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Policy implications of drought's cascading effects on sustainable livelihoods and natural resource management in South-Central Mindanao, Philippines

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ABSTRACT

Drought, a severe issue exacerbated by climate change, is a pressing concern in South-Central Mindanao, Philippines. This study examines the impact of the 2015-2016 drought events on livelihood and natural resource management in Koronadal and Kidapawan cities. It aims to highlight the pressing necessity for policy interventions to address the cascading effects of drought in local communities. A comprehensive research method was conducted between July 2017 and February 2018, including surveys, focus groups with farmers, and a literature review. The findings revealed that the 2015–2016 drought, a severe seven-month dry period, severely impacted farmers, leading to significant crop losses and financial hardships. Depleting water supplies resulted in lower agricultural yields, increased food poverty, and detrimental ecological impacts. Crop growth and cattle mortality were impeded by reduced soil moisture, increasing pest infestations, bushfires and wildfires, and soil cracking. The drought also increased the cost of agricultural supplies, putting farmers under financial stress and forcing them to take out loans and accumulate more debt. Some resorted to unsustainable practices like charcoal making in Koronadal City, while others in Kidapawan City suffered from food poisoning after consuming wild cassava.

Drought impacts the environment and economy, leading to social issues like hunger and migration for alternative income sources. Education is compromised, and community involvement in crafting and implementing contextually relevant policies becomes crucial. The policies holistically encompass environmental, economic, and social dimensions, preparation before drought events, management and survival during drought, and recovery after drought. Immediate relief and long-term strategies are essential to safeguard sustainable livelihoods and enhance the resilience of natural resource management in recurring drought events. Key policy recommendations include formulating comprehensive drought management plans and policies that promote sustainable agriculture/agroforestry, establishing effective water management systems, diverse livelihoods, drought-tolerant agricultural practices, and strengthening community-based disaster risk reduction efforts.

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KEYWORDS

drought, sustainable livelihood, natural resource management, cascading impacts

It is crucial to stress the need for diverse livelihoods, as this adaptability is critical to resilience in drought. This study underscores the pressing need for policy intervention due to vulnerability in livelihood, food security, and water resource management since drought has cascading effects on agriculture and communities. Policymakers and other agencies/organizations involved in drought management in the South-Central Mindanao region are crucial in developing and implementing policies.

INTRODUCTION

Sustainable livelihoods need effective management of natural resources, particularly in farming communities that heavily depend on rainfall, as climate change consequences, such as drought, can present serious vulnerabilities. According to Sam et al. (2023), drought is becoming more complicated due to climate change, with severe consequences for tropical countries' water supplies and agricultural practices. The main effect of drought on agricultural and human life is water shortage, which carries substantial financial burdens, especially in developing countries like the Philippines. The urgency of effective management of natural resources and the need for sustainable livelihoods in these communities cannot be overstated.

Most of the drought years in the Philippines are influenced by El Niño events (de Guzman, undated), which increase the chances of drier conditions (Hilario et al., 2009). The impact of drought is prevalent, especially in communities that rely on agriculture, and its effects extend to different sectors (Wilhite & Glantz, 1985). The drought episodes in the Philippines have devastating impacts on water resources, agricultural production, and food security, placing the country's socio-economic condition at risk. Hilario et al. (2009) documented an estimated damage of P 4.09 billion, constituting 71% of the total estimated agricultural production loss in the 1991-1992 drought episode, severely impacting Mindanao. On the other hand, the 1997-1998 episode wreaked havoc on approximately 74,000 hectares of agricultural lands covering 18 provinces across the nation, resulting in 74 fatalities and leaving millions of people in dire need (Inter-agency Regional Analysts Network, 2015).

The 2015-2016 drought episode in the Philippines inflicted severe hardship on 181,687 farmers. It impacted 224,834 hectares of agricultural land cultivated with rice, corn, and high-value crops, as reported by the International Federation of Red Cross and Red Crescent Societies (2016). Once again, the Visayas and Mindanao regions bore the consequences of the 2015-2016 drought catastrophe.

Drought inflicts extensive damage to agriculture, hindering sustainable livelihoods and limiting adaptation pathways (Ahmad et al., 2022). Sustainable livelihood is defined by Chambers and Conway (1991) as capabilities, assets (stores, resources, claims, and access), and activities required to secure a means of living. Livelihood is sustainable when it enables people to cope and become resilient from stress and shock, maintaining or enhancing their capabilities and assets in the present and the future. Despite these challenges, farming communities in regions like South-Central Mindanao, Philippines, have shown remarkable resilience. Climate change and extreme weather events, such as drought, significantly affect agricultural crop production and sustainable livelihood activities. The importance of sustainable livelihoods and natural resource management cannot be overstated, particularly in these areas, where these aspects are essential to the well-being of communities and ecosystems. Sustainable livelihoods and effective natural resource management are the cornerstones of resilience, prosperity, and environmental stewardship. Agriculture is the backbone of this region, employing a significant portion of the population in farming and agribusiness activities. Its proximity to the equator has made the region susceptible to the adverse effects of drought. Its cultivation of vital crops such as rice, corn, and bananas, as well as livestock farming, has been compromised since the agricultural sector heavily relies on consistent and ample rainfall to sustain crop and livestock production. Drought severely impacts crop yields, food security, and the livelihoods of farming communities.

This study addresses the urgent need to understand and address the multifaceted impacts (environmental, social, and economic) of drought in South-Central Mindanao, Philippines. Drought has emerged as a recurring and escalating challenge that affects water resources and severely threatens the region's sustainable livelihood and natural resource management. By exploring the cascading effects of drought, the study aims to inform policymakers, local communities, and other stakeholders in enhancing a proactive and adaptive approach to the adverse consequences of drought and other climate change impacts. Policy formulation and implementation should offer targeted strategies to enhance resilience, protect livelihoods, and sustainably manage natural resources in South-Central Mindanao.

The study aims to assess comprehensively the policy implications of the cascading effects based on the 2015-2016 drought episode on sustainable livelihoods and natural resource management in South-Central Mindanao, Philippines.

Specifically, the study aims to:

1. Examine the historical drought trends in the study sites;
2. Identify the social, economic, and environmental impacts of the 2015-2016 drought;
3. Determine the relationship between the impacts of the 2015-2016 drought event and the sustainable livelihood capital; and
4. Provide evidence-based recommendations for enhancing resilience, adapting to adverse impacts, and promoting sustainable livelihoods and resource management practices in South-Central Mindanao, Philippines.

MATERIALS AND METHODS

Study area and brief description

The study sites are the cities of Koronadal and Kidapawan in South-Central Mindanao, as illustrated in Figure 1. These locations are the focal points declared a state of calamity during the 2015-2016 drought event, and their reliance on agriculture and natural resources for economic and social well-being.

As reported by CNN Philippines (2016) and cited by Sabino et al. (2020) in March 2016, the City of Koronadal declared a state of calamity in response to a severe drought. As Sabino *et al.* (2020) highlighted, this phenomenon severely impacted the weather-dependent livelihoods of local communities, affecting both the food supply and overall livelihoods.

The selection of these sites was prompted by the substantial impact of the 2015-2016 drought and the scarcity of research that connects drought-cascading effects with sustainable livelihood capitals in the region.

Both cities primarily rely on farming as the primary source of livelihood.

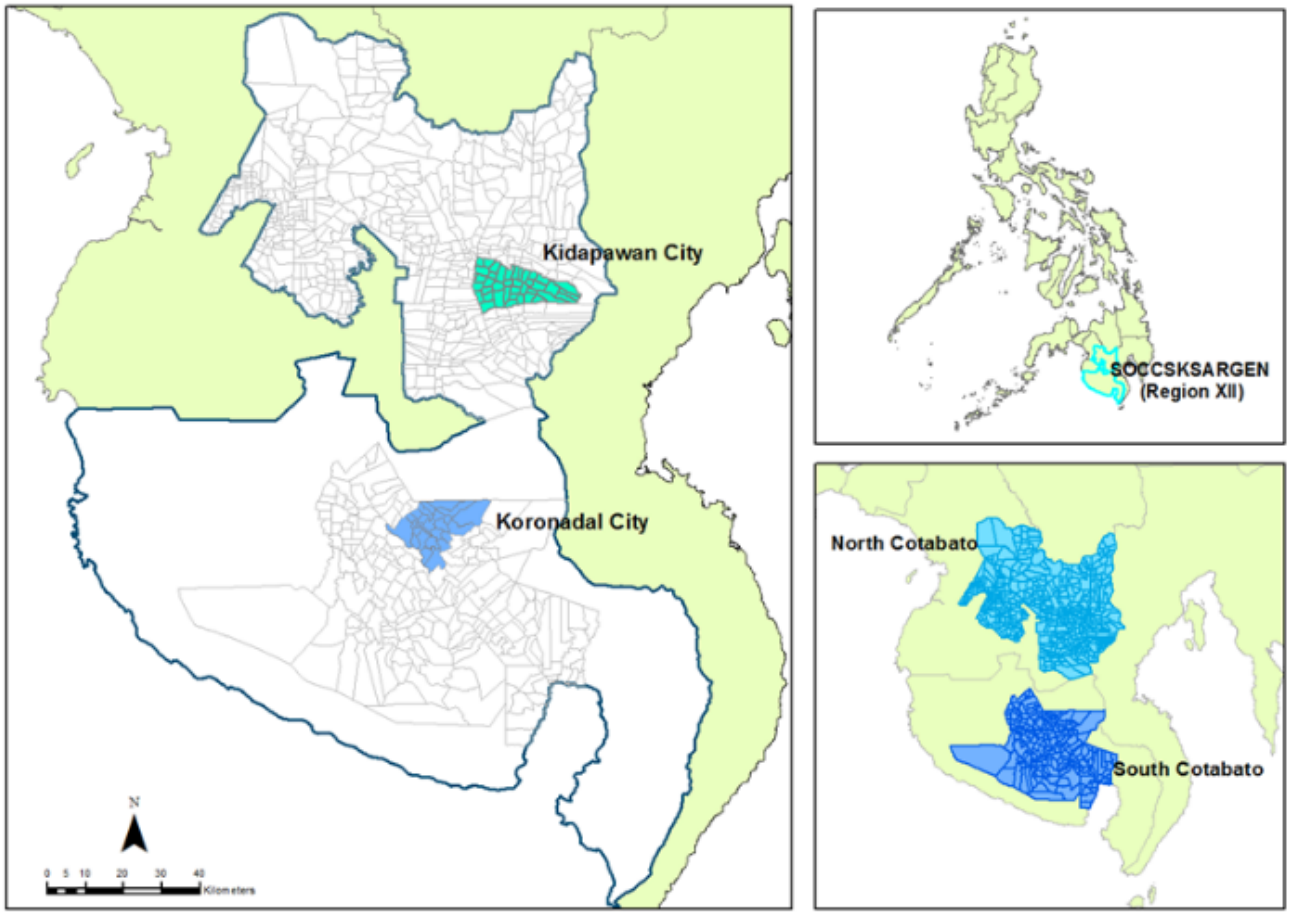

Figure 1: Location map of the study sites in South Central Mindanao, Philippines.

City of Koronadal, Province of South Cotabato

Koronadal City, the capital of South Cotabato province, is strategically located 58 kilometers from General Santos City, allowing a one-hour travel time between the two cities. The administrative regional capital of Cotabato Region 12, in the northeastern part of South Cotabato Province, shares borders with Tantangan, Banga, Tupi, Tampakan, and Lutayan in Sultan Kudarat.

Koronadal City, a landlocked area of 27 barangays, covers 27,700 hectares, making up 8.41% of South Cotabato's total land area. As of May 2020, its population was 195,398 (Philippine Statistics Authority, 2020).

The city falls under a Type IV climate classification, characterized by an evenly distributed rainfall pattern throughout the year and no distinct maximum rain period (City Government of Koronadal, 2009). This climate condition is advantageous for agriculture and vital to the city's economy.

Rice, corn, root crops, high-value crops, and ornamentals are the most often grown crops. Although rice, corn, and coconuts are the most important agricultural products produced in the city, in addition to drought, other climate hazards the area is susceptible to include extreme heat, heavy precipitation, landslides, and flash floods. These environmental issues significantly impact Farmers' productivity, making it difficult for them to maintain their way of life.

City of Kidapawan, Province of North Cotabato

According to the 2016 City of Kidapawan Comprehensive Land Use Plan, Kidapawan City is located at the base of Mt. Apo, the highest peak in the Philippines, in the southeast of the province of Cotabato. According to cadastral surveys, the city's landscapes encompass 34,007.20 hectares of total land area, of which approximately 5,036.4 hectares are classified as timberland.

Kidapawan City has a Type III climate, meaning a brief dry season lasts one to three months, from December to February or March to May, and no discernible peak rainy period. This kind of climate is also characterized by year-round rainfall. In contrast, three barangays, including Balag, Perez, and Ilomavis, are categorized as Type IV because of their more consistent annual rainfall pattern.

The city's economy is mainly based on agriculture, with about 79 percent of its entire land area used for this purpose. The environment is conducive to growing crops, such as root crops, legumes, coconuts, fruits (such as rambutan, durian, mangosteen, and rice), vegetables, and cereals (like corn and rice). The 2020 Census of Population and Housing, carried out by the Philippine Statistics Authority (PSA, 2020), recorded 160,791 people living in Kidapawan City as of May 1, 2020.

Data collection methods and analysis

This research employed a mixed-methods approach, integrating quantitative and qualitative methods to triangulate findings and enhance credibility and reliability (Teddlie & Tashakkori, 2009). It was conducted from July 2017 to February 2018, and courtesy visits were conducted with local government units in two study sites.

The study also employed structured and semi-structured survey instruments, focus group discussions in local communities, and secondary data on historical drought trends. In the survey phase, stratified random sampling methods were employed to select 101 (53%) farmer respondents from the City of Koronadal and

90 (47%) from the City of Kidapawan, resulting in a total of 191 respondents across upland, midland, and lowland communities. Likert scales were used to gather quantitative data on the effects of the 2015 and 2016 droughts, divided into three categories: environmental, social, and economic, and their relationship to farmers' sustainable livelihood. Impact chain analysis was done during the focus group discussions with farmers and local government representatives for qualitative insights.

The correlation technique examined quantitative data regarding the relationship between the drought's social, economic, and environmental impacts. The variables that impact the environment include dust exposure, land productivity, the frequency of wildfires, the availability of water for irrigation, and potable water usage. The production of crops, cattle, and fruits, wood yields, labor productivity, and market prices for agricultural inputs and outputs are all examples of economic impact variables. Food availability, migration trends, and conflict incidents are examples of social consequences.

Tables 1 and 2 show drought impact variables and sustainable livelihood capital variables, such as financial, social, physical, natural, and human capital indicators. However, descriptive analysis and an impact chain diagram were used to assess qualitative social, economic, and environmental data.

