10.7% (147). A study by Islam mentioned that climate events, especially floods and drought will affect food production by affecting the quality of the soil which further can cause harvest failure. Changes in the soil quality also will affect the quality of the crops and can reduce the nutrient in them (146). Low quantity and quality of crops will further affect the nutrient intake of the food that is served, which further can cause undernutrition. Cereal crops are known as the primary food for most people in NTT (21) and it is also known as the main source of protein (31), reduced nutrients in cereal crops will further affect nutrient intake. This study found that the trends of the total rice, fruits, and vegetables in NTT are rising in the past 10 years. The data about the projection of crop production in NTT were not found. However, a study about the projection of rice production on Java Island shows that there is a trend of increasing production of rice in 2021-2035 (148). The climate types in Java and NTT are quite different, as in Java, the climate type is tropical climate rather than semi-arid. Considering that the climate type in Pakistan is also semi-arid like NTT, it is possible that NTT will have a similar prediction.

- Care Pathway
  The impacts of climate change on undernutrition through care pathway are mostly impacting women. This study found that as one of the provinces with low water availability, drought will make it more difficult to get water. As the primary water collector in NTT, walking more than 4 Km to get water will increase the workload of the female in NTT. The extra workload on females during drought will affect the quality of care to the children as it can influence breastfeeding patterns and frequency (39). It is predicted that heat stress could affect the quality and quantity of breast milk

(39,105). Data related to the influence of increasing temperature and breastfeeding are lacking, however, a study by Nakstad et al mentioned that climate change could increase the risk of dehydration in mothers due to high temperatures and limited access to water (149). Enough fluid intake is important to breastfeeding women to maintain the production of breast milk and avoid dehydration (149).

- Health Pathway

  In the health pathway, climate change affects undernutrition by damaging health facilities and increasing the risk of vector-borne and water-borne diseases. Extreme weather, shifting rainfall patterns and temperature rise are potentially increasing the risk of vector-borne and water-borne diseases (40,106). The studies related to Malaria and Dengue were conducted in several areas of Indonesia and showed inconsistent relationships (108). A study about climate patterns and mosquito-borne diseases in South and Southeast Asia mentioned that rainfall patterns also showed inconsistent relations with vector-borne diseases. Increasing rainfall can affect the breeding process of mosquitos both positively and negatively (150). A similar study in China mentioned that the correlations between climate and vector-borne diseases are also influenced by climatic differences between regions (151). The different phases of the development of mosquitos also play a role in this inconsistent relation as every phase requires a different optimum temperature (25). Therefore, specific research in each phase of mosquito development needs to be done.

  Diarrhoea is one of the most common diseases after flooding, especially in areas with limited access to proper sanitation (25,152). A study in India stated that droughts also can cause diarrhoea due to the increasing concentration level of pathogenic microorganisms in the water caused by limited dilution due to water scarcity, and also because droughts contribute to poor hygienic conditions and environmental sanitation which are important factors that can cause diarrhoea (25,153). In NTT, a high number of diarrhoea cases happened in 2018, as well as an extreme drought of 60 days without rain. The regency with the highest number of diarrhoea cases was Sumba Barat Daya which only 18% of its household have access to improved sanitation (42,114,115). When the case of vector-borne, water-borne, and other diseases are increasing, access to health facilities is important to avoid the accelerated number of diseases (31). In 2022, Pakistan experienced a malaria outbreak from January until August. The number of the case was rising in Balochistan and Sindh Provinces after a huge flood in the middle of June which damaged more than a thousand health facilities causing insufficient healthcare workers and medical supplies (154). Therefore, the availability of health facilities can also affected by climate events.

4.3. Mitigation and Adaptation

- Mitigation

  Despite its pledge to reduce its emission, Indonesia experienced a significant surge in its total energy supply, with a nearly 60% increase from 2000 to 2021. This growth was caused by the rising demand for energy, which was met predominantly by coal. The country's energy sector now emits approximately one-third more CO2 per unit of energy consumed compared to the levels recorded in 2000. By 2021, Indonesia's energy

sector emissions reached approximately 600 million tonnes of carbon dioxide (Mt CO2), making its position the ninth-largest emitter globally (155).

