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Climate-induced stressors to peace: a review of recent literature

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TOPICAL REVIEW

Climate-induced stressors to peace: a review of recent literature

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Abstract

Climate change is increasingly recognized as a threat to global peace and security. This paper intends to provide a better understanding of the nature of interactions between climate change and events that undermine peace through a systematic review of recent literature. It highlights major methodological approaches adopted in the literature, elaborates on the geographic focus of the research at the nexus of climate change and peace, and provides further information on how various climatic stressors, such as extreme temperature, floods, sea-level rise, storms, and water stress may be linked to different events that undermine peace (e.g. civil conflict, crime, intercommunal violence, interstate conflict, political conflict, and social conflict) through direct and indirect pathways. Results confirm previous findings that statistical techniques and qualitative case studies are dominant methods in climate-conflict research but show that there has been an increase in the geographic information system based risk analyses and qualitative comparative analyses in the recent years. In line with previous reviews, results show that the literature is mainly focused on certain regions of the world and several major regions that have experienced numerous conflicts over the past few years and/or are vulnerable to adverse climatic events are understudied. However, a new finding is that, in the past few years, there has been an increasing focus on Asia, which contrasts with previous reviews that show an African focus in the literature. Also, there is an unbalanced attention to different climatic stressors and peace-related events. Interactions between water stress/extreme temperature and civil and interstate conflicts have received more attention. A major finding is that, only under certain conditions climatic stressors may act as driving forces or aggravating factors. In fact, there is a strong consensus that climate change is less likely to undermine peace in isolation from a wide range of contextual socio-economic and institutional factors such as political instability, poor governance, poverty, homogeneous livelihood structures, and ethnic fractionalization. However, such contextual factors can contribute to undermining peace via either direct or indirect pathways. The former may occur through direct psychological/ physiological effects of climatic impacts or via competition over scarce resources. In contrast, in indirect pathways climate change may lead to conflict through diminishing livelihood capacities and/or inducing migration. In addition to synthesizing literature on contextual factors and direct/indirect pathways, the review identifies gaps that need further research.

1. Introduction

Potential linkages between climate change and events that undermine peace and security are increasingly discussed in science and policy circles (Koubi 2019). Interest in understanding interactions between climate change and peace has, in particular, increased since the publication of the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR4) that warned about the potential detrimental impacts of accelerating climate change on global peace and security (IPCC 2007). Also, more recently, the IPCC's Fifth Assessment Report (AR5) included a separate chapter on human security (chapter 12), further highlighting the need for a comprehensive assessment of the climate-conflict nexus question (IPCC 2014). It is worth noting that two major different conceptualizations of peace exist: 'positive peace' and 'negative peace' (Galtung 1969). The main difference between these two is that 'positive peace' indicates conditions conducive to creating and maintaining peaceful communities but 'negative peace' refers to absence of conflict and/or violence (Amadei 2019, IEP 2019). In this study whenever the term 'peace' is mentioned, it refers to 'negative peace'. In order to appraise and update earlier reviews that synthesized evidence of the relationship between climate change and armed conflict, we have focused on recent studies that discuss how climate-induced events may undermine negative peace.

Over the past decade, several review papers have been published that are mainly focused on the nexus between climate change and two events related to the absence of peace, namely armed conflict and direct or physical violence (Burke *et al* 2015, Koubi 2019). Existing review papers report divergent findings on the causal links between climate change and peace. While there are some works demonstrating that climate change impacts trigger and/or accelerate conflict, others challenge the existence of direct causal relationships and caution against overlooking pre-existing conditions that make certain places fertile grounds for the onset of conflict and violence (Burke *et al* 2015, Bonds 2016, Theisen 2017, Koubi 2019). For instance, it is argued that the onset of conflict is more likely in low-income contexts, where livelihoods of people are dependent on land and water resources that are directly affected by climate change (Burke *et al* 2015, Koubi 2017). There are also other socio-economic and political conditions such as poor governance and socio-economic inequalities that erode coping capacity of individuals and communities and make them prone to conflict and violence (Akresh 2016, Koubi 2017, Shaffer 2017, Ide 2018).