Table 1: Drought impact variables

Environmental Aspect	
Code	**Description**
DIE1	No water for irrigation and potable water
DIE2.	A decrease in the availability of water supply/limited source of water.
DIE3.	Unproductive land area (cracked soils) resulting in infertile soils
DIE4.	Incidence of forest/grass fire
DIE5.	Damage to irrigation canals
DIE6.	Exposure to dust
Economic Aspect	
Code	**Description of drought impact variables**
DIEC2.	No production
DIEC3.	Crop damage resulting in a low harvest
DIEC4.	Mortality of poultry/livestock
DIEC5.	Mortality of planted fruit trees
DIEC6.	Decrease working hours due to illness.
DIEC7.	Increase the prices of farm inputs.
DIEC8.	The market price of farm produce has dropped due to decreased quality.
Social Aspect	
DIS1.	Food shortage
DIS2.	Hunger
DIS3.	Migration of family members
DIS4.	Water use conflict

Table 2: Sustainable livelihood indicators

Social capital indicators	
Code	**Description**
SLSoc1.	Resorted to eating wild yam
SLSoc2.	Social unrest
SLSoc3.	Stealing of poultry/livestock
SLSoc4.	Livestock trespassing results in farm damage.
SLSoc5.	Stealing farm produce
Financial capital indicators	
Code	**Description**
SLFin1.	No income
SLFin2.	Decrease in household income.
SLFin3.	Decrease in savings
SLFin4.	Decreasing purchasing power
SLFin5.	Increase/decrease in debts
SLFin6.	Decrease access to credit/loans.
Physical capital indicators	
Code	**Description**
SLPhy1.	High demand for water pumps
SLPhy2.	Broken water pumps/water sources
SLPhy3.	High demand for energy
Natural capital indicators	
Code	**Description**
SLNat1.	Deteriorating water quality
SLNat2.	Increase the occurrence of pests.
SLNat3.	Infestation of diseases
SLNat4.	Decrease pasture lands for livestock.
SLNat5.	Decrease cultivated lands
Human capital indicators	
Code	**Description**
SLHum1.	Farm planning disruption
SLHum2.	Increase the incidence of health illnesses.
SLHum3.	Disruption of children's schooling
SLHum4.	Gender imbalances/shift in production/reproduction, and community roles

Conceptual Framework

The conceptual framework (Figure 2) examines the policy implications of the ripple effects of drought on sustainable livelihoods and natural resource management in South-Central Mindanao, Philippines. The research explores drought trends in South-central Mindanao, focusing on frequency, duration, intensity, and policy implications, examining social, economic, and environmental dimensions. Examining the effects of drought on water, land, and forest/grassland is part of the environmental impact of drought. While farmers' markets and labor productivity are the primary focus of economic consequences, food supply, hunger, migration, and conflicts over water use are explicitly examined in terms of social impacts.

The study investigates how these effects ripple across sustainable livelihood indicators, including financial, economic, social, physical, and natural.

Financial capital indicators include income, savings, credit availability, and purchasing power. Social capital indices cover food scarcity, hunger, disputes over water use, and social cohesiveness among farmers. Water systems, energy supplies, and infrastructure are all considered physical capital. Pests and diseases, land productivity, and water quality are the metrics for assessing natural capital. Variables, including gender roles, planning, health, and education, are all part of human capital.

The study further explores drought's impact on natural resource management, aiming to inform policymakers about addressing socio-ecological systems and the interconnections between drought impacts and sustainable livelihood.

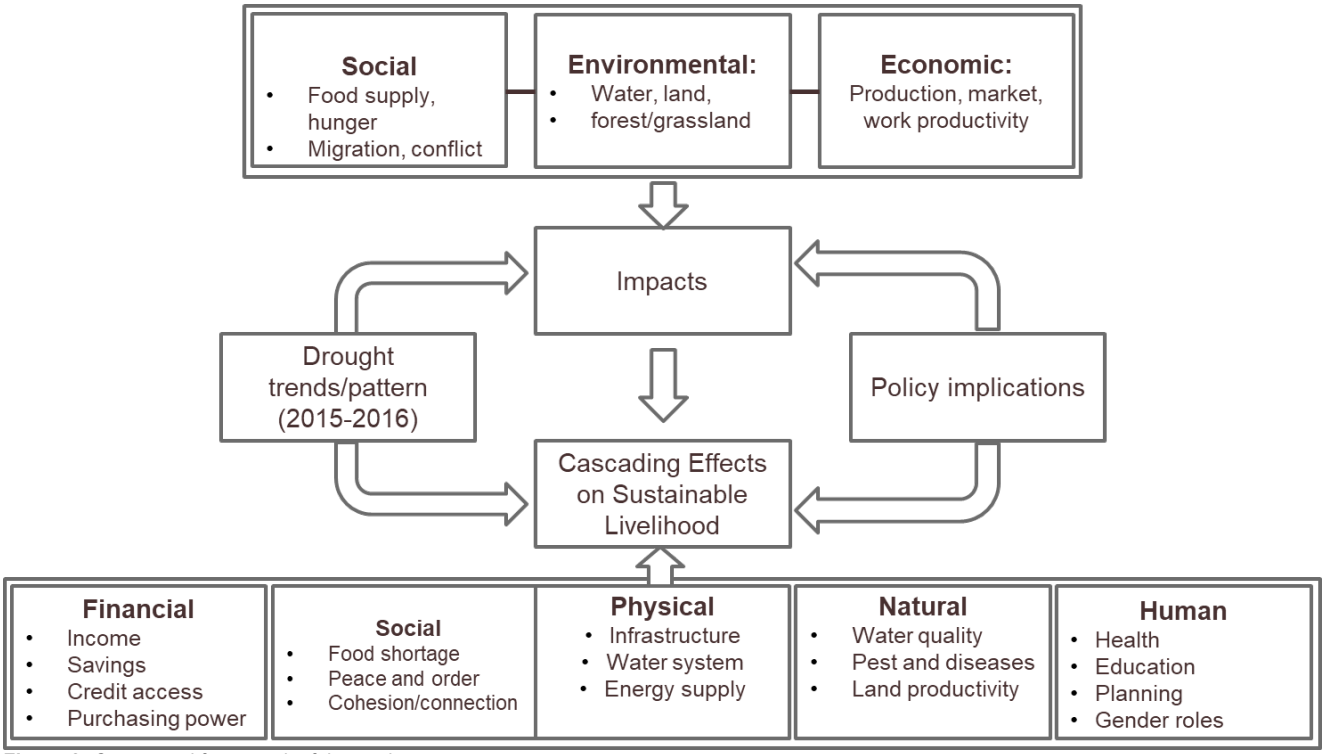

Figure 2: Conceptual framework of the study.

RESULTS AND DISCUSSION

Historical Analysis of Trends in Drought Occurrence in the Philippines

The study conducted a survey and focus group discussions to gather data on the frequency of drought events in two cities, Kidapawan and Koronadal, from 1950 to 2020. Despite challenges in tracing drought occurrences, respondents reported droughts occurred once to three times per decade between 1950 and 2016, typically lasting 3 to 9 months. Both cities experienced a severe drought for seven months in 2015-2016, leading to significant crop losses and financial difficulties for local farmers. The study also checked data from the National Oceanic and Atmospheric Administration website, revealing 19 documented drought episodes in the Philippines from 1951 to 2016.

Based on secondary data, Table 3 summarizes the historical trends of drought in the Philippines during a seven-decade period from 1951 to 2020. Eight were categorized as weak, three as weak to moderate, six as weak to strong, and two as moderate to strong.

Three distinct drought events occurred in the country between 1950 and 1960, each lasting from seven to twenty-one months and varying in severity from weak to vigorous. The last event was the worst in terms of severity. From 1961 to 1970, three more severe drought events ranged from mild to intense and lasted 8 to 14 months. Three occurrences with moderate to solid intensity and durations ranging from five to eleven months were noted in the 1970s. The longest episode took place between 1976 and 1978.

In the 1980s, two major drought events were recorded: one from 1982 to 1983 and another from 1986 to 1988, each lasting 15 to 18 months and varying in severity from weak to vigorous. The 1990s witnessed three drought events lasting between 6 and 14 months, with the most severe occurring between 1997 and 1998. From 2010 to 2016, three drought episodes were observed, including a severe drought in 2014 lasting six months and a prolonged drought from 2015 to 2016 lasting 19 months. These events, particularly the 2015 to 2016 drought, were the most severe in history, and leading to significant agricultural and water supply challenges.

Over seven decades, the most severe drought events between 1951 and 2016 occurred in 1957-1959, 1965-1966, 1972-1973, 1982-1983, 1986-1988, 1991-1992, 1997-1998, and 2015-2016, impacting the Mindanao region. During this period, they have severely affected the Mindanao region, including 1997-1998, 2009-2010, and 2014-2016. On average, a drought event was recorded approximately three times per decade, lasting from five to twenty-one months and varying in severity from moderate to vigorous. Severe and prolonged droughts marked the 1980s and the 1997-1998 episodes. Recent trends in 2010-2020 revealed a mix of weak to moderate episodes, with a severe drought in 2014 and an extended episode in 2015-2016. However, the study sites had already experienced pronounced dryness during November and December 2014, which became severe from October 2015 to February 2016, resulting in the delayed start of agricultural activities. In 2019, as reported by Gotinga (2019), Mindanao suffered another seven-month drought.

The Philippines has faced recurrent severe droughts that have profoundly affected agricultural productivity, especially in South-Central Mindanao. Long-term droughts have strained water resources, posing challenges in water supply across multiple sectors. Analyzing these trends and patterns is crucial for understanding the implications of climate change on drought frequency and severity, thereby contributing to mitigation and adaptation strategies.

Table 3: Historical episodes of drought in the Philippines from 1951 to 2020.

Decades	Specific year*	Severity	Duration (months)*
1950s	1951/195	Weak	7
	1953/1954	Weak	13
	1957/1959	Weak to strong	21
1960s	1963/1964	Weak to moderate	8
	1965/1966	Weak to strong	11

	1968-1969	Weak	14
1970s	1972-1973	Moderate to strong	11
	1976-1978	Weak	11
	1979-1980	Weak	5
1980s	1982-1983	Weak to strong	15
	1986-1988	Weak to strong	18
1990s	1991-1992	Weak to strong	14
	1994-1995	Weak	6
	1997-1998	Moderate to strong	13
2000	2002-200	Weak to moderate	9
	2004-2005	Weak	10
	2006-2007	Weak	5
2010-2020	2009-2010	Weak to moderate	10
	2014	Severe	6
	2015-2016	Weak to strong	19
	2018-2019	Severe to extreme	7

Sources: www.cpc.noaa.gov*, Hilario et al., 2010**, and ***International Federation of Red Cross and Red Crescent Societies (IFRC), 2016, and PAGASA.

Understanding historical patterns is crucial for developing effective drought adaptation and mitigation strategies while strengthening monitoring systems and early warning mechanisms, which aid communities in preparing and responding to drought events.

Drought Impacts on the Environment, Economy, and Society

Assessment of climate change impacts has become a crucial component in global climate negotiations and international assessment reports. In the Philippine setting, changing climate patterns have intensified drought episodes, which have severe consequences for water resources, agricultural production, and food security. This has significantly jeopardized the country's socio-economic well-being.

Most drought years in the Philippines are influenced by El Niño events (de Guzman, undated), which increase the chances of drier conditions (Hilario et al., 2009). The impact of drought is prevalent, especially in communities that rely on agriculture, and its effects extend to different sectors (Wilhite & Glantz, 1985). Sewando et al. (2016) found that drought events increase farmers' vulnerability, severely impacting their livelihoods, particularly farming, which relies heavily on weather-dependent income.

Hilario et al. (2009) estimated that the 1991-1992 drought caused ₱4.09 billion in losses, 71% of total agricultural production damage, affecting Mindanao. Subsequent droughts, 1997-1998 and 2015-2016, continue to wreak havoc on agricultural lands. In the Visayas and Mindanao areas, the 2015–2016 drought had a devastating effect on 224,834 hectares of agricultural land and 181,687 farmers, resulting in widespread hunger and economic hardship (International Federation of Red Cross and Red Crescent Societies (IFRC), 2016).

Impact chain diagrams case studies from Koronadal City (Figure 3) and Kidapawan City (Figure 4) in Southern Mindanao during the 2015-2016 extreme droughts reveal the multifaceted effects of drought on the environment, economic and social repercussions, and eroded sustainable livelihood capital of farmers. These findings highlighted the urgent need for adaptive measures to address the challenges of climate change.

Environmental impacts

Drought in the studied areas showed various environmental effects, such as decreased soil moisture, decreased soil fertility due to unproductive fields with visible soil cracking, and a loss in water supplies for irrigation and residential use (including potable water). There have also been reports of dust buildup, irrigation canal damage, and the incidence of grassland and bushfires. Fishponds dried up, and cattle died due to grassland fires and a drop in water supplies. Participants noted that drought increased disease incidence and pest infestation. Furthermore, grassland fires and a decline in water supply contributed to livestock mortality and the drying of fishponds. The extreme drought directly led to unfavorable rooting conditions in cracked soil, hindering crop growth and causing crop mortality. These impacts permeate all facets of farmers' lives. In 2018, the Intergovernmental Panel on Climate Change (IPCC) warned about potential consequences such as a decline in agricultural productivity and heightened wildfire risks. Environmental impacts of drought were documented in both cities, directly exacerbating farmers' socio-economic conditions. The extreme drought adversely affected all aspects of farmers' livelihoods derived from their agricultural activities.

Economic impacts

Farmers in the study areas faced significant financial hardship due to drought, which led to income losses from reduced crop yields, crop failure, crop damage, and no production for some farmers. Drought, grassland and bushfires, and a lack of water also resulted in the death of planted fruit trees, animal losses (goats, carabao, and cattle), dried-up fishponds, and a reduction in working hours in the farm due to intense heat and illness.

Farmers' financial stability was further strained by the rising costs of agricultural inputs and a drop in market value due to the lower quality of farm output. Due to their situation, several farmers were obliged to take out loans and accrue debt. Some farmers in Koronadal City resorted to producing charcoal as a substitute source of income, but this eventually proved insufficient and unsustainable. Drought can lead to job and income losses in other sectors, such as tourism and manufacturing, further impacting the broader economy (Food and Agriculture Organization, 2016). It can also potentially increase consumer food prices and significantly negatively impact agricultural and livestock production (IPCC, 2018). The prolonged economic impacts of drought hinder the affected communities' capacity to recover from this catastrophic event.

Social impacts

The impacts of drought extend beyond environmental and economic consequences, affecting the social aspects of the communities involved. Farmers in both cities keenly felt the effects of the severe drought, which resulted in food shortages and hunger. In Kidapawan City, farmers even had food poisoning after consuming wild cassava, a substitute food source. Additionally, family members migrated in search of alternative income sources, often working as domestic helpers or construction workers. Water use conflicts also arose in communities severely affected by water availability issues. For some families, losing farming income meant they could not afford their children's education, leading to school dropouts. Drought also heightened the risk of stealing farm produce and livestock and trespassing on other farms.

The Food and Agriculture Organization (2016) highlighted that drought can lead to food insecurity, malnutrition, and displacement, exacerbating social inequalities. It disproportionately affects vulnerable populations, especially

women and children. The social impacts include increased poverty, reduced access to education and healthcare, and further displacement. Extreme drought also poses psychosocial challenges, impacting farmers' livelihoods and survival.

In both cities, severe drought led to a rise in theft, migration (e.g., individuals seeking employment as domestic helpers or construction workers to offset the loss of income from farming), and families, stopping children's education. In Kidapawan City, farmers from neighboring municipalities organized a protest rally that escalated into violence.