- Adaptation

  Several regions of Indonesia submitted their adaptation plan several years before Climate Resilience Development Policy was launched. There were two documents of adaptation plan from 1 regency (Sabu Raijua) and 1 municipality (Kupang City) in NTT found. Both of the adaptation plans did not mention specifically about undernutrition, but the efforts to adapt in other sectors such as through agriculture and sanitation. There are no reports about the update of the adaptation plan in Sabu Raijua and Kupang City. According to the findings of this study, 57.28% of households in Sabu Raijua did not have access to clean water, so Sabu Raijua could add an adaptation plan related to access to clean water to anticipate water crises due to extreme climate events.

  To compare, Jakarta as the capital city of Indonesia also reported their adaptation plan in 2012 (156). The plans of action in Jakarta's adaptation plan were adjusted to the vulnerability of Jakarta such as vulnerable to flood, and waste problems. For example, in the infrastructure sector, Jakarta planned to fix the drainage system. However, the official report on the progress of the adaptation plan was also not found. Singapore as the neighbouring country of Indonesia reported their adaptation efforts in their 5th national communication and fifth biennial update report in 2022 (157). They explained the progress that they had made since 2013 (158). Singapore also includes public health and food security in their adaptation report. The National Environment Agency (NEA) of Singapore run the Wolbachia project to suppress the population of Aedes aegypti (157). As for their food supply, the Singapore Food Agency (SFA) has been diversifying food sources, growing local produce, and giving support to agrifood companies to grow overseas (157).

  Unfortunately, not all regulations and reports about climate adaptation plans in Indonesia can be found and accessed, so it is hard to analyse the progress. However, the new Climate Resilience Development Policy for 2020-2045 set a new way of monitoring and evaluating regional adaptation plan progress, which later will be reported in the local and international reports (128).

4.4. Relevancy of Conceptual Framework

Salm et al's climate change and nutrition framework was used in this study. This framework was helpful in analyzing how climate change can lead to undernutrition. All discussions in this study are based on the steps in the framework.

4.5. Strength and Limitations

This study is quite comprehensive by analyzing both the situation of the determinants of undernutrition in NTT and also the potential consequences that climate change can have on nutrition, especially in children under five. In addition, this study also tried to analyze

the efforts that have been made in facing climate change. However, this study is a literature review that depends on the availability of data. In addition, administratively, NTT is divided into several regions, where each region has its own policies regarding health and climate policies. Not all publications from these regions can be found or accessed.

Chapter 5: Conclusions and Recommendations

5.1. Conclusions

Undernutrition of children under five years of age in NTT is directly affected by dietary intake and health status which are determined by several factors such as the availability of nutrient-rich food, feeding practices, maternal education, maternal health, access to clean water and improved sanitation, socioeconomic, and health services and facilities.

climate events will cause several impacts that affect the determinants of undernutrition. The impacts caused by climate events include disruption of food production, prices, and processing, disruption of the process of providing nutrition to children due to increased workload on women, especially mothers, and increased risk of dehydration. In addition, climate events also increase the risk of increased water-borne and vector-borne diseases and also hamper the availability of health facilities.

To reduce the potential impact of malnutrition caused by climate events, it is necessary to make mitigation efforts to cope with widespread climate change and dynamic adaptation efforts to reduce the impact caused by climate events. It is also important to set an adaptation plan which is focussing on the impact of climate change on undernutrition. The adaptation plan itself should be adjusted to the vulnerability of the region.

5.2. Recommendations

The recommendations according to the findings, discussions, and conclusions of this study are formulated for policy, intervention, and research levels.

Policy Level

- Reassess the adaptation plan in each region, and put risk of undernutrition into the adaptation plan.

Intervention

- Improve coordination between MoH, the Ministry of Environment, and local government to create more impactful policies that link the effect of climate change on health, especially undernutrition.
- Oblige the local government to publish all the policies related to climate adaptation programs without ruling out the adaptation efforts in the health sector.
- Monitoring and evaluation are important to measure the success of the adaptation efforts, so the government need to allocate a budget to monitoring and evaluation.

Research

- Deeper research about the characteristic of the determinants of undernutrition in one area with the climate profile is important to expand the information about the causes of undernutrition in each area, and how climate change will exacerbate it.