Overall, existing review papers have been successful in improving our understanding of the nature of interactions between climate change and peace. However, they are mainly focused on the interactions between climate change and either conflict or violence and do not differentiate various events and how they undermine peace simultaneously. Although more attention has been paid to the negative impacts of climate change, there is also a relatively smaller number of studies arguing that climate change impacts are likely to offer opportunities for cooperation and conflict resolution (Brzoska 2018). In addition, although existing reviews provide information on different climate-conflict pathways and discuss various pre-existing conditions that may contribute to conflict, there is still a lack of systematic reviews that provide more nuanced information on the nature and typology of interactions between climate change and events that challenge/undermine peace. For instance, the relative frequency distribution of different types of conflicts is unknown; or it is unclear what is the amount of attention paid to different climatic stressors that may influence conflict dynamics. These are major gaps that this study aims to fill through a systematic review of literature published over the past five years. This systematic review also aims to provide further information on pathways through which climate impacts may contribute to conflict and to highlight and categorize important intervening factors that have received more attention in the literature. Furthermore, review of recent literature helps to understand if and how the geographic focus on this field of research has changed over time. Previous studies show an African focus in the literature and it is worth examining if this has changed over time (Hendrix 2017, Adams *et al* 2018).

2. Materials and methods

We developed a broad-based search string composed of a combination of terms related to various events that can undermine peace, such as violence, conflict, tension, war, terror, unrest, crime, protest, riot, murder, and weapons (see the supplementary appendix (S1) (available online at stacks.iop.org/ERL/16/073006/mmedia)). We acknowledge that a holistic view of peace provides a more comprehensive understanding of the relationship between climatic conditions and conflict and a better integration between peace and development (Sharifi *et al* 2021). However, given that we aim to differentiate negative and positive types of peace by focusing on the former, the selection of search terms was limited to specific events, i.e. types of armed conflict and direct or physical violence that undermine negative peace. Hence, terms related to human security (Paris 2001), social justice (Galtung 1969), sustainable development (UN 2015), and attitudes, institutions, and structures that create and maintain peaceful societies (IEP 2019), were excluded. While climate change undoubtedly undermines human security and other conditions that create and maintain a peaceful soci-

ety, there have been debates on whether climate triggers conflict or not. This review synthesizes more recent evidence that inform these debates. Hence, in addition to focusing on events that undermine negative peace, we reviewed the literature according to the pathways in which climate acts as a multiplier of conflict risks due to various political, economic, and social factors (Koubi 2019). Furthermore, this review excludes incidents of natural hazards and anthropogenic environmental disasters because they are not considered as armed conflict or direct (social) violence, although they do result in equally or even more massive loss of lives. However, our search string includes incidents of armed conflict and direct violence following these disasters.

As our intention was to review the recent literature, we have only searched for articles published since 2015. The initial search for this string in the Web of Science returned 2313 articles on 14 April 2019. We understand that more research has been published since the cut-off date of 14 April 2019, but we believe the large number of papers retrieved for the study period would allow us to obtain sufficient information for exploring relationships between climate change and peace.

The titles and abstracts of the retrieved articles were screened by the first two authors to exclude articles that are not directly related to the aims and objectives of this study. At the end of this stage, 290 articles were retained in the database that were used for the systematic review. To follow a deductive coding method, an information extraction sheet (codebook) was developed in Microsoft Excel that was used to collect information related to various issues such as the geographic focus of the research, climatic factor(s), research method(s), events related to peace, natural resources involved in the nexus, nature of pathway, and different pre-existing and intervening factors that may influence the dynamics of the climate-peace nexus. Aligned with the review objectives, this information extraction sheet was developed in a way that allows us to not only gain updated information on the nexus, but also provide more details on the pathways and interactions mentioned in the previous reviews (Koubi 2019).