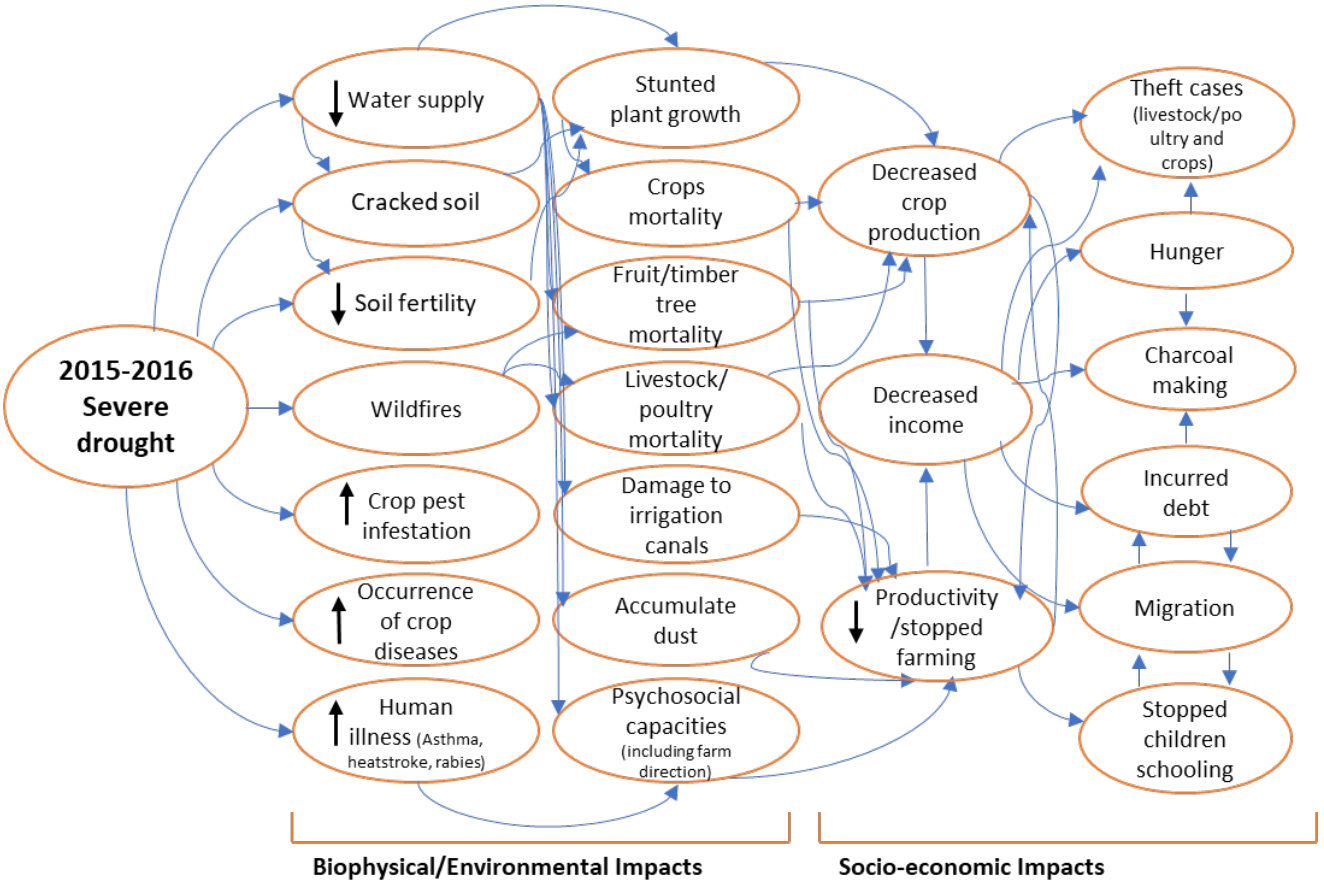

Figure 3: The cascading impacts of the 2015-2016 drought episode in the City of Koronadal, South Cotabato.

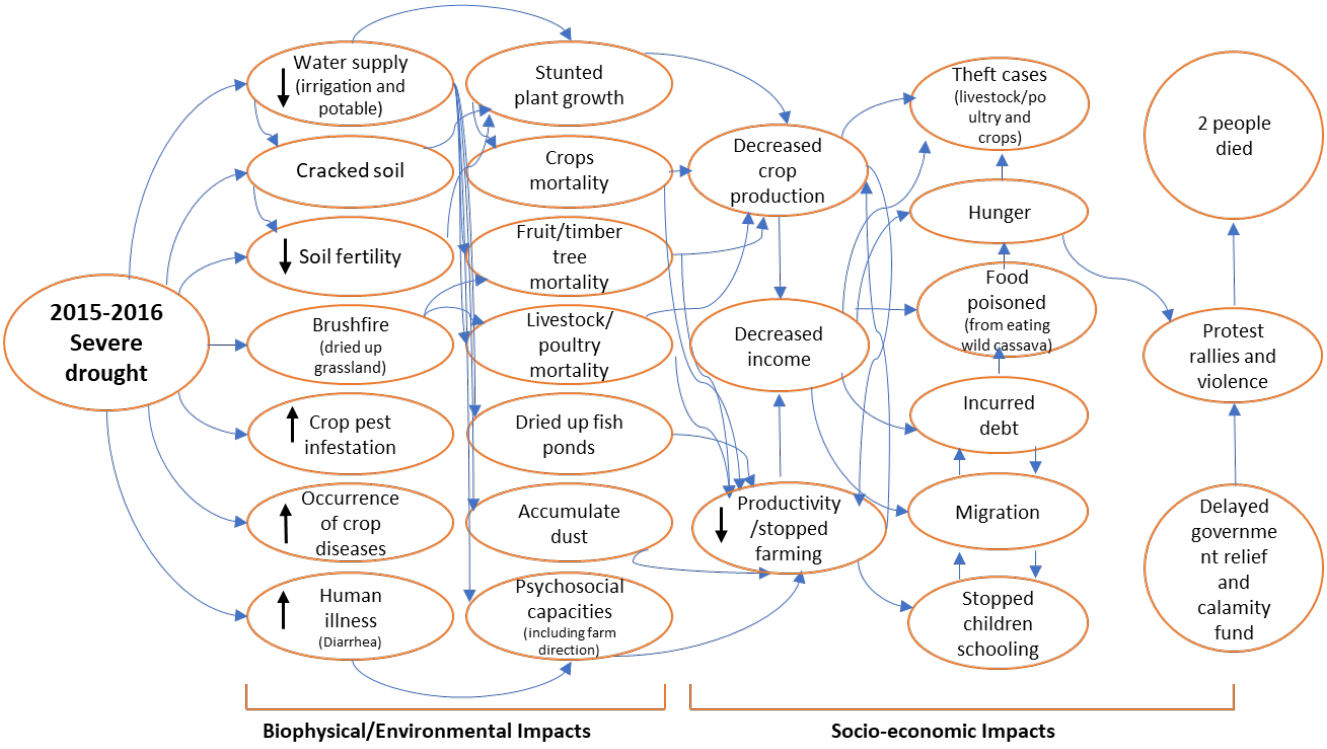

Figure 4: The cascading impacts of the 2015-2016 Kidapawan, North Cotabato drought episode.

According to the Philippine Commission of Human Rights (2016), the 2016 Kidapawan incident led to the loss of two farmer protesters, with two police officers sustaining severe injuries and 179 individuals left wounded. The delayed response from the local government was recognized as a critical factor contributing to the public protests and subsequent social unrest.

Correlation analysis between the 2015–2016 drought impacts and sustainable livelihood indicators

The study used Spearman's rank correlation coefficient to analyze the relationship between sustainable livelihood indicators and the impacts of the 2015-2016 drought event. It assessed how changes in sustainable livelihood capital, including social, human, financial, natural, and physical capital, corresponded with the drought's effects. Understanding these correlations is crucial for designing targeted interventions and adaptation strategies that strengthen livelihoods and enhance resilience against future climate-related challenges.

Drought impacts variables and the sustainable livelihood social indicators.

Two of the six social indicators related to sustainable livelihood and the six environmental impact variables in the City of Koronadal demonstrated statistical significance (p-value of 0.001), as shown in Table 4. These significant variables include "incidence of forest and grass fires (DEI4)" and "damage to irrigation canals (DEI5)," both of which were found to be linked to the practice of "resorting to consuming wild yam or cassava" (SLSoc1). Due to the impact of climate change, particularly drought, Kolanek et al. (2021) indicated that forest fires are a growing threat to human life, health, and property.

According to FAO, wildfires can severely affect the economy and society. It can have catastrophic effects and meet the criteria for being classified as a "disaster," which includes substantial harm and loss to property, fatalities, and infrastructure like irrigation. Many people in Koronadal rely heavily on agriculture for their livelihood, and irrigation canals are essential to this industry. A disruption in agricultural productivity caused by damage to irrigation canals resulted in financial losses and food insecurity.

Table 4: Correlation matrix between drought environmental impacts and the social sustainable livelihood indicators in the City of Koronadal

		DEI1	DEI2	DEI3	DEI4	DEI5	DEI6
SLSoc 1	Spearman 's rho	0.209	0.067	-0.002	0.322	-0.336	-0.198
	p-value	0.037*	0.511	0.988	0.001**	<.001**	0.049*
SLSoc 2	Spearman 's rho	NaN	NaN	NaN	NaN	NaN	NaN
	p-value	NaN	NaN	NaN	NaN	NaN	NaN
SLSoc 3	Spearman 's rho	-0.094	0.124	-0.221	-0.061	-0.185	-0.143
	p-value	0.356	0.221	0.028*	0.548	0.067	0.159
SLSoc 4	Spearman 's rho	0.114	0.046	0.15	0.077	-0.131	-0.094
	p-value	0.263	0.651	0.14	0.452	0.196	0.356
SLSoc 5	Spearman 's rho	0.185	-0.018	0.066	0.137	-0.175	-0.14
	p-value	0.066	0.857	0.517	0.176	0.082	0.166
SLSoc 6	Spearman 's rho	0.196	-0.247	0.096	0.21	-0.091	-0.027
	p-value	0.051*	0.014*	0.346	0.037*	0.372	0.794

Note. * p < .05, ** p < .01, *** p < .001

Legend: Environmental impacts: DIE1. No water for irrigation and potable; DIE2. Decrease in the availability of water supply/limited water source; DIE3. Unproductive land area (cracked soils) resulting in infertile soils; DIE4. Incidence of forest/grass fire; DIE5. Damage to irrigation canals; DIE6. Exposure to dust. Sustainable capital (social indicator): SLSoc1. Resorted to eat wild yam/cassava; SLSoc2. Social unrest; SLSoc3. Stealing of poultry/livestock; SLSoc4. Livestock trespassing resulting in farm damage; SLSoc5. Stealing farm produce; SLSoc6. Loss of social connection/cohesion

According to Vlachos (1972), irrigated agriculture and the prudent use of scarce financial resources are crucial in achieving social and economic development goals. In Kidapawan City, environmental impact variables, specifically "No water for irrigation and potable water (DIE1)," "Incidence of forest/grass fire (DIE4)," and "Damage to irrigation canals (DIE5)," exhibited strong associations with the practice of "resorting to consuming wild yam/cassava (SLSoc1)." Turning to eating wild cassava proves farmers' food security is impacted when irrigation equipment is damaged.

In the same manner, Table 5 shows that an “unproductive land area due to cracked soils (DIE3), resulting in infertile soils, is associated with the “stealing of farm produce (SLSoc1). When there is an increased incidence of forest and grass fires in an area, it often results in significant environmental disruption. These fires destroy vegetation and soil, reducing the availability of natural food sources.

Table 5: Correlation matrix between drought environmental impacts and the social aspects of sustainable livelihood indicators in the City of Kidapawan

		DIE1	DIE2	DIE3	DIE4	DIE5	DIE6
SLSoc 1	Spearman's rho	0.27	0.17	0.131	0.527	0.577	-0.026
	p-value	0.01**	0.106	0.214	<.001***	<.001***	0.804
SLSoc 2	Spearman's rho	0.153	0.099	0.02	0.142	0.04	0.246
	p-value	0.147	0.349	0.851	0.179	0.706	0.019*
SLSoc 3	Spearman's rho	-0.142	0.016	0.163	0.139	0.056	0.001
	p-value	0.18	0.878	0.122	0.188	0.6	0.991
SLSoc 4	Spearman's rho	0.029	0.047	0.337	0.16	0.064	-0.126
	p-value	0.788	0.661	0.001***	0.131	0.546	0.234
SLSoc 5	Spearman's rho	-0.002	0.061	0.296	0.008	0.074	-0.021
	p-value	0.987	0.564	0.004**	0.941	0.483	0.843
SLSoc 6	Spearman's rho	0.031	0.023	-0.242	0.208	0.462	0.231
	p-value	0.772	0.829	0.021*	0.047*	<.001***	0.027*

Note. * p < .05, ** p < .01, *** p < .001

Legend: Environmental impacts: DIE1. No water for irrigation and potable; DIE2 Decrease in the availability of water supply/limited water source; DIE3. Unproductive lan area (cracked soils) resulting in infertile soils; DIE4. Incidence of forest/grass fire; DIE5 Damage to irrigation canals; DIE6. Exposure to dust.
Sustainable capital (social indicator): SLSoc1. Resorted to eat wild yam/cassava SLSoc2. Social unrest; SLSoc3. Stealing of poultry/livestock; SLSoc4. Livestoc trespassing resulting in farm damage; SLSoc5. Stealing farm produce; SLSoc6. Loss social connection/cohesion

Table 6 shows that in the City of Koronadal, the economic impact factors, such as "no production (DIEC2)" and "less harvest due to crop failure (DIEC1)," were found to be strongly correlated with a p-value of 0.001 with "resorted to eating wild yam/cassava (SLSoc1). This implies that the community is more likely to turn to wild yam/cassava as an alternative food source when there is a failure in crop harvest or no production.

Correlations were observed between the variable "resorted to eating wild yam/cassava (SLSoc1)" and other factors, such as the mortality of poultry and cattle (DIEC4), the decreased working hours owing to illness (DIEC6), and the mortality of planted fruit trees (DIEC5).

The community's reliance on wild yams or cassava for sustenance is linked to challenges such as no production,

livestock loss, and crop/fruit tree loss, which affect food security and economic stability. The community residents eat wild yams or cassava as a coping mechanism to address food shortages caused by environmental factors, leading to food insecurity. Prolonged droughts have caused soil moisture loss and damaged irrigation canals, crucial for agriculture as they reduce crop water supply. During drought or water scarcity, crop yields are affected.

Table 6: Correlation matrix between drought economic impacts and the social sustainable livelihood indicators in the City of Koronadal

		DIEC1	DIEC2	DIEC3	DIEC4	DIEC5	DIEC6	DIEC7	DIEC8
SLSoc1	Spearman's rho	0.561	0.542	0.035	0.234	0.289	0.106	0.185	0.022
	p-value	<.001***	<.001***	0.734	0.028*	0.004**	0.297	0.067	0.826

Note. * p < .05, ** p < .01, *** p < .001

Legend: Economic impacts: DIEC1. Less harvest due to crop failure; DIEC2. No production; DIEC3. Crop damage resulting in a low harvest
DIEC4. Mortality of poultry/livestock; DIEC5. Mortality of planted fruit trees; DIEC6. Decreased working hours due to illness; DIEC7. Increased prices of farm inputs; DIEC8. Dropped market price of farm produce due to decreased quality.
Sustainable capital (social indicator): SLSoc1. Resorted to eat wild yam/cassava;

Table 7 shows that several economic impact factors in Kidapawan City were closely associated with particular social indicators of sustainable livelihood:

- The practice of "eating wild yam/cassava (SLSoc1)" was significantly linked to the "increase in the prices of farm inputs (DIEC7)" and the "drop in market prices of farm produce due to decreased quality (DIEC8)".
- The practice of "eating wild yam/cassava (SLSoc1)" was significantly linked to the "increase in the prices of farm inputs (DIEC7)" and the "drop in market prices of farm produce due to decreased quality (DIEC8)".
- The "mortality of poultry/livestock (DIEC4)" and "drop in market prices of farm produce due to decreased quality (DIEC8)" were correlated with "social unrest (SLSoc5)." According to Rappler.com (2016), two farmers were killed and 116 were injured during the dispersal of the drought protest in Kidapawan City on April 1, 2016.
- Both the "drop in market prices of farm produce due to decreased quality (DIEC8)" and the "increase in the prices of farm inputs (DIEC7)" showed high correlations with the act of "stealing poultry and livestock (SLSoc3)".
- "Crop damage resulting in a low harvest (DIEC3.)" "increased prices of farm inputs (DIEC7)," " and the "drop in market prices of farm produce due to decreased quality (DIEC8)," were associated with "livestock trespassing resulting in farm damage (SLSoc4)".
- "Decreased working hours due to illness (DIEC6)" was linked to the "loss of social connection/cohesion (SLSoc6)".