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Appendix 1

Possible impacts of climate change that can affect undernutrition (31,39)

Change in Climate	Climate Events	Impacts	Pathway
Long term warming and altered precipitation	Drought, Forest and Land Fires	Increased irrigation water requirements	Food pathway
		Increased CO in the atmosphere - Huge impacts on agricultural production and livelihood assets. - Reduce the nutrient levels such as protein, iron, and zinc in plant foods, especially cereals, and legumes. - Displacing the Nitrogen which is necessary for protein synthesis and reduces mineral content in the plants. - Affect calories and nutrition intake.	1. Food pathway 2. Food, Care, and Health pathway 3. Food, Care, and Health pathway 4. Food, Care, and Health pathway
		Stored plants and grains can be stressed, Plants can also be spoiled before and after harvesting.	Food pathway
warmer ambient temperatures	Drought, Forest and Land Fires	Crops, livestock, fish, and humans will be exposed to new pests and disease vectors.	Health pathway
		Microbial growth and increase the transmission of food-borne illnesses.	Health pathway

		Decreasing access to clean water, sanitation and hygiene.	Health pathway
		Increase the risk of diarrhoea and dehydration.	Health pathway
		Maternal stress.	Care pathway
		Affect fetal growth and the breastfeeding ability of a mother.	Care pathway
		Dehydration; Affecting quality of breastmilk.	Food and Care pathway
		Lack of appropriate mother-child spaces.	Care pathway
Extreme Weather Conditions	Landslides, Flood, Drought, Forest and Land Fires, Tidal Waves/Abrasion, Tornado	Affect the appropriate care and feeding practices.	Care pathway
		Destroy facilities, infrastructure, and health commodities such as medicines, nutritional, supplemental and therapeutic foods.	Health pathway
		Unavailability of the regular maternal and childcare health services.	Health and Care pathway
Changes in rainfall patterns	Landslides, Flood, Drought, Forest and Land Fires, Tidal Waves/Abrasion.	Women's availability to give adequate feeding and care.	Care pathway
		Increased labour migration.	Food, Health, and Care pathway

		Increased female workloads.	Care pathway
Climate shocks and stresses	Landslides, Flood, Drought, Forest and Land Fires,Tidal Waves/Abrasion, Tornado	Exacerbating poor early child care practices.	Care pathway
		Inadequate breastfeeding practices, inappropriate complementary feeding, poor access to food, and inadequate micronutrient intake.	Food, Health, and Care pathway

Appendix 2

The keywords used for the search.

TERM	AND	OR
Undernutrition	Nusa Tenggara Timur	Indonesia
“Undernutrition Children Under 5”	Nusa Tenggara Timur	Indonesia
“Undernutrition Children Under 5” “Nusa Tenggara Timur”	Food Security	Food Intake
“Undernutrition Children Under 5” “Nusa Tenggara Timur”	Breastfeeding	Complementary Feeding
“Undernutrition Children Under 5” “Nusa Tenggara Timur”	“Water” “Sanitation”	Healthcare
“Undernutrition Children Under 5” “Nusa Tenggara Timur”	Infection	Diseases
“Climate Change”	Indonesia	“NTT” “Timor Leste”
“Climate Change”	Health	Undernutrition
“Climate Change”	“Food”	“Food Security”
“Climate Change”	“Maternal Care”	“Child Care”
“Climate Change”	“Feeding Practice”	“Caregiving”
“Climate Change”	“Health Access”	“Infrastructure”
“Climate Change”	“Mitigation Indonesia”	“Mitigation Nusa Tenggara Timur"
“Climate Change” “undernutrition”	“Adaptation Indonesia”	“Mitigation Nusa Tenggara Timur"
Undernutrition	Nusa Tenggara Timur	Indonesia
“Undernutrition Children Under 5”	Nusa Tenggara Timur	Indonesia

Appendix 1

The details of the food security and its elements scores of each Regency and City in NTT (54) and the rank of stunting, wasted, and underweight in each regency in NTT (19), sorted by the lowest food security score.