The selected articles were distributed among the co-authors for detailed review and data extraction. In addition to completing the Excel sheet, each contributing author was also asked to summarize evidence reported on different pathways through which climate change undermines peace and various pre-existing conditions and intervening factors that affect the dynamics of the pathways. Upon completion of the first round of the review, the first author checked all entries and modified the coded the data wherever needed. Coding was done following a deductive method and using a codebook (in MS Excel) that was designed based on common classifications in the literature in order to maintain consistency. For instance,

based on Koubi (2019), pathways were determined as either direct or indirect. Also, based on works such as Ide (2017), the following categories were identified for research methods: case study analysis, historical analysis[9], modeling and scenario making, spatial analysis, statistical analysis, surveys and interviews, and literature review and meta-analysis. The first author also randomly reviewed three articles assigned to each contributing author to check the quality of the work. The updated data sheet along with comments on the quality of the review were fed back to each author for a second round of review. After the results of the second round were returned, the first author did another round of quality control by reading abstracts and conclusions of all the 290 articles in the database. We believe that this multiple-round process has contributed to improving the accuracy of the data extraction process.

Upon completion of the data extraction process, simple statistical analyses were conducted to summarize and categorize the selected data and identify dominant patterns and pathways. In addition, the Tableau software was used to map interactions between different factors related to the nexus between climate change and peace. An important point that needs to be mentioned is that some studies may focus on interactions between multiple factors (e.g. multiple climate-induced stressors). In that case, all of the interactions have been coded and counted separately. For instance, when pathways related to multiple stressors are discussed in a paper, they have all been counted separately and this has been reflected in the Sankey diagrams presented in the following section.

3. Results

Before discussing the results, some basic information related to the reviewed literature is provided and we explain the basis for classification of different types of geographic focus areas, climatic stressors, and events related to peace.

In terms of document type, most of the reviewed articles are research papers (90%), followed by review papers (6.2%), viewpoints and commentaries (2.8%), and letters (1%). In terms of disciplinary focus, according to the Web of Science categories, the reviewed articles are mainly related to environmental sciences, government law, international relations, geography, and economics, as shown in figure S1. The selected articles deal with the climate change-peace nexus at various geographic scales, ranging from local (14%), to national (25%), regional (31%), and global (30%). Papers with a local focus deal with the issue at the sub-national level

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[9] Note that in this study historical analysis refers to studies that have examined climate-peace interactions during historical periods before the 19th century.

(e.g. Akinyemi and Olaniyan 2017). The nationally-focused articles examine the issue at the state level (Azmeh 2016). In contrast, some papers address the issue within the context of several (often neighboring) countries (e.g. Mertz *et al* 2016). Finally, many papers discuss the issues from a global perspective (e.g. Cattaneo and Bosetti 2017) (table 1 of the appendix (S1)).

The reviewed articles have been published in 168 different journals, indicating that the nexus has a broad base and has been studied by researchers from different disciplines, including but not limited to, peace studies, climate change, political science, geography, disaster management, and earth and environmental sciences. As shown in table 2 of the appendix (S1), *Journal of Peace Research*, *Current* Climate Change Reports, *Global Environmental Change*, *Political Geography* and *World Development* are the top five journals in terms of the number of articles.