Table 7: Correlation matrix between drought economic impacts and the social sustainable livelihood indicators in the City of Kidapawan

		DIEC1	DIEC2	DIEC3	DIEC4	DIEC5	DIEC6	DIEC7	DIEC8
SLSoc1	Spearman's rho	0.174	0.173	0.16	0.127	0.253	0.066	0.427	0.318
	p-value	0.099	0.102	0.131	0.231	0.016*	0.536	<.001***	0.002**
SLSoc2	Spearman's rho	0.267	0.259	0.218	0.358	0.264	0.033	0.148	0.346
	p-value	0.011*	0.013*	0.038*	<.001***	0.012*	0.754	0.162	<.001***
SLSoc3	Spearman's rho	0.183	0.142	0.25	0.084	0.135	0.104	0.344	0.309
	p-value	0.087	0.179	0.017*	0.429	0.201	0.326	<.001***	0.003**
SLSoc4	Spearman's rho	0.304	0.276	0.343	0.184	0.176	0.018	0.484	0.364
	p-value	0.003**	0.008**	<.001***	0.08	0.096	0.866	<.001***	<.001***
SLSoc5	Spearman's rho	0.193	0.173	0.234	0.167	0.236	-0.038	0.274	0.299
	p-value	0.067	0.1	0.026*	0.113	0.024*	0.743	0.009**	0.004**
SLSoc6	Spearman's rho	-0.196	-0.212	-0.138	-0.092	-0.007	-0.579	-0.013	-0.041
	p-value	0.062	0.044*	0.191	0.385	0.951	<.001***	0.902	0.702

Note. * p < .05, ** p < .01, *** p < .001

Legend: Economic impacts: DIEC1. Less harvest due to crop failure; DIEC2. No production; DIEC3. Crop damage resulting in low harvest; DIEC4. Mortality of poultry/livestock; DIEC5. Mortality of planted fruit trees; DIEC6. Decreased working hours due to illness; DIEC7. Increased prices of farm inputs; DIEC8. Dropped market price of farm produce due to decreased quality.
Sustainable capital (social indicator): SLSoc1. Resorted to eat wild yam/cassavaa; SLSoc2. Social unrest; SLSoc3. Stealing of poultry/livestock; SLSoc4. Livestock trespassing resulting in farm damage; SLSoc5. Stealing farm produce; SLSoc6. Loss of social connection/cohesion

Table 8 shows that in the City of Koronadal, some social impact variables—"Hunger (DIS2)" and "Migration of family members (DIS3)"—showed a statistically significant correlation with the practice of "Resorting to eating wild yam (SLSoc1)" at a significance level of 0.05. This implies that people who experience hunger or have family members who migrate because of drought are more likely to turn to wild yams/cassava as a source of nutrition.

In Kidapawan City, however, all social impact variables were linked to the sustainable livelihood social indicators (Table 9), except "Food shortage (DIS1)", "Hunger (DIS1)", and "social connection/cohesion (SLSoc6)". These variables do not display a statistically significant relationship with the identified social indicators.

Table 8: Correlation matrix between drought social impacts and the social sustainable livelihood indicators in the City of Koronadal

		DIS1	DIS2	DIS3	DIS4
SLSoc1	Spearman's rho	0.135	0.22	0.249	0.197
	p-value	0.184	0.028*	0.013*	0.05*

Note. * p < .05, ** p < .01, *** p < .001

Legend: Social impacts: DIS1. Food shortage; DIS2. Hunger; DIS3. Migration of family members; DIS4. Water use conflict Sustainable capital (social indicator): SLSoc1. Resorted to eat wild yam/cassava.

Table 9: Correlation matrix between drought social impacts and the social sustainable livelihood indicators in the City of Kidapawan

		DIS1	DIS2	DIS3	DIS4
SLSoc1	Spearman's rho	0.424	0.425	0.3	0.536
	p-value	<.001***	<.001***	0.004**	<.001***
SLSoc2	Spearman's rho	0.266	0.36	0.402	0.372
	p-value	0.011*	<.001***	<.001***	<.001***
SLSoc3	Spearman's rho	0.296	0.208	0.267	0.146
	p-value	0.004**	0.048*	0.01*	0.167
SLSoc4	Spearman's rho	0.316	0.211	0.351	0.18
	p-value	0.002**	0.045*	<.001***	0.088
SLSoc5	Spearman's rho	0.251	0.207	0.417	0.153
	p-value	0.016*	0.049*	<.001***	0.149
SLSoc6	Spearman's rho	-0.058	0.128	0.242	0.382

	p-value	0.585	0.228	0.021*	< .001***

Note. * p < .05, ** p < .01, *** p < .001

Legend: Social impacts: DIS1. Food shortage; DIS2. Hunger; DIS3. Migration of family members; DIS4. Water use conflict
Sustainable capital (social indicator): SLSoc1. Resorted to eat wild yam/cassava; SLSoc2. Social unrest; SLSoc3. Stealing of poultry/livestock; SLSoc4. Livestock trespassing resulting in farm damage; SLSoc5. Stealing farm produce; SLSoc6. Loss of social connection/cohesion

Drought impacts variables and the sustainable livelihood financial indicators.

Only two environmental impacts of drought, "No water for irrigation and potable (DIE1)" and "Unproductive land area (cracked soils) resulting in infertile soils (DIE3), showed a highly significant correlation (p-values less than 001) with financial indicators of sustainable livelihood in the City of Koronadal, specifically "No income (SLFin1)," as shown in Tables 10 and 11. The lack of irrigation water in Koronadal City affects agricultural productivity and livelihoods. Potable water was also affected, leading to health issues and increased expenses for alternative water sources, further affecting financial stability.

Conversely, the impact of "Unproductive land area (cracked soils) resulting in infertile soils (DIE3)" emphasized how drought affects land productivity, particularly the formation of cracked and infertile soils as a result of extended dry conditions. Infertile soils directly hinder agricultural productivity and reduce crop yields, substantially negatively impacting farmers' income and financial well-being.

Table 10: Correlation matrix between drought environmental impacts and the financial sustainable livelihood indicators in the City of Koronadal

		DEI1	DEI2	DEI3	DEI4	DEI5	DEI6
SLFin1	Spearman's rho	0.343	0.117	0.355	0.279	-0.207	-0.289
	p-value	< .001***	0.247	< .001***	0.005**	0.04*	0.004**
SLFin2	Spearman's rho	0.161	0.094	-0.091	-0.003	-0.133	-0.065
	p-value	0.112	0.353	0.369	0.974	0.189	0.526
SLFin3	Spearman's rho	0.125	0.007	-0.041	0.016	-0.129	-0.046
	p-value	0.217	0.947	0.688	0.877	0.204	0.651
SLFin4	Spearman's rho	0.038	0.224	0.224	0	0.263	0.382
	p-value	0.707	0.026*	0.026*	0.996	0.008**	< .001***
SLFin5	Spearman's rho	0.049	0.027	0.001	0.151	-0.178	-0.137
	p-value	0.631	0.794	0.994	0.137	0.079	0.177
SLFin6	Spearman's rho	0.071	0.274	0.039	0.031	-0.113	-0.145
	p-value	0.482	0.006**	0.704	0.764	0.267	0.154

Note. * p < .05, ** p < .01, *** p < .001

Legend: Environmental impacts: DIE1. No water for irrigation and potable; DIE2. Decrease in the availability of water supply/limited water source; DIE3. Unproductive land area (cracked soils) resulting in infertile soils; DIE4. Incidence of forest/grass fire; DIE5. Damage to irrigation canals; DIE6. Exposure to dust.
Sustainable capital (Financial indicators): SLFin1. No income; SLFin2. Decrease in household income; SLFin3. Decrease in savings; SLFin4. Decreasing purchasing power; SLFin5. Increase/incurred in debts; and SLFin6. Decrease access to credit/loans.

There was a substantial correlation (p <.001) between "exposure to dust (DIE6)" and "decreasing purchasing power (SLFin4)". The term "environmental impact due to exposure to dust" describes the increased presence of dust particles in the environment, most likely due to drought-related conditions that reduce soil moisture and vegetation cover. Decreasing purchasing power suggests a decline in the ability of individuals to buy goods and services due to financial constraints. Exposure to dust might indirectly contribute to this decrease by potentially causing unproductivity and health issues, which lead to reduced disposable income.

Kidapawan City's sustainable livelihood financial indicators, such as "No income (SLFin1)," "Decrease in household income (SLFin2)," "Decreasing purchasing power (SLFin4)," and "Increase/incurred in debts (SLFin5)," were strongly correlated with environmental impact variables, such as "No water for irrigation and potable (DIE1)," "Decrease in the availability of water supply/limited source of water (DIE2)," and "Unproductive land area (cracked soils) resulting in infertile soils (DIE3)."

"No income (SLFin1)" indicates severe financial hardship for households. "Decrease in household income (SLFin2)" indicates a decrease relative to prior periods, indicating economic strain. "Decreasing purchasing power (SLFin4)" suggests that households are less able to buy goods and services because of financial limitations. "Increase/incurred in debts (SLFin5)" indicates an increase in debts or financial obligations, which can further aggravate household financial hardship.

The analysis reveals a significant correlation between environmental impact variables and financial indicators of sustainable livelihood. Water scarcity directly impacts agricultural productivity and household water availability, affecting income generation and financial stability. Decreased water availability affects agricultural output and household water usage, affecting income levels and financial resilience. Unproductive land area results in infertile soils, directly affecting agricultural yields, land utilization, household income, and economic well-being.

Table 11: Correlation matrix between drought environmental impacts and the financial sustainable livelihood indicators in the City of Kidapawan

		DIE1	DIE2	DIE3	DIE4	DIE5	DIE6
SLFin1	Spearman's rho	0.436	0.28	0.424	0.102	-0.069	0.258
	p-value	< .001***	0.007**	< .001***	0.337	0.518	0.014*
SLFin2	Spearman's rho	0.451	0.721	0.463	0.058	0.23	0.072
	p-value	< .001***	< .001***	< .001***	0.582	0.028*	0.495
SLFin3	Spearman's rho	0.206	0.198	0.19	0.003	-0.063	0.126
	p-value	0.05*	0.06	0.072	0.976	0.556	0.234
SLFin4	Spearman's rho	0.587	0.54	0.464	-0.057	0.234	0.196
	p-value	< .001***	< .001***	< .001***	0.593	0.025*	0.062
SLFin5	Spearman's rho	0.341	0.413	0.415	0.157	0.269	0.177
	p-value	< .001***	< .001***	< .001***	0.138	0.01*	0.094
SLFin6	Spearman's rho	0.047	0.149	0.097	0.41	0.411	0.051
	p-value	0.657	0.157	0.362	< .001***	< .001***	0.631

Note. * p < .05, ** p < .01, *** p < .001

Legend: Environmental impacts: DIE1. No water for irrigation and potable; DIE2. Decrease in the availability of water supply/limited water source; DIE3. Unproductive land area (cracked soils) resulting in infertile soils; DIE4. Incidence of forest/grass fire; DIE5. Damage to irrigation canals; DIE6. Exposure to dust.
Sustainable capital (Financial indicators): SLFin1. No income; SLFin2. Decrease in household income; SLFin3. Decrease in savings; SLFin4. Decreasing purchasing power; SLFin5. Increase/incurred in debts; and SLFin6. Decrease access to credit/loans.

As indicated by Table 12, economic impact variables in the City of Koronadal, such as "No harvest due to crop failure (DIEC1)," "No production (DIEC2)," and "Increase in the prices of farm inputs (DIEC7)," demonstrated a strong correlation (p-value of 0.001) with the financial indicator "No Income (SLFin1)". This suggests that crop failure, likely caused by unfavorable weather, pest infestations, or crop disease outbreaks, results in a situation where farmers cannot harvest their crops successfully, impacting their financial status.

However, a lack of or no production also means a lack of income generation, which adds to the financial indicator "No Income

(SLFin1)". Furthermore, the variable "Increase in the prices of farm inputs (DIEC7)" indicated an increase in the necessary inputs needed for agricultural output, including machinery, seeds, fertilizer, and pesticides.

Due to rising input prices, farmers experience more extraordinary production expenses, which lower their profitability. Thus, they might be unable to pay their bills or make enough money, which would add to the financial burden of "No Income (SLFin1)."

Table 12: Correlation matrix between drought economic impacts and the financial sustainable livelihood indicators in the City of Koronadal

		DIEC1	DIEC2	DIEC3	DIEC4	DIEC5	DIEC6	DIEC7	DIEC8
SLFin1	Spearman's rho	0.659	0.641	0.0 6	0.11 9	0.20 3	0.0 82	0.336	0.1 34
	p-value	<.00 1***	<.00 1***	0.5 58	0.24	0.04 4*	0.4 2	<.00 1***	0.1 87
SLFin2	Spearman's rho	0.102	0.127	0.2 54	0.09 7	0.24 2	0.1 36	0.098	-0.1 47
	p-value	0.314	0.211	0.0 11*	0.34	0.01 6*	0.1 79	0.337	0.1 46
SLFin3	Spearman's rho	0.026	0.015	0.0 25	0.24 7	0.18 9	0.0 01	-0.003	0.0 96
	p-value	0.798	0.883	0.8 03	0.01 4*	0.06 1	0.9 91	0.975	0.3 44
SLFin4	Spearman's rho	0.031	-0.03	0.0 92	0.06 9	0.02 6	0.0 66	0.199	0.1 28
	p-value	0.758	0.769	0.3 63	0.5	0.80 1	0.5 15	0.048 *	0.2 06
SLFin5	Spearman's rho	0.199	0.173	0.1 06	0.28 8	0.26	0.1 94	0.154	0.1 18
	p-value	0.048 *	0.087	0.2 97	0.00 4**	0.00 9**	0.0 55*	0.128	0.2 46
SLFin6	Spearman's rho	0.284	0.296	0.1 33	0.17 9	0.24 3	0.0 16	0.021	0.1 27
	p-value	0.004 **	0.003 **	0.1 91	0.07 6	0.01 5*	0.8 78	0.835	0.2 12

Note. * p < .05, ** p < .01, *** p < .001

Legend: Economic impacts: DIEC1. Less harvest due to crop failure; DIEC2. No production; DIEC3. Crop damage resulting in low harvest; DIEC4. Mortality of poultry/livestock; DIEC5. Mortality of planted fruit trees; DIEC6. Decreased working hours due to illness; DIEC7. Increased prices of farm inputs; DIEC8. Dropped market price of farm produce due to decreased quality.
Sustainable capital (Financial indicators): SLFin1. No income; SLFin2. Decrease in household income; SLFin3. Decrease in savings; SLFin4. Decreasing purchasing power; SLFin5. Increase/incurred in debts; and SLFin6. Decrease access to credit/loans.