Regencies	Availability Score	Access Score	Utilization Score	Food Security Score	Rank of Stunting	Rank of Wasted	Rank of Underweight
Sabu Raijua	56.01	47.1	50.25	51.03	12	4	3
Sumba Barat Daya	92.11	36.8	48.22	57.96	4	15	7
Timor Tengah Selatan	89.09	41.01	51.2	59.51	1	11	2
Alor	79.19	57.58	49.46	60.82	3	9	8
Manggarai Timur	91.1	38.49	57.16	61.74	5	17	15
Sumba Tengah	93.81	40.99	53.76	61.94	11	16	18
Sumba Barat	86.76	49.91	59.06	64.63	10	18	12
Sumba Timur	90.83	50.83	59.29	66.21	17	21	20
Rote Ndao	83.93	51.92	64.15	66.41	7	1	4
Kupang	86.79	58.28	57.24	66.42	6	3	1
Timor Tengah Utara	83.66	55.2	62.04	66.47	2	10	6
Malaka	93.58	66.16	47.9	67.08	15	2	5
Ende	80.22	59.4	69.04	69.5	19	7	16
Lembata	92.12	56.81	64.36	70.43	14	8	9
Manggarai	90.33	61.93	65.5	71.88	13	19	22
Belu	89.32	69.84	60.37	71.89	8	12	10
Manggarai Barat	95.5	66.54	58.26	71.92	9	22	17
Flores Timur	75.82	77.02	66.26	72.36	22	6	11
Sikka	83.78	71.25	67.58	73.54	20	5	13
Nagekeo	89.08	76.15	62.05	74.39	18	14	19
Kupang City		81.77	70.63	75.64	21	13	14

Ngada	93.1	74.13	74.25	79.87	16	20	21
NTT	86.48	58.60	59.91	67.35			

Appendix 4

The Percentage of Households by Regency and Municipality with Improved Sanitation (sorted by the lowest number in 2019) (6)

Regency/Municipality	2018	2019	Rank of Stunting	Rank of Wasted	Rank of Underweight
Sumba Barat Daya	18.75	28.24	4	15	7
Sumba Tengah	10.71	31.8	11	16	18
Timor Tengah Selatan	45.61	35.03	1	11	2
Manggarai Timur	10.83	36.86	5	17	15
Sumba Barat	29.56	37.7	4	15	7
Sumba Timur	35.78	49.62	17	21	20
Manggarai Barat	33.55	52.27	9	22	17
Manggarai	19.64	56.14	13	19	22
Timor Tengah Utara	57.99	62.67	2	10	6
Belu	55.47	64.9	8	12	10
Kupang	40.64	67.15	6	3	1
Malaka	57	67.28	15	2	5

Rote Ndao	48.34	74.85	7	1	4
Sabu Raijua	26.99	78.62	12	4	3
Sikka	71.34	79.21	20	5	13
Nagekeo	79.99	81.61	18	14	19
Ngada	71.05	82.96	16	20	21
Alor	53.78	83.9	3	9	8
Flores Timur	76.71	86.38	22	6	11
Kupang Municipality	81.36	88.02	21	13	4
Lembata	79.73	90.36	14	8	9
Ende	79.25	91.49	19	7	16
East Nusa Tenggara	50.72	64.55			

Appendix 2

Table 9. The summary of the assessment of each sector from the Indonesia Climate Change Sectoral Roadmap Synthesis Report (ICCSR) (129,130)

Sector	Hazards	Projection
Water	Water shortage	By 2020-2030, Java-Bali and Sumatra will face severe water shortages. At present, Java-Bali already experienced water deficit. Because of the increase in temperature and change in rainfall, the water supply can gradually decrease, affecting other areas.
	Floods	Downstream areas of Java, Eastern Sumatra, Western-southern and eastern Kalimantan, Eastern Sulawesi, and Southern Papua are extremely high risk. These areas are located along major rivers.
	Droughts	Extremely high risk areas are Central Java, Sumatra, and Nusa Tenggara.
Marine and fisheries	Coastal inundation	Java Island, especially in the north coastal area
	Sea surface temperature	1-2℃ of temperature rise potentially increase coral bleaching by 2030
	Extreme events	- Increased frequency of El Nino and La Nina (from an average of every 3–7 years to every 2–6 years) - Increasing extreme weather events such as storm surges, tropical cyclones and high waves
Agriculture	Food production	- Decreasing area of paddy fields caused by sea level rise - The increasing temperature and

		decreasing precipitation will decrease food production
	Plantation production	Production of coffee, cacao, and palm oil are decreasing
Health	Vector-borne infectious diseases	- Increasing morbidity and mortality because of climate disasters - The decreasing food production will adversely affect food supplies which will increase malnutrition - Increasing diseases triggered by changing temperatures, air pollution, water congenital disease, food and congenital disease vector and rodents
	Diarrhoeal diseases	