Regarding methodological approaches, seven major categories can be identified as shown in table 2 of the appendix. The most common method is using theoretical discourses and literature review to elaborate on the nexus (27%). About 17% have used econometrics methods and statistical analyses such as regression and Granger causality tests to examine causal linkages between climate change and peace (e.g. Lee *et al* 2016a and Ang and Gupta 2018). Other commonly used methods are (comparative) case studies (17%), surveys and interviews (15%), modeling and scenario making (13%), historical analyses (7%) and spatial analyses (5%). Case studies are often qualitative and based on field observations or ancillary data (e.g. McNamara *et al* 2018). These are sometimes coupled with household questionnaire surveys, semi-structured interviews, and focus group discussions to obtain primary data on the causes of conflict at local and regional scales (e.g. Okpara *et al* 2016a and Radel *et al* 2018). Modeling and scenario making approaches are mostly used to predict impacts of future climatic changes and socio-economic scenarios on the dynamics of the nexus. A good example is the study by Hegre *et al* (2016) that examines the implications of different shared socio-economic pathways (SSPs) for future armed conflicts. As for historical analysis methods, they have mainly been used by several groups of authors who have studied the impacts of climatic changes on the civil conflicts and wars that have historically occurred in China and Europe (e.g. see Lee *et al* 2017 and Mrgic 2018). Finally, some studies have adopted spatial analysis using geographic information systems (GIS) and remote sensing to track associations between climatic changes and war and conflict (e.g. Linke *et al* 2018a and Eklund *et al* 2017). This categorization of research methods is, to a large extent, aligned with the classification reported in Ide (2017). Our results also confirm Ide's findings that statistical techniques and qualitative case studies are dominant

in climate-conflict research, but with more GIS-based risk analyses and qualitative comparative analyses in more recent years.

3.1. Geographic focus of the literature, major climate-induced stressors, and dominant events related to peace

In order to identify the geographic focus of the reviewed articles we followed the classification used by The Armed Conflict Location & Event Data Project (ACLED, see https://acleddata.com/)[10]. This classification is suitable for the purpose of this study as it allows more granular and context-specific examination of the nexus. For climate-induced stressors, we have used the following categorization: extreme temperature (i.e. extreme heat and cold), floods, sea level rise, storms (e.g. typhoons, tornados, hurricanes, etc), water stress (i.e. drought and other precipitation anomalies), and wildfires. As for events that undermine peace, after the first round of review, we selected the following classes based on the common classifications in the literature: civil conflicts, interstate conflict, intercommunal violence, social conflict, political conflict, and crime (Koubi *et al* 2018, Koubi 2019). Apart from the latter, these events often occur between different groups (e.g. communities or states). Here, civil conflict refers to acts that often occur within a country and involve violence directed towards the government. Previous research differentiates between civil war (>1000 battle-related deaths) and civil conflict (>25 battle-related death) (Koubi 2019). However, as the number of deaths is not always mentioned in the literature, here we have bundled them together as 'civil conflict'. Interstate conflict is another type of intergroup conflict that involves violent conflict between states. Intercommunal violence refers to events that occur between competing communities within a state. Social conflict refers to low-intensity and relatively less violent conflicts between different groups in a society (e.g. protests, social dispute, tensions between refugees and host communities, etc). Political conflicts in this study refers to conflicts between states over various issues such as resource management, geopolitical security, climate actions, and responsibility to climate refugees. Finally, crime refers to interpersonal acts such as assault, aggression, sexual violence, and robbery.

As figure 1 shows, apart from papers that have a generic focus, recent literature has focused on 16 different regions. Cumulatively, Asian countries have received the most attention (∼30% of the reviewed papers). This figure and figure 2 of the appendix (S1) show that Southern Asia has been extensively studied in the literature (∼10%) and the focus in this region has mainly been on civil, social, and interstate