Table 13 presents several economic impact variables for the City of Kidapawan that were highly correlated (p <.001) with the financial indicator "No income (SLFin1)." These variables include:

- Less harvest due to crop failure (DIEC1): Farmers' income was directly impacted by crop failure since they cannot produce or sell enough crops, resulting in fewer harvests.
- No production (DIEC2): Farmers unable to produce agricultural products cannot earn money, which adds to their lack of revenue.
- Crop damage resulting in low harvest (DIEC3): Crop damage reduces harvest yields, lowering farmers' income, and preventing them from selling as much produce.
- Mortality of planted fruit trees (DIEC5) lowers fruit production, which impacts farmers' revenue from fruit sales.
- Increase in the prices of farm inputs (DIEC7): The rising costs of inputs, including herbicides, fertilizers, and seeds, impact farmers' capacity to make a living.
- Drop in the market price of farm produce due to decreased quality (DIEC8): Reduced quality of farm produce results in lower selling prices, reducing farmers' income.

In addition, several economic impact variables showed relationship with sustainable livelihood financial indicators, such as "decrease in household income (SLFin 2)," "decreasing purchasing power (SLFin 4)," "increase/incurred debts (SLFin 5)," and "decrease in access to credit/loan (SLFin 6)."

Table 13: Correlation matrix between drought economic impacts and the financial sustainable livelihood indicators in the City of Kidapawan

		DIEC1	DIEC2	DIEC3	DIEC4	DIEC5	DIEC6	DIEC7	DIEC8
SLFin1	Spearman's rho	0.73 6	0.73 1	0.70 8	0.3 13	0.36 2	0.0 1	0.5	0.46 6
	p-value	<.00 1***	<.00 1***	<.00 1***	0.0 03*	<.00 1***	0.9 26	<.00 1***	<.00 1***
SLFin2	Spearman's rho	0.36 8	0.34 7	0.49 2	0.0 79	0.35	0.2 85	0.24 1	0.29 1
	p-value	<.00 1***	<.00 1***	<.00 1***	0.4 54	<.00 1***	0.0 06*	0.02 2*	0.00 5**
SLFin3	Spearman's rho	0.15 1	0.12 6	0.25 6	0.0 75	0.18 2	0.2 61	0.11 7	0.24 1
	p-value	0.15 2	0.25 6	0.01 4*	0.4 82	0.08 4	0.0 12*	0.26 9	0.02 1
SLFin4	Spearman's rho	0.53 1	0.53 1	0.50 1	0.2 15	0.34 9	0.1 66	0.37 1	0.48 3
	p-value	<.00 1***	<.00 1***	<.00 1***	0.0 4*	<.00 1***	0.1 16	<.00 1***	<.00 1***
SLFin5	Spearman's rho	0.43 8	0.43 3	0.49 7	0.1 6	0.28 6	0.2 45	0.41 7	0.39 5
	p-value	<.00 1***	<.00 1***	<.00 1***	0.1 29	0.00 6**	0.0 19*	<.00 1***	<.00 1***
SLFin6	Spearman's rho	0.11 5	0.09 5	0.20 4	0.0 8	0.13 3	0.2 44	0.00 2	0.35 3
	p-value	0.27 6	0.36 8	0.05 2	0.4 53	0.20 8	0.0 2*	<.00 3**	<.00 1***

Note. * p < .05, ** p < .01, *** p < .001

Legend: Economic impacts: DIEC1. Less harvest due to crop failure; DIEC2. No production; DIEC3. Crop damage resulting in low harvest; DIEC4. Mortality of poultry/livestock; DIEC5. Mortality of planted fruit trees; DIEC6. Decreased working hours due to illness; DIEC7. Increased prices of farm inputs; DIEC8. Dropped market price of farm produce due to decreased quality. Sustainable capital (Financial indicators): SLFin1. No income; SLFin2. Decrease in household income; SLFin3. Decrease in savings; SLFin4. Decreasing purchasing power; SLFin5. Increase/incurred in debts; and SLFin6. Decrease access to credit/loans.

In the City of Koronadal, among various social impact variables, the "shortage of food (DIS1)" was the only one that demonstrated a very significant connection (with a p-value of 0.001) with the "decrease in household income" (SLFin2), as shown in Table 14. This implies that food shortages are closely associated with a reduction in household income.

Table 14: Correlation matrix between drought social impacts and the financial sustainable livelihood indicators in the City of Koronadal

		DIS1	DIS2	DIS3	DIS4
SLFin1	Spearman's rho	0.107	0.296	0.313	-0.129
	p-value	0.29	0.003**	0.002**	0.202
SLFin2	Spearman's rho	-0.316	-0.078	0.056	0.026
	p-value	0.001***	0.444	0.579	0.795
SLFin3	Spearman's rho	-0.163	-0.043	0.15	0.197
	p-value	0.107	0.675	0.139	0.05*
SLFin4	Spearman's rho	0.169	0.27	0.117	-0.121
	p-value	0.094	0.007**	0.247	0.234
SLFin5	Spearman's rho	0.101	0.053	0.104	0.244
	p-value	0.318	0.599	0.307	0.015*
SLFin6	Spearman's rho	-0.038	-0.027	0.237	0.059
	p-value	0.707	0.794	0.018*	0.565

Note. * p < .05, ** p < .01, *** p < .001

Legend: Social impacts: DIS1. Food shortage; DIS2. Hunger; DIS3. Migration of family members; DIS4. Water use conflict. Sustainable capital (Financial indicators): SLFin1. No income; SLFin2. Decrease in household income; SLFin3. Decrease in savings; SLFin4. Decreasing purchasing power; SLFin5. Increase/incurred in debts; and SLFin6. Decrease access to credit/loans.

Table 15 demonstrates that several social impact variables, including "food shortage (DIS1)," "hunger (DIS2), "family member migration (DIS3)," and "water use conflicts (DIS4)," have a strong correlation with financial indicators, such as SLFin2 (a decline in household income), SLFin4 (a decline in purchasing power), SLFin5 (an increase in debt), and SLFin6 (a decrease in credit or loan availability).

Food insecurity and hunger were prevalent in communities due to various factors. Households often experienced financial strain due to decreased income, limiting their ability to afford food and leading to hunger. Family members' migration for better economic opportunities can also impact household income, increasing debts. Conflict over water usage can disrupt agricultural activities and livelihoods, especially in areas dependent on irrigation. Water scarcity or disputes over access can lead to decreased agricultural productivity and income, reducing household income (SLFin2).

Table 15: Correlation matrix between drought social impacts and the financial sustainable livelihood indicators in the City of Kidapawan

		DIS1	DIS2	DIS3	DIS4
SLFin1	Spearman's rho	0.364	0.337	0.1	0.17
	p-value	< .001***	0.001	0.345	0.107
SLFin2	Spearman's rho	0.356	0.439	0.342	0.351
	p-value	< .001***	< .001***	< .001***	< .001***
SLFin3	Spearman's rho	0.04	0.028	0.029	0.012
	p-value	0.704	0.789	0.782	0.908
SLFin4	Spearman's rho	0.378	0.555	0.515	0.559
	p-value	< .001***	< .001***	< .001***	< .001***
SLFin5	Spearman's rho	0.382	0.522	0.453	0.475
	p-value	< .001***	< .001***	< .001***	< .00***1
SLFin6	Spearman's rho	0.329	0.326	0.448	0.454
	p-value	0.001**	0.002**	< .001***	< .001***

Note. * p < .05, ** p < .01, *** p < .001

Legend: Social impacts: DIS1. Food shortage; DIS2. Hunger; DIS3. Migration of family members; DIS4. Water use conflict. Sustainable capital (Financial indicators): SLFin1. No income; SLFin2. Decrease in household income; SLFin3. Decrease in savings; SLFin4. Decreasing purchasing power; SLFin5. Increase/incurred in debts; and SLFin6. Decrease access to credit/loans.

Drought impacts variables and the sustainable livelihood natural indicators.

Among the environmental impact variables examined in the City of Koronadal, "unproductive land (DIE3)" was the sole variable that exhibited a significant correlation (p < .001) with the natural indicator of sustainable livelihood, which is the "decline in water quality (SLNat1)" as reflected in Table 16. Unproductive land due to cracked soil was strongly associated with deteriorating water quality.

Table 16: Correlation matrix between drought environmental impacts and the natural sustainable livelihood indicators in the City of Koronadal

		DEI1	DEI2	DEI3	DEI 4	DEI5	DEI6
SLNat 1	Spearman's rho	0.283	0.135	0.379	0.26 9	0.03	0.024
	p-value	0.004**	0.182	< .001**	0.00 7	0.766	0.817
SLNat 2	Spearman's rho	-0.132	0.23	0.281	-0.06 9	-0.069	-0.09
	p-value	0.192	0.022 *	0.005**	0.49 4	0.497	0.374
SLNat 3	Spearman's rho	0.072	0.187	-0.006	0.16	-0.263	-0.25
	p-value	0.476	0.064	0.952	0.11 4	0.008**	0.013 *
SLNat 4	Spearman's rho	0.053	-0.056	0.226	-0.00 3	0.14	0.129
	p-value	0.606	0.58	0.025*	0.97 5	0.168	0.202
SLNat 5	Spearman's rho	0.056	0.069	0.222	-0.10 5	-0.249	-0.055
	p-value	0.584	0.499	0.027*	0.30 3	0.013*	0.587

Note. * p < .05, ** p < .01, *** p < .001

Legend: Environmental impacts: DIE1. No water for irrigation and potable; DIE2. Decrease in the availability of water supply/limited water source; DIE3. Unproductive land area (cracked soils without infertile soils); DIE4. Incidence of forest/grass fire; DIE5. Damage to irrigation canals; DIE6. Exposure to dust. Sustainable capital (Financial indicators): SLNat1. Deteriorating water quality; SLNat2. Increase occurrence of pest; SLNat3—infestation of diseases; SLNat4. Decrease pasture lands for livestock; SLNat5. Decrease cultivated lands

In the City of Kidapawan, 15 environmental impact variables were significantly associated with natural indicators of sustainable livelihood, with p < .001, as depicted in Table 17.

These associations include:
"No water for irrigation and potable (DIE1)" was correlated with:

1. "Deteriorating water quality (SLNat1)"
2. "Increased occurrence of pests (SLNat2)"
3. "Infestation of diseases (SLNat3)"
4. "Decreased pasture lands for livestock (SLNat4)"

"Decrease in the availability of water supply/limited source of water (DIE2)" correlated with:

1. "Deteriorating water quality (SLNat1)"
2. "Increased occurrence of pests (SLNat2)"
3. "Infestation of diseases (SLNat3)"
4. "Decreased pasture lands for livestock (SLNat4)"

"Unproductive land area (cracked soils) resulting in infertile soils (DIE3)" was associated with:

1. "Deteriorating water quality (SLNat1)"
2. "Increased occurrence of pests (SLNat2)"
3. "Infestation of diseases (SLNat3)"
4. "Decreased pasture lands for livestock (SLNat4)"
5. "Decrease in cultivated lands (SLNat5)"

"Damage to irrigation canals (DIE5)" was correlated with:

1. "Increased occurrence of pests (SLNat2)".
2. "Infestation of diseases (SLNat3)".

These findings highlight the relationship between various environmental factors and natural indicators of sustainable livelihood in the City of Kidapawan. Issues such as water scarcity, land degradation, and damage to irrigation infrastructure have cascading effects on water quality, pest and disease occurrences, and the availability of resources for livestock and agriculture.

Table 17: Correlation matrix between drought environmental impacts and the natural sustainable livelihood indicators in the City of Kidapawan

		DIE1	DIE2	DIE3	DIE 4	DIE5	DIE6
SLNa t1	Spearman's rho	0.758	0.51	0.495	0.14 5	0.099	-0.24
	p-value	< .001* **	< .001* **	< .001* **	0.17 2	0.351	0.022 *
SLNa t2	Spearman's rho	0.483	0.404	0.554	-0.07 2	0.355	-0.307
	p-value	< .001* **	< .001* **	< .001* **	0.49 7	< .001* **	0.003 **
SLNa t3	Spearman's rho	0.494	0.437	0.554	0.11 4	0.434	-0.187
	p-value	< .001* **	< .001* **	< .001* **	0.28 3	< .001* **	0.075
SLNa t4	Spearman's rho	0.399	0.343	0.54	0.18 1	0.119	-0.046
	p-value	< .001* **	< .001* **	< .001* **	0.08 6	0.26	0.667
SLNa t5	Spearman's rho	0.316	0.298	0.498	0.24 4	0.079	0.01
	p-value	0.002**	0.004**	< .001* **	0.02 *	0.457	0.923

Note. * p < .05, ** p < .01, *** p < .001

Legend: Environmental impacts: DIE1. No water for irrigation and potable; DIE2. Decrease in the availability of water supply/limited water source; DIE3. Unproductive

land area (cracked soils) resulting in infertile soils; DIE4. Incidence of forest/grass fire; DIE5. Damage to irrigation canals; DIE6. Exposure to dust.
Sustainable capital (Financial indicators): SLNat1. Deteriorating water quality; SLNat2. Increase occurrence of pest; SLNat3—infestation of diseases; SLNat4. Decrease pasture lands for livestock; SLNat5. Decrease cultivated lands

In Table 18, the economic impact variables showing a robust correlation (p-value of 0.001) with natural capital include "Less harvest due to crop failure (DIEC1)," "No production (DIEC2)," and "Increase in the prices of farm inputs (DIEC7)," which were associated with "Deteriorating water quality (SLNat1)." Increasing farm input prices may lead to unsustainable agricultural practices, potentially causing pollution and affecting water quality. Farmers may use more agrochemicals, such as fertilizers and pesticides, to improve crop health and yield when crops fail or produce lower yields. Excessive use of these chemicals can lead to runoff into nearby water sources, contributing to water pollution and declining water quality.

The rising input costs may lead farmers to seek cost-effective solutions, which sometimes involve using cheaper but environmentally harmful practices or products. For example, opting for cheaper fertilizers or pesticides that contain more pollutants can worsen water quality when they enter water bodies through runoff or leaching. This suggests that economic factors such as crop failure, reduced production, and increased input costs are associated with declining water quality, indicating potential environmental challenges.

Table 18: Correlation matrix between drought economic impacts and the natural sustainable livelihood Indicators in the City of Koronadal

		DIEC1	DIEC2	DIEC3	DIEC4	DIEC5	DIEC6	DIEC7	DIEC8
SLNat1	Spearman's rho	0.395	0.401	0.123	0.280	0.287	0.076	0.399	0.233
	p-value	<.01**	<.01**	0.234	0.008**	0.007**	0.455	<.001***	0.027*
SLNat2	Spearman's rho	-0.068	-0.084		0.283	0.253	0.061	0.057	-0.238
	p-value	0.504	0.414	<.01**	0.008**	0.016*	0.547	0.575	0.018*
SLNat3	Spearman's rho	0.227	0.199	0.036	0.446	0.372	0.141	0.084	-0.219
	p-value	0.029*	0.049*	0.726	<.01**	<.01**	0.165	0.406	0.030*
SLNat4	Spearman's rho	0.068	0.036	0.007	0.333	0.243	0.069	0.198	0.089
	p-value	0.504	0.704	0.946	<.01**	0.013*	0.495	0.049*	0.381
SLNat5	Spearman's rho			0.104	0.333	0.350	0.072	0.201	-0.021
	p-value	0.003**	0.002**	0.283	<.01**	<.01**	0.479	0.046*	0.833

Note. * p < .05, ** p < .01, *** p < .001

Legend: Economic impacts: DIEC1. Less harvest due to crop failure; DIEC2. No production; DIEC3. Crop damage resulting in low harvest; DIEC4. Mortality of poultry/livestock; DIEC5. Mortality of planted fruit trees; DIEC6. Decreased working hours due to illness; DIEC7. Increased prices of farm inputs; DIEC8. Dropped market price of farm produce due to decreased quality.
Sustainable capital (Financial indicators): SLNat1. Deteriorating water quality; SLNat2. Increase occurrence of pest; SLNat3—infestation of diseases; SLNat4. Decrease pasture lands for livestock; SLNat5. Decrease cultivated lands

Additionally, "Crop damage resulting in low harvest (DIEC3)" strongly correlated with "Increased occurrence of pests (SLNat2)." Crop damage often occurs due to pest infestations, which can reduce the overall harvest. In the same manner, farmers linked drought with an increase in the occurrence of pests, which creates a more favorable environment for pests to thrive. The connection between crop damage and pest occurrence highlights the impact of changing environmental conditions on agricultural productivity and economic stability.