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[10] Some regions such as Oceania and Eastern Asia are not included in the ACLED database, but we added them because there were some studies focused on them.
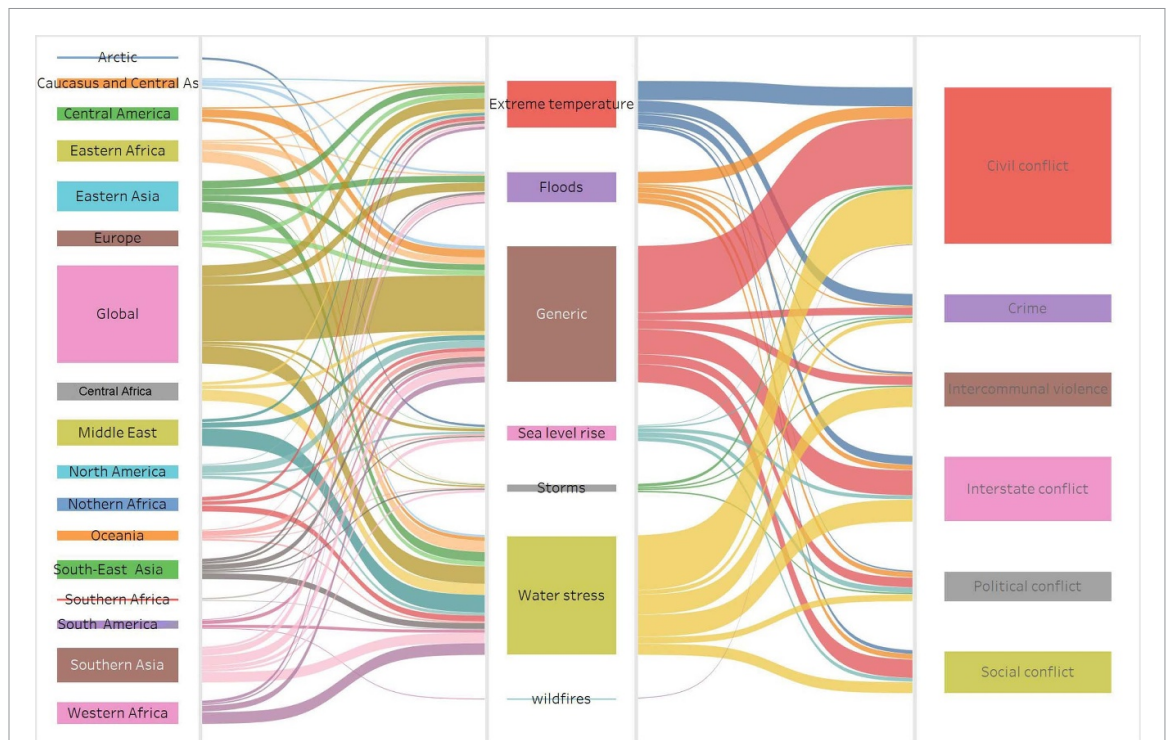
Figure 1. Interlinkages between geographic focus, climatic stressors, and events related to peace. Note that the width of flows is proportional to the frequency of connections between two columns. For instance, among studies that have examined linkages between water stress (in the second column) and peace-related events (the third column) the share of those examining possible connections between water stress and civil conflict is the largest. In contrast, only a few studies have examined connections between water stress and crime.
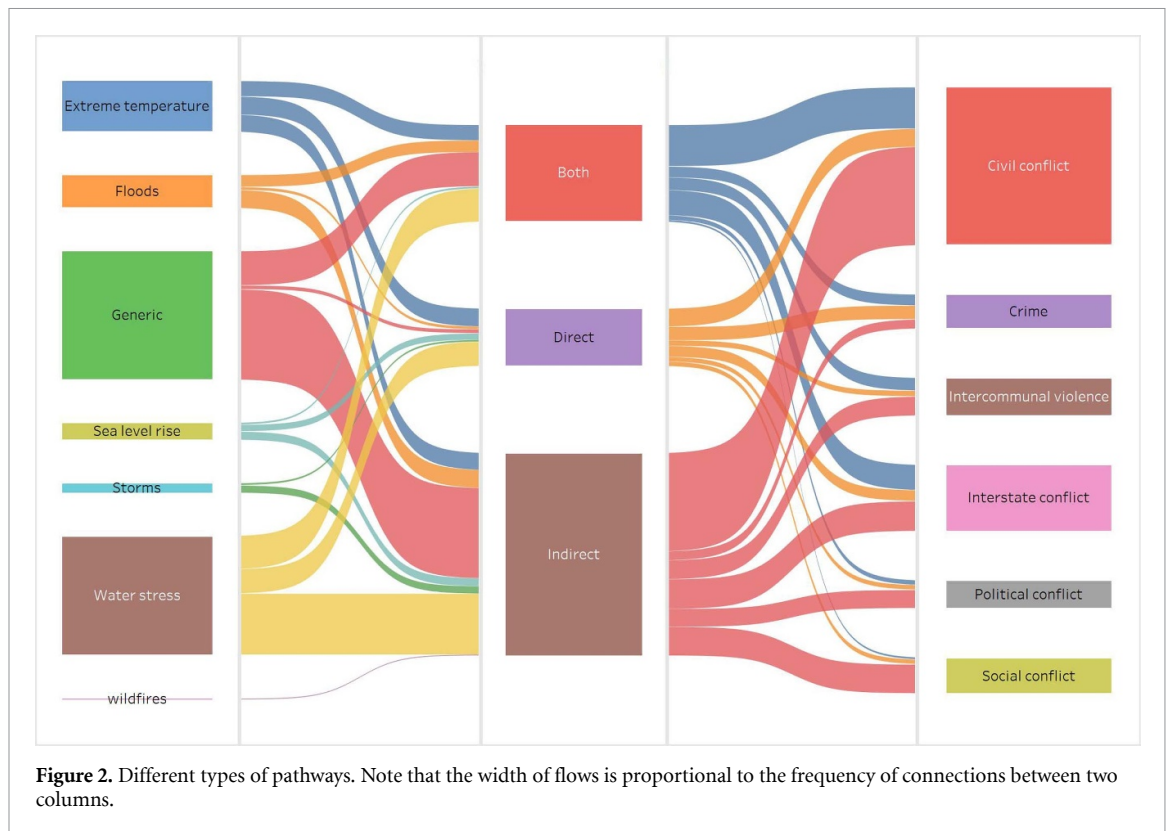
conflicts triggered by water stress, floods, and storms. Eastern Asia has also received considerable attention in the literature (∼8%). Literature related to this region is mainly focused on China and involves historical analyses of the impacts of water stress, floods, and extreme temperature on the onset and duration of civil and interstate conflicts (e.g. Su *et al* 2016, Lee *et al* 2016b, Lee 2018). There are also studies examining the linkages between extreme temperature and crime in Japan (Takahashi 2017), Taiwan (Yu *et al* 2017), and China (Hu *et al* 2017). In the Middle East (accounting for ∼8%) the focus is mainly on civil and interstate conflicts linked