"Mortality of planted fruit trees (DIEC5)" was also significantly correlated with "Infestation of diseases (SLNat3)." This highlights the vulnerability of fruit tree cultivation to disease infestations, which can have adverse economic implications by reducing fruit yields and income for farmers.

"Mortality of poultry/livestock (DIEC4)" was associated with "Decrease in pasture lands for livestock (SLNat4)," and "Mortality of planted fruit trees (DIEC5)" was linked with "Decrease in cultivated lands (SLNat4)." These associations suggest that livestock and fruit trees' mortality correlate with diminishing pasture and cultivated lands, indicating potential environmental pressures affecting agricultural practices and livelihoods in Koronadal City.

In the City of Kidapawan (Table 19), numerous economic impact variables strongly correlate ($p < .001$) with natural indicators. For example, "Less harvest due to crop failure (DIEC1)," "No production (DIEC2)," "Crop damage resulting in low harvest (DIEC3)," "Mortality of poultry/livestock (DIEC4)," "Mortality of planted fruit trees (DIEC5)," "Increase in the prices of farm inputs (DIEC7)," and "Drop in market price of farm produce due to decreased quality (DIEC8)" were associated with "Deteriorating water quality (SLNat1)". This suggests that economic factors influence the environmental health of water resources in the region.

Table 19: Correlation matrix between drought economic impacts and the natural sustainable livelihood indicators in the City of Kidapawan

		DIEC1	DIEC2	DIEC3	DIEC4	DIEC5	DIEC6	DIEC7	DIEC8
SLNat1	Spearman's rho	0.52	0.52	0.56	0.38	0.36		0.39	0.35
	p-value	<.01**	<.01**	<.01**	<.01**	<.01**	0.215	<.01**	<.01**
SLNat2	Spearman's rho	0.36	0.34	0.38	0.15	0.38		0.42	0.20
	p-value	<.01**	<.01**	<.01**	0.147	<.01**	0.15	<.01**	0.047*
SLNat3	Spearman's rho	0.32	0.30	0.33	0.21	0.39	0.106	0.39	0.20
	p-value	0.002**	0.003**	<.001***	0.037*	<.01**	0.318	<.01**	0.051
SLNat4	Spearman's rho	0.42	0.40	0.41	0.45	0.47		0.34	0.39
	p-value	<.01**	<.01**	<.01**	<.01**	<.01**	0.106	<.01**	<.01**
SLNat5	Spearman's rho	0.34	0.32	0.36	0.42	0.36		0.34	0.22
	p-value	0.001**	0.002**	0.001**	<.01**	0.001**	0.034	<.01**	0.027*

Note. * p < .05, ** p < .01, *** p < .001

Legend: Economic impacts: DIEC1. Less harvest due to crop failure; DIEC2. No production; DIEC3. Crop damage resulting in low harvest; DIEC4. Mortality of poultry/livestock; DIEC5. Mortality of planted fruit trees; DIEC6. Decreased working hours due to illness; DIEC7. Increased prices of farm inputs; DIEC8. Dropped market price of farm produce due to decreased quality.
Sustainable capital (Financial indicators): SLNat1. Deteriorating water quality; SLNat2. Increase occurrence of pest; SLNat3—infestation of diseases; SLNat4. Decrease pasture lands for livestock; SLNat5. Decrease cultivated lands

Also, the social impact variable "Hunger (DIS2)" demonstrated a significant association ($p < .001$) with the natural indicator "Increased occurrence of pests (SLNat2) as seen in Table 18." This implies that the prevalence of pests in crops correlates with a heightened occurrence of hunger, indicating potential challenges in food security and agricultural productivity. This finding suggests that the increase in pest occurrence is likely to cause or exacerbate food insecurity and hunger within the community, and as pests damage crops, leading to reduced food

availability and access, which in turn contributes to increased hunger.

Table 20: Correlation matrix between drought social impacts and the natural sustainable livelihood indicators in the City of Koronadal

		DIS1	DIS2	DIS3	DIS4
SLNat1	Spearman's rho	0.117	0.193	0.185	-0.009
	p-value	0.248	0.055*	0.066	0.931
SLNat2	Spearman's rho	0.168	0.355	0.088	-0.1
	p-value	0.097	< .001***	0.388	0.327
SLNat3	Spearman's rho	-0.145	-0.075	0.205	0.271
	p-value	0.151	0.458	0.042*	0.007**
SLNat4	Spearman's rho	0.014	-0.035	-0.081	0.001
	p-value	0.892	0.734	0.426	0.995
SLNat5	Spearman's rho	-0.02	-0.072	0.066	0.033
	p-value	0.846	0.48	0.514	0.744

Note. * p < .05, ** p < .01, *** p < .001

Legend: Social impacts: DIS1. Food shortage; DIS2. Hunger; DIS3. Migration of family members; DIS4. Water use conflict
Sustainable capital (Financial indicators): SLNat1. Deteriorating water quality; SLNat2. Increase occurrence of pest; SLNat3—infestation of diseases; SLNat4. Decrease pasture lands for livestock; SLNat5. Decrease cultivated lands

As shown in Table 20, there was a strong correlation between social impact variables such as "Hunger (DIS2)," "Migration of family members (DIS3)," and "Water use conflict (DIS4)" with the natural indicator "Deteriorating water quality (SLNat1)". Food insecurity and hunger can lead to unsustainable agricultural practices, such as the overuse of fertilizers and pesticides, which can contribute to water pollution. Conflicts over water usage often arise from competing demands for limited water resources, such as between agriculture, industry, and domestic needs. These conflicts can result in unsustainable water management practices, over-extraction of water, and pollution due to improper waste disposal or runoff, ultimately leading to a decline in water quality.

Additionally, “Hunger (DIS2),” "and "Water use conflict (DIS4)" were associated with "Increased occurrence of pests (SLNat2)," This suggests that factors related to food insecurity, population movement, and conflicts over water usage were closely linked to the heightened presence of pests within the city. Addressing these social challenges may be crucial in managing pest infestations and promoting sustainable agricultural practices. Furthermore, “Hunger (DIS2)" and "Water use conflict (DIS4)" were associated with "Infestation of diseases to crops (SLNat3),"

In agriculture, malnourished plants are more susceptible to diseases and pest infestations, reducing crop yields and lowering agricultural productivity. When a significant portion of crops is affected by diseases or pests, overall agricultural output declines, impacting food availability and economic livelihoods and leading to hunger among farmers.

Farmers facing food shortages may also lack the resources to invest in disease-resistant crop varieties or proper agricultural practices, increasing the risk of crop diseases. “Food shortage (DIS1)” and “Hunger (DIS2)” were strongly associated with “Decreased pasture lands for livestock (SLNat4)”.

Table 21: Correlation matrix between drought social impacts and the natural sustainable livelihood indicators in the City of Kidapawan

		DIS1	DIS2	DIS3	DIS4
SLNat1	Spearman's rho	0.308	0.614	0.334	0.435
	p-value	0.003**	< .001***	0.001**	< .001***
SLNat2	Spearman's rho	0.259	0.448	0.237	0.467
	p-value	0.013*	< .001***	0.023*	< .001***
SLNat3	Spearman's rho	0.251	0.492	0.288	0.488
	p-value	0.016*	< .001***	0.006**	< .001***
SLNat4	Spearman's rho	0.362	0.357	0.221	0.163
	p-value	< .001***	< .001***	0.036*	0.122
SLNat5	Spearman's rho	0.358	0.211	0.101	-0.009
	p-value	< .001***	0.045*	0.343	0.93

Note. * p < .05, ** p < .01, *** p < .001

Legend: Social impacts: DIS1. Food shortage; DIS2. Hunger; DIS3. Migration of family members; DIS4. Water use conflict
Sustainable capital (Financial indicators): SLNat1. Deteriorating water quality; SLNat2. Increase occurrence of pest; SLNat3—infestation of diseases; SLNat4. Decrease pasture lands for livestock; SLNat5. Decrease cultivated lands

Drought impacts variables and the sustainable livelihood physical indicators.

There was no statistically significant correlation at ($p < .001$) in Koronadal City, except at $p < .05$, which was exclusively between the "unproductive land area characterized by cracked soil resulting in infertile soils (DIE3)" and "damage to irrigation canals (DIE5)" and the sustainable livelihood indicator, which is "high demand for energy (SLPhy1)" during drought periods as observed in Table 22 and cracked soil and canal damage due to drought lead to reduced crop productivity.

Consequently, farmers may turn to energy-intensive irrigation methods, such as water pumps and advanced technologies, to compensate for the lack of natural water availability.

Table 22: Correlation matrix between drought environmental impacts and the physical sustainable livelihood indicators in the City of Koronadal

		DEI1	DEI2	DEI3	DEI4	DEI5	DEI6
SLPhy1	Spearman's rho	0.132	0.105	-0.161	-0.092	0.034	0.035
	p-value	0.194	0.299	0.112	0.367	0.737	0.732
SLPhy2	Spearman's rho	0.082	0.12	-0.149	0.024	-0.023	0.029
	p-value	0.42	0.236	0.142	0.816	0.818	0.778
SLPhy3	Spearman's rho	0.097	0.127	-0.195	-0.142	-0.214	-0.103
	p-value	0.342	0.21	0.053*	0.161	0.033*	0.31

Note. * p < .05, ** p < .01, *** p < .001

Legend: Environmental impacts: DIE1. No water for irrigation and potable; DIE2. Decrease in the availability of water supply/limited water source; DIE3. Unproductive land area (cracked soils) resulting in infertile soils; DIE4. Incidence of forest/grass fire; DIE5. Damage to irrigation canals; DIE6. Exposure to dust.
Sustainable capital (Physical indicators): SLPhy1. High demands for water pumps; SLPhy2. Broken water pumps/water sources; SLPhy3. High demand for energy

Environmental impact variables such as "Damage to irrigation canals (DIE5)" were significantly associated ($p < .001$) with the high demand for water pumps (SLPhy1) and broken water pumps/water sources (SLPhy2), as reflected in Table 22. Damage to irrigation canals can disrupt water flow to agricultural fields, leading to a higher demand for water pumps to compensate for the loss of irrigation water.

Additionally, broken water pumps or water sources further exacerbate the situation, as farmers may rely more heavily on functioning water pumps to meet their irrigation needs.

"Unproductive land area (cracked soils) resulting in infertile soils (DIE3)" and exposure to dust (DIE6) were associated with high energy demand (SLPhy3). Unproductive land areas with cracked soil typically require additional energy-intensive interventions, such as irrigation or mechanized farming practices, to make them suitable for cultivation.

Exposure to dust, which often occurs during drought, can hinder agricultural operations and necessitate increased energy usage for soil conservation measures or dust mitigation.

Table 23. Correlation matrix between drought environmental impacts and the physical sustainable livelihood indicators in the City of Kidapawan

		DIE1	DIE2	DIE3	DIE4	DIE5	DIE6
SLPhy1	Spearman's rho	0.156	0.259	0.172	0.21	0.427	0.295
	p-value	0.14	0.013 *	0.103	0.04* 6	< .001* **	0.005* *
SLPhy2	Spearman's rho	0.178	0.224	0.188	0.271	0.403	0.171
	p-value	0.092	0.033 *	0.075	0.009 **	< .001* **	0.105
SLPhy3	Spearman's rho	0.313	0.328	0.376	0.288	0.119	0.373
	p-value	0.002 **	0.002 **	< .001* **	0.006 **	0.263	< .001* **

Note. * p < .05, ** p < .01, *** p < .001

Legend: Environmental impacts: DIE1. No water for irrigation and potable; DIE2. Decrease in the availability of water supply/limited water source; DIE3. Unproductive land area (cracked soils) resulting in infertile soils; DIE4. Incidence of forest/grass fire; DIE5. Damage to irrigation canals; DIE6. Exposure to dust.
Sustainable capital (Physical indicators): SLPhy1. High demands for water pumps; SLPhy2. Broken water pumps/water sources; SLPhy3. High demand for energy

There was no statistically significant correlation at ($p < .001$) between the economic impact variables and the sustainable physical livelihood indicator, except for a few variables at $p < .05$ (Table 24). These variables include "Mortality of poultry/livestock (DIEC4)" and its association with the high demand for water pumps (SLPhy1) and high energy demand (SLPhy3). This implies that poultry or livestock mortality may increase reliance on water pumps and higher energy consumption, potentially for activities like refrigeration or alternative livestock care methods.

"Mortality of poultry/livestock (DIEC4)," "Mortality of planted fruit trees (DIEC5)," and "Decreased working hours due to illness (DIEC6)" were associated with high energy demand (SLPhy3). This suggests that factors related to livestock and agricultural productivity and health-related issues affecting labor availability may contribute to increased energy usage within the community.

These findings highlight the complex interaction between economic activities, agricultural practices, and energy demands, emphasizing the need for holistic approaches to address sustainability challenges in Koronadal City.

Table 24: Correlation matrix between drought economic impacts and the physical sustainable livelihood indicators in the City of Koronadal

		DIEC1	DIEC2	DIEC3	DIEC4	DIEC5	DIEC6	DIEC7	DIEC8
SLPhy1	Spearman's rho	- 0.17 2	- 0.16 8	- 0.05 7	0.21 6	- 0.04 9	- 0.02 3	0.01 6	0.00 2
	p-value	0.08 8	0.09 6	0.57 8	0.03 2*	0.63	0.81 8	0.87 3	0.98 8
SLPhy2	Spearman's rho	0.08 4	0.11 7	0.11 5	0.02 7	0.13 9	- 0.07 6	0.17 4	0.09 4
	p-value	0.40 7	0.24 8	0.25 6	0.79	0.17 1	0.45 5	0.08 5	0.35 3
SLPhy3	Spearman's rho	- 0.02 3	- 0.03 6	- 0.01 2	0.27 2	0.19 9	0.27 3	0.13 4	- 0.15 5
	p-value	0.82 4	0.72 3	0.90 7	0.00 6**	0.04 9*	0.00 6**	0.18 5	0.12 6

Note. * p < .05, ** p < .01, *** p < .001

Legend: Economic impacts: DIEC1. Less harvest due to crop failure; DIEC2. No production; DIEC3. Crop damage resulting in low harvest; DIEC4. Mortality of poultry/livestock; DIEC5. Mortality of planted fruit trees; DIEC6. Decreased working hours due to illness; DIEC7. Increased prices of farm inputs; DIEC8. Dropped market price of farm produce due to decreased quality.
Sustainable capital (Physical indicators): SLPhy1. High demands for water pumps; SLPhy2. Broken water pumps/water sources; SLPhy3. High demand for energy

In Kidapawan City, similar to Koronadal City, there was no statistically significant correlation at ($p < .001$) between the economic impact variables and the sustainable physical livelihood indicator with high energy demand (SLPhy3), except for a few variables at $p < .05$ (Table 25). Economic impact variables associated with this include "less harvest due to crop failure (DIEC1)," "Crop damage resulting in low harvest (DIEC3)," "Mortality of poultry/livestock (DIEC4)," "Mortality of planted fruit trees (DIEC5)," "Increase the prices of farm inputs (DIEC7)," and "Drop market price of farm produce due to decreased quality (DIEC8)."

Economic factors such as crop failure, livestock mortality, and market price fluctuations may contribute to variations in energy usage and other variables related to agricultural practices, technology adoption, and energy infrastructure, like water pumps, significantly determining overall agricultural productivity. Thus, the absence of a water pump, for example, during drought, may lead to crop failure or damage.

Table 25: Correlation matrix between drought economic impacts and the physical sustainable livelihood indicators in the City of Kidapawan

		DIEC1	DIEC2	DIEC3	DIEC4	DIEC5	DIEC6	DIEC7	DIEC8
SLPhy1	Spearman's rho	- 0.09 1	- 0.10 6	0.01 4	0.16 3	0.10 5	0.11 7	0.16 6	- 0.07 2
	p-value	0.38 9	0.31 7	0.89 9	0.12 2	0.32 1	0.26 9	0.11 5	0.49 8
SLPhy2	Spearman's rho	0.06 6	0.04 3	0.13 9	0.04 2	0.07 2	0.04 7	0.19 8	0.04
	p-value	0.53 4	0.68 8	0.18 8	0.69 1	0.49 6	0.66 1	0.06	0.70 7
SLPhy3	Spearman's rho	0.22 4	0.19 8	0.26 3	0.21 7	0.29 7	0.09 4	0.31 1	0.32 6
	p-value	0.03 3*	0.06	0.01 2*	0.03 9*	0.00 4**	0.37 4	0.00 3**	0.00 2**

Note. * p < .05, ** p < .01, *** p < .001

Legend: Economic impacts: DIEC1. Less harvest due to crop failure; DIEC2. No production; DIEC3. Crop damage resulting in low harvest; DIEC4. Mortality of poultry/livestock; DIEC5. Mortality of planted fruit trees; DIEC6. Decreased working hours due to illness; DIEC7. Increased prices of farm inputs; DIEC8. Dropped market price of farm produce due to decreased quality.
Sustainable capital (Physical indicators): SLPhy1. High demands for water pumps; SLPhy2. Broken water pumps/water sources; SLPhy3. High demand for energy

Social impact variables strongly associated with the physical indicators (Table 26) in the City of Koronadal include "Food shortage (DIS1)" and "Hunger (DIS2)," which were correlated with high energy demand like electricity (SLPhy3). Food shortages and hunger can induce social and economic stress within communities, leading to increased energy usage for coping mechanisms such as extended lighting, heating, or cooling in households.

Table 26: Correlation matrix between drought social impacts and the physical sustainable livelihood indicators in the City of Koronadal

		DIS1	DIS2	DIS3	DIS4
SLPhy1	Spearman's rho	-0.246	-0.222	-0.155	0.078
	p-value	0.014*	0.027*	0.127	0.442
SLPhy2	Spearman's rho	-0.108	-0.066	0.185	0.111
	p-value	0.288	0.518	0.066	0.274
SLPhy3	Spearman's rho	-0.358	-0.386	-0.017	0.231
	p-value	< .001***	< .001***	0.866	0.022*

Note. * p < .05, ** p < .01, *** p < .001

Legend: Social impacts: DIS1. Food shortage; DIS2. Hunger; DIS3. Migration of family members; DIS4. Water use conflict
Sustainable capital (Physical indicators): SLPhy1. High demands for water pumps; SLPhy2. Broken water pumps/water sources; SLPhy3. High demand for energy

The findings revealed that in Kidapawan City, most social impact variables were not strongly correlated with physical indicators of sustainable livelihood (Table 27). However, "Hunger (DIS2)" and "Migration of family members (DIS3)" stand out as exceptions, showing associations with both "High demands for water pumps (SLPhy1)" and high energy demand (SLPhy3). This implies that hunger and migration patterns may directly or indirectly influence the community's water resources and energy consumption needs.

Table 27: Correlation matrix between drought social impacts and the physical sustainable livelihood indicators in the City of Kidapawan

		DIS1	DIS2	DIS3	DIS4
SLPhy1	Spearman's rho	0.014	0.221	0.279	0.193
	p-value	0.893	0.035*	0.007**	0.067
SLPhy2	Spearman's rho	0.102	0.124	0.143	0.188
	p-value	0.336	0.243	0.175	0.074
SLPhy3	Spearman's rho	0.268	0.246	0.276	0.153
	p-value	0.01*	0.019*	0.008**	0.148

Note. * p < .05, ** p < .01, *** p < .001

Legend: Social impacts: DIS1. Food shortage; DIS2. Hunger; DIS3. Migration of family members; DIS4. Water use conflict
Sustainable capital (Physical indicators): SLPhy1. High demands for water pumps; SLPhy2. Broken water pumps/water sources; SLPhy3. High demand for energy

Drought Impacts Variables and the Sustainable Livelihood Human Indicators

In Koronadal City, environmental impact variables that show statistically significant correlations ($p < .001$) with human capital indicators include "Unproductive land area (cracked soils) resulting in infertile soils (DIE3)" with "Farm planning disruption (SLHum1)" as shown in Table 28. Farm planning disruption (SLHum1) will likely occur when farmers face challenges cultivating unproductive land. This can hinder effective crop planning and management, ultimately impacting human capital development.

The "No water for irrigation and potable (DIE1)" and "Incidence of forest/grass fire (DIE4)" were strongly associated with "Disruption of children's schooling (SLHum3)". Without water for irrigation and potable use (DIE1), agricultural activities can be disrupted, leading to economic hardship for farming families. This, in turn, can affect children's schooling (SLHum3) as families may prioritize agricultural labor over education during water scarcity. Forest/grass fires (DIE4) pose environmental hazards, potentially affecting the safety and accessibility of schools. These incidents directly contribute to disrupting children's schooling (SLHum3).

"Unproductive land area (cracked soil) resulting in infertile soils (DIE3)" was linked with "Gender imbalances/shift in production/reproduction and community roles (SLHum4)." Gender imbalances/shifts in production/reproduction and community roles (SLHum4) may arise due to disparities in land productivity. When land becomes unproductive due to cracked soils (DIE3), it can impact traditional gender roles within farming households, potentially leading to shifts in responsibilities and community dynamics.

Table 28: Correlation matrix between drought environmental impacts and the human sustainable livelihood indicators in the City of Koronadal

		DEI1	DEI2	DEI3	DEI4	DEI5	DEI6
SLHum1	Spearman's rho	0.186	0.073	0.363	0.07	0.154	0.236
	p-value	0.065	0.475	<.001**	0.488	0.129	0.019*
SLHum2	Spearman's rho	0.193	-0.043	0.308	0.25	-0.036	-0.096
	p-value	0.056*	0.672	0.002**	0.013*	0.722	0.345
SLHum3	Spearman's rho	0.57	-0.003	0.079	0.402	0.078	0.021
	p-value	<.001**	0.975	0.435	<.001**	0.442	0.834
SLHum4	Spearman's rho	0.098	-0.106	0.446	0.004	0.123	0.24
	p-value	0.334	0.295	<.001**	0.967	0.225	0.017*

Note. * p < .05, ** p < .01, *** p < .001

Legend: Environmental impacts: DIE1. No water for irrigation and potable; DIE2. Decrease in the availability of water supply/limited water source; DIE3. Unproductive land area (cracked soils) resulting in infertile soils; DIE4. Incidence of forest/grass fire; DIE5. Damage to irrigation canals; DIE6. Exposure to dust.
Sustainable capital (Human indicators): SLHum1. Farm planning disruption; SLHum2. Increase the incidence of health illnesses; SLHum3. Disruption of children's schooling; SLHum4. Gender imbalances/shift in production/reproduction, and community roles

In Kidapawan City, several environmental impact variables exhibit significant associations ($p < .001$) with human capital indicators (Table 29). For instance, "Decrease in the availability of water supply/limited source of water (DIE2)" and "Unproductive land area (cracked soils) resulting in infertile soils (DIE3)" correlated with "Farm planning disruption (SLHum1)." The decrease in water supply and the presence of unproductive land due to cracked soil can disrupt farm planning activities. Water scarcity affects agricultural productivity, while unproductive land limits the potential for cultivation, hindering effective farm planning.

Factors such as "No water for irrigation and potable (DIE1)," "Decrease in the availability of water supply/limited source of water (DIE2)," and "Damage to irrigation canals (DIE5)" were linked with "Increase in the incidence of health illnesses (SLHum2)." The absence of water for irrigation and potable use, decreased water availability, and damage to irrigation canals increase the incidence of health illnesses. Limited access to clean water for drinking and sanitation, as well as disruptions in irrigation systems, can lead to health hazards and higher illness rates among community members.

The occurrence of forest/grass fires (DIE4) and damage to irrigation canals (DIE5) were associated with the disruption of children's schooling (SLHum3) and "Gender imbalances/shift in production/reproduction and community roles (SLHum4)." Forest/grass fires and damage to irrigation canals disrupt children's schooling by affecting the safety and accessibility of educational facilities.

These environmental incidents can lead to temporary closures or evacuations of schools, disrupting students' learning and educational progress. Environmental challenges such as forest/grass fires and damage to irrigation canals can exacerbate gender imbalances and shift community roles. For example, women may take on additional responsibilities in coping with environmental crises, leading to shifts in traditional gender roles. This can affect gender equality, reproductive health, and community dynamics.

Table 29: Correlation matrix between drought environmental impacts and the human sustainable livelihood indicators in the City of Kidapawan

		DIE1	DIE2	DIE3	DIE4	DIE5	DIE6
SLHum1	Spearman's rho	0.319	0.41	0.422	0.151	0.227	-0.122
	p-value	0.002**	<.001**	<.001**	0.154	0.031*	0.251
SLHum2	Spearman's rho	0.355	0.356	0.283	0.03	0.34	0.048

		< .001*	< .001*	0.007*		< .001*	
	p-value	**	**	*	0.777	**	0.655
SLHu	Spearm						
m3	an's rho	0.152	0.275	0.131	0.38	0.59	0.097
			0.008*		< .001*	< .001*	
	p-value	0.15	*	0.218	**	**	0.359
SLHu	Spearm						
m4	an's rho	0.097	0.197	0.071	0.432	0.533	0.327
					< .001*	< .001*	0.002
	p-value	0.36	0.062	0.505	**	**	**

Note. * p < .05, ** p < .01, *** p < .001

Legend: Environmental impacts: DIE1. No water for irrigation and potable; DIE2. Decrease in the availability of water supply/limited water source; DIE3. Unproductive land area (cracked soils) resulting in infertile soils; DIE4. Incidence of forest/grass fire; DIE5. Damage to irrigation canals; DIE6. Exposure to dust.
Sustainable capital (Human indicators): SLHum1. Farm planning disruption; SLHum2. Increase the incidence of health illnesses; SLHum3. Disruption of children's schooling; SLHum4. Gender imbalances/shift in production/reproduction, and community roles

In the City of Koronadal, nine economic impact variables showed strong associations ($p < .001$) with sustainable livelihood indicators, particularly human indicators (Table 30). These variables included "less harvest due to crop failure (DIEC1)," "no production (DIEC2)," and "increase in the prices of farm inputs (DIEC7)," which were linked with farm planning disruption (SLHum1) and an increase in the incidence of health illnesses (SLHum2). These economic impact variables directly affect agricultural productivity and profitability. Crop failures and production losses disrupt farmers' income sources and livelihoods while increasing input costs strain their financial resources. These challenges lead to farm planning disruption (SLHum1) as farmers struggle to plan and manage their agricultural activities effectively. Reduced agricultural productivity due to crop failure or production losses may lead to food insecurity and malnutrition, increasing susceptibility to health issues.

Also, "less harvest due to crop failure (DIEC1)," "no production (DIEC2)," and "drop in the market price of farm produce due to decreased quality (DIEC8)" were associated with the disruption of children's schooling (SLHum3). Decreased income from farming activities can affect families' ability to afford education-related expenses, such as school fees and supplies. Economic hardships may force children to contribute to household labor instead of attending school, leading to absenteeism and dropout rates.

Table 30: Correlation matrix between drought economic impacts and the human sustainable livelihood indicators in the City of Koronadal

		DIE C1	DIE C2	DIE C3	DI EC 4	DIE C5	DI EC 6	DIE C7	DIE C8
	Spear				-		-		
SLH	man's	0.35	0.34	0.11	0.0	0.09	0.0	0.45	0.20
um1	rho	4	1	3	67	4	88	1	1
	p-	< .00	< .00	0.26	0.5	0.35	0.3	< .00	0.04
	value	1***	1***	7	08	7	88	1***	7*
	Spear						-		
SLH	man's	0.49	0.48	0.09	0.1		0.0	0.36	0.16
um2	rho	8	8	3	93	0.26	51	3	8
	p-	< .00	< .00	0.35	0.0	0.00	0.6	< .00	0.09
	value	1***	1***	7	55*	9**	2	1***	6
	Spear								
SLH	man's	0.39	0.40	0.27	0.1	0.03	0.0	0.28	0.37
um3	rho	6	1	6	01	6	74	9	5
	p-	< .00	< .00	0.00	0.3	0.72	0.4	0.00	< .00
	value	1***	1***	6**	2	3	66	4**	1***
	Spear						-		
SLH	man's	0.11	0.13	0.08	0.0	0.06	0.1	0.29	0.29
um4	rho	6	1	7	29	6	87	6	5
	p-	0.25	0.19		0.7	0.51	0.0	0.00	0.00
	value	2	5	0.39	76	8	64	3**	3**

Note. * p < .05, ** p < .01, *** p < .001

Legend: Economic impacts: DIEC1. Less harvest due to crop failure; DIEC2. No production; DIEC3. Crop damage resulting in low harvest, DIEC4. Mortality of poultry/livestock; DIEC5. Mortality of planted fruit trees; DIEC6. Decrease working hours due to illness; DIEC7. Increase the prices of farm inputs; DIEC8. The market price of farm produce has dropped due to decreased quality. Sustainable capital (Human indicators): SLHum1. Farm planning disruption; SLHum2. Increase the incidence of health illnesses; SLHum3. Disruption of children's schooling; SLHum4. Gender imbalances/shift in production/reproduction, and community roles

In Kidapawan City, five economic variables, namely "less harvest due to crop failure (DIEC1)," "no production (DIEC2)," "crop damage resulting in low harvest (DIEC3)," "increase in the prices of farm inputs (DIEC7)," and "drop in the market price of farm produce due to decreased quality (DIEC8)," exhibited strong associations with farm planning disruption (SLHum1)" as presented in Table 31.

Table 31: Correlation matrix between drought economic impacts and the human sustainable livelihood indicators in the City of Kidapawan

		DIE C1	DIE C2	DIE C3	DI EC 4	DI EC 5	DI EC 6	DIE C7	DIE C8
	Spear								
SLH	man's	0.41	0.40	0.39	0.3	0.2	0.0	0.46	
um1	rho	9	3	8	08	9	13	3	0.35
					0.0	0.0			
	p-	< .00	< .00	< .00	03*	05*		< .00	< .00
	value	1***	1***	1***	*	*	0.9	1***	1***
	Spear								
SLH	man's	0.10	0.08	0.25	0.1	0.1	0.1	0.22	
um2	rho	9	9	7	25	87	86	5	0.26
	p-	0.30	0.39	0.01	0.2	0.0	0.0	0.03	0.01
	value	3	9	4*	39	76	78	2*	3*
	Spear								
SLH	man's	0.00			0.0	0.0	0.2	0.28	0.06
um3	rho	7	-0.01	0.14	91	84	52	3	3
	p-	0.94	0.92	0.18	0.3	0.4	0.0	0.00	0.55
	value	6	6	6	89	3	16*	7**	1
	Spear	-							
SLH	man's	0.01		0.05	0.0	0.0	0.2	0.23	0.21
um4	rho	9	-0.02	7	75	81	62	8	3
	p-	0.85	0.84	0.59	0.4	0.4	0.0	0.02	0.04
	value	8	8	5	77	48	12*	3*	3*

Note. * p < .05, ** p < .01, *** p < .001

Legend: Economic impacts: DIEC1. Less harvest due to crop failure; DIEC2. No production; DIEC3. Crop damage resulting in low harvest, DIEC4. Mortality of poultry/livestock; DIEC5. Mortality of planted fruit trees; DIEC6. Decrease working hours due to illness; DIEC7. Increase the prices of farm inputs; DIEC8. The market price of farm produce has dropped due to decreased quality. Sustainable capital (Human indicators): SLHum1. Farm planning disruption; SLHum2. Increase the incidence of health illnesses; SLHum3. Disruption of children's schooling; SLHum4. Gender imbalances/shift in production/reproduction, and community roles

The associated economic variables that directly impact agricultural productivity, leading to disruptions in farm planning, and "crop damage resulting in low harvest (DIEC3)," further exacerbated these challenges, making it difficult for farmers to plan their agricultural activities effectively. It also signifies a financial burden on farmers due to rising costs of essential inputs like seeds, fertilizers, and pesticides. This increased expenditure can disrupt farm planning as farmers may need to adjust their budgets and production strategies accordingly. The variable "drop in the market price of farm produce due to decreased quality (DIEC8)" reflects market fluctuations and reduced profitability for farmers. Such market instability can disrupt farm planning as farmers may need to reconsider crop selection, marketing strategies, and overall production plans to adapt to changing market conditions.

Four variables strongly correlated with the human capital indicators for the social impacts in the City of Koronadal. These variables include "Hunger (DIS2)" and "Migration of family members (DIS3)," which were associated with "Farm planning disruption (SLHum1)" and "Gender imbalances/shift in production/reproduction and community roles" (SLHum4).

Hunger disrupts farm planning (SLHum1) by limiting individuals' ability to engage in agricultural activities effectively. Similarly, migration can disrupt farm planning by reducing the available labor force and impacting community cohesion and productivity. Both factors may also contribute to gender imbalances and shifts in production and community roles (SLHum4), as households may experience changes in gender roles and responsibilities due to the absence of family members and increased strain on remaining community members.

"Water use conflict (DIS4)" was linked with "Gender imbalances/shift in production/reproduction and community roles (SLHum4)", as shown in Table 32. Conflicts over water

usage also play a role in shaping human capital indicators. Water use conflicts often stem from competing demands for limited water resources, leading to disruptions in agricultural activities and community dynamics. These conflicts exacerbate gender imbalances and shift in production and community roles (SLHum4), as they can disproportionately affect certain community members and exacerbate existing social inequalities.

Table 32: Correlation matrix between drought social impacts and the human sustainable livelihood indicators in the City of Koronadal

		DIS1	DIS2	DIS3	DIS4
SLHum1	Spearman's rho	0.294	0.487	0.347	-0.177
	p-value	0.003**	< .001***	< .001***	0.079
SLHum2	Spearman's rho	0.018	0.153	0.107	0.01
	p-value	0.862	0.129	0.29	0.925
SLHum3	Spearman's rho	0.085	0.141	-0.087	0.095
	p-value	0.402	0.165	0.391	0.348
SLHum4	Spearman's rho	0.209	0.451	0.1	-0.319
	p-value	0.038*	< .001***	0.324	0.001***

Note. * p < .05, ** p < .01, *** p < .001

Legend: Social impacts: DIS1. Food shortage; DIS2. Hunger; DIS3. Migration of family members; DIS4. Water use conflict
Sustainable capital (Human indicators): SLHum1. Farm planning disruption; SLHum2. Increase the incidence of health illnesses; SLHum3. Disruption of children's schooling; SLHum4. Gender imbalances/shift in production/reproduction, and community roles

In Kidapawan City, social impact indicators such as "Food shortage (DIS1)," "Hunger (DIS2)," "Migration of family members (DIS3)," and "Water use conflict (DIS4)" exhibited strong associations ($p < .001$) with human capital indicators (Table 33). Specifically, these social factors were correlated with "Farm planning disruption (SLHum1)," "Increase in the incidence of health illnesses (SLHum2)," "Disruption of children's schooling (SLHum3)," and "Gender imbalances/shift in production/reproduction and community roles (SLHum4)."

The strong associations between social impact and human capital indicators in Kidapawan City highlight the interconnectedness between societal challenges and individual well-being. Factors such as food shortage, hunger, migration, and water use conflicts significantly impact various aspects of human capital, including farm planning, health, education, and gender roles.

Table 33: Correlation matrix between drought social impacts and the human sustainable livelihood indicators in the City of Kidapawan

		DIS1	DIS2	DIS3	DIS4
SLHum1	Spearman's rho	0.419	0.468	0.44	0.446
	p-value	< .001***	< .001***	< .001***	< .001***
SLHum2	Spearman's rho	0.26	0.413	0.49	0.449
	p-value	0.013*	< .001***	< .001***	< .001***
SLHum3	Spearman's rho	0.246	0.495	0.486	0.582
	p-value	0.019*	< .001***	< .001***	< .001***
SLHum4	Spearman's rho	0.234	0.454	0.433	0.577
	p-value	0.026*	< .001***	< .001***	< .001***

Note. * p < .05, ** p < .01, *** p < .001

Legend: Social impacts: DIS1. Food shortage; DIS2. Hunger; DIS3. Migration of family members; DIS4. Water use conflict
Sustainable capital (Human indicators): SLHum1. Farm planning disruption; SLHum2. Increase the incidence of health illnesses; SLHum3. Disruption of children's schooling; SLHum4. Gender imbalances/shift in production/reproduction, and community roles

Cascading Impacts of Drought on Sustainable Livelihoods and Natural Resources

The cascading effects of drought on livelihoods and resource management refer to the multifaceted repercussions of prolonged water scarcity, particularly in regions like South-central Mindanao. As illustrated in Figures 2 and 3, the impact chain diagrams highlight how drought disrupts various facets—the environmental, economic, and social aspects of human life and ecosystem functioning. This disruption sets off a chain reaction of adverse outcomes across different dimensions of sustainable livelihood, including social, financial, natural, physical, and human capital.

Several ways in which drought impacts also affect sustainable livelihoods include:

- Effects on social capital. Some farmers in the study areas were forced to migrate for water, food, or livelihood opportunities. Migration disrupts social networks as families and communities are separated, leading to a loss of social capital built upon trust, reciprocity, and shared experiences. It creates conflicts over water resources, as competition for limited resources such as water and strained relationships between community farmers.

- Effects on financial capital. The 2015-2016 drought event led to crop failures, decreased agricultural productivity, and scarcity of water resources. This resulted in economic stress for farmers who rely on agriculture and communities dependent on these sectors. Droughts directly impact agriculture by reducing crop yields, livestock productivity, and the mortality of plants and animals, threatening farmers' food security and livelihoods. This agricultural downturn led to economic losses and heightened vulnerability to food insecurity. Moreover, declines in agricultural production led to food shortages and price increases, exacerbating food insecurity for vulnerable populations. Loss of livelihoods and rising food prices also push households deeper into poverty, heightening vulnerability to malnutrition, health issues, and other socioeconomic risks.

- Effects on natural capital. The 2015-2016 drought disrupted the provision of ecosystem services, particularly the continuous flow of water for irrigation and potable. Water shortages for human consumption and agricultural use exacerbate competition for limited water resources and trigger social capital conflicts. In addition, wildfires were reported. Pressure on natural resources also increases as communities (e.g., the practice of charcoal making) attempt to cope with the impacts of drought, leading to overexploitation of forests and other ecosystems. Traditional resource management practices may become unsustainable during prolonged drought, requiring adaptation strategies and support to implement more resilient approaches. Moreover, the 2015-2016 drought led to soil degradation through reduced vegetation cover and decreased soil moisture. This impaired soil fertility decreases agricultural productivity and exacerbates land degradation.

- Effects on physical capital. The 2015-2016 drought destroyed irrigation water canals, causing significant disruptions to agricultural water management systems.

- Effects on human capital. Drought exacerbates health issues such as diarrhea and heat stroke. It also leads to psychological stress and disrupts farmers' farm planning and decision-making. It disrupts children's schooling, which leads to learning loss and disrupts their academic progress. During droughts, families forced to migrate for water, food, or livelihood opportunities uproot children from their schools. The 2015-2016 drought exacerbated gender imbalances and shifted production, reproduction, and community roles within societies.

Existing policies and potential policies on enhancing sustainable livelihoods and natural resource management

Policies on drought management

Koronadal City implemented several policies to manage drought conditions effectively. Before a drought, some farmers avail themselves of insurance from the Philippine Crop Insurance Corporation (PCIC), and the city government conducts information drives, such as radio programs, to inform and prepare farmers. The city agriculture office visits farms for inventory purposes and recommends starting gestation crops, while the City Disaster Risk Management (CDRM) office allocates funds for mitigation measures.

Farmers are encouraged to shift to drought-resistant crops like watermelon and other summer crops during a drought. The Local Government Unit (LGU) provides cash assistance to affected farmers, and alternative employment opportunities are offered, including laundry work (*labada*), house help, construction work, and *habal-habal* (motorcycle) driving. After a drought, the city provides various assistance to help farmers recover. This includes distributing 11 tube-well units from the Department of Agriculture (DA), providing continued financial aid, and supplying necessary farm inputs to support replanting and recovery efforts. The city promotes planting indigenous species such as bamboo, which serves as a source of raw materials like *kawayan tinik* and involves people with disabilities (PWDs). Preparations are made for La Niña to anticipate and mitigate potential adverse effects.

Before the drought, farmers stocked rice, planted root crops, and maintained permanent crops in Kidapawan City. The LGU facilitates federation meetings, conducts information drives, runs radio programs to prepare farmers, and provides planting materials such as sweet potatoes and cassava. During drought events, farmers conserve water, boil water for drinking, seek alternative income sources such as construction work, lend to traders, apply for emergency loans from Pag-IBIG, and apply for insurance. The LGU delivers water to affected families, implements cash-for-work and food-for-work programs, distributes 10 kilograms of rice per household, and addresses social unrest. After drought events, the city reinforces water management practices and encourages farmers to diversify their livelihoods using other income sources, such as piggery.

The existing policies in Koronadal City and Kidapawan City demonstrate a well-rounded approach to managing drought conditions, focusing on preparation, mitigation, and recovery. While these policies are commendable, enhancements could further strengthen drought resilience in certain areas, particularly to strengthen proactive measures and preparedness.

Potential policies on drought management

A comprehensive approach will address various stages of drought (before, during, and after) and include immediate relief and long-term resilience measures. However, there is always room for improvement in Koronadal and Kidapawan, especially in scalability, accessibility of insurance schemes, early warning systems, long-term water management, integration of climate change adaptation strategies, and sustainable livelihood management. In addition, there is a compelling need to formulate holistically comprehensive drought management policies encompassing environmental, economic, and social dimensions, preparedness before drought events, managing and coping during drought, and recovery after drought. Here are some key policy recommendations:

- Policy addressing drought's economic impacts involves implementing financial mechanisms for affected farming communities. Ensure that all farmers, particularly those in remote and affected areas, have access to insurance and information. Expanding coverage and accessibility is crucial for widespread resilience. Allocating drought relief funds for drought-resistant infrastructure, protecting livelihood income sources/activities, and investing in water-efficient technologies and practices and climate-smart agricultural techniques enhance resilience and sustainability. Moreover, policies that guarantee access to credit and loans for affected communities, particularly during droughts, are needed. Funds to support timely response efforts are also needed since drought events in the study areas are recurring. While alternative income sources are encouraged, there could be more structured programs and support for economic diversification, ensuring farmers have multiple stable income streams.

- Policy on addressing the environmental impacts of drought includes developing and implementing comprehensive water management strategies that include water conservation practices, rainwater harvesting, and efficient irrigation systems to ensure sustainable water use. It also includes protecting and restoring ecosystems, managing land use effectively, promoting sustainable agriculture or agroforestry, adopting climate change adaptation strategies, investing in monitoring and more advanced early warning systems for drought prediction, and raising public awareness. This includes monitoring meteorological data, water levels, and agricultural conditions to anticipate drought impacts. This would allow for more timely interventions and better preparedness. Moreover, there is also a need to integrate broader climate change adaptation strategies into drought management policies, considering the long-term impacts of climate change on agricultural practices and water resources. Thus, policymakers should implement regulations and incentives that promote sustainable practices, such as sustainable agriculture and water conservation, to protect and restore natural ecosystems.

- Policy addressing the social impacts of drought includes strengthening social support systems, particularly in Kidapawan City, to address potential social unrest during drought periods. This includes enhancing social safety nets such as continuing food assistance programs and income support, implementing community-based drought management plans, improving access to education and healthcare in affected areas, and providing mental health support.

Continuous training and capacity building on sustainable agricultural practices, water management, and financial literacy are provided to enhance farmers' resilience. It ensures equitable distribution of resources and assistance to marginalized groups. Lastly, robust monitoring and evaluation frameworks should be established to assess the effectiveness of drought management policies and make necessary adjustments based on feedback and outcomes.

CONCLUSION

The study provided a comprehensive analysis of the recurring drought challenges in South-Central Mindanao. It also emphasized the urgent need for a multifaceted policy response to mitigate the far-reaching impacts of drought on sustainable livelihoods and natural resource management. The findings highlighted the cascading effects of drought, including diminished agricultural productivity, increased health risks, disrupted social cohesion, and increased vulnerabilities among affected populations.

Addressing these cascading effects requires adoption of an integrated approach that holistically considers the environment, economic, and social dimensions of drought management, focusing on safeguarding and ensuring sustainable livelihoods. Priority actions should include scaling up insurance mechanisms for the most affected and vulnerable areas, more advanced early warning systems, implementing effective risk reduction strategies, ensuring sustainable and targeted fund allocations, and strengthening community-based support mechanisms. Equally important are initiatives promoting responsible water use, development of alternative livelihood options (on- and off-farm), the adoption of water-saving technologies, utilization of renewable energy, and initiatives to reduce greenhouse gas emissions. Policies must also prioritize food security and nutrition to combat hunger and food shortages during drought periods.

In summary, this research discussed the profound consequences of drought and provided a clear and actionable roadmap for policymakers, local authorities, and stakeholders. The study emphasized the urgency of addressing these challenges and promoting long-term resilience and sustainability in the face of a changing climate.

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CONFLICT OF INTEREST

The authors declare no conflict of interest. The research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest. Funding, if any, was used solely to support academic and field research activities related to the study.

CONTRIBUTIONS OF INDIVIDUAL AUTHORS

1. **Lorena L. Sabino:** Conceptualized the study, led the field data collection, and contributed significantly to writing the manuscript.
2. **Lara Paul A. Ebal**: Contributed to data gathering, conducted data analysis, and led in interpreting findings, manuscript preparation, and editing.
3. **Noel G. Sabino**: Contributed to the study's conceptualization, manuscript preparation, and editing.
4. **Maricel T. Villamayor**: Contributed to data gathering and manuscript editing.
5. **Liezl B. Grefalda**: Assisted in data collection and manuscript editing.
6. **Juan M. Pulhin**: Served as mentor, provided overall guidance in the conduct of the study, and contributed to manuscript editing.

All authors: Reviewed and approved the final manuscript and agree to be accountable for all aspects of the work.

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