with water stress. This includes studies on the long-standing Israeli–Palestinian conflict (Ide and Frohlich 2015), and the recent civil conflict in Syria (Kelley *et al* 2015), Iraq (Eklund *et al* 2017), and Yemen (Weiss 2015). Finally, literature focused on Southeast Asia mainly covers interlinkages between climatic stressors such as water stress, extreme temperature and floods, and civil, interstate, and political conflicts. Noteworthy examples are civil conflicts in the Philippines (Crost *et al* 2018, Eastin 2018) and conflicts over transboundary water resources in the Mekong Basin (Yuan *et al* 2019).

Africa is the second most studied continent (∼22%). Among different African regions, Eastern Africa (∼6%), Western Africa (∼6%), Central Africa (∼5%), and Northern Africa (∼4%) have received more attention. These include multiple

studies focused on sub-Saharan Africa (Detges 2017, Witmer *et al* 2017, Seter *et al* 2018). The figures show that literature focusing on Africa has mainly examined the impacts of water stress on civil conflict and intercommunal violence, and limited attention has been paid to other climatic stressors and events that undermine peace.

Relatively less attention has been given to other regions of the world. About 4% of the papers are focused on Europe that mainly examine historical civil and interstate conflicts related to extreme temperature (Alfani and Grada 2018, Mrgic 2018, De Juan and Wegenast 2019), and social conflicts over resource management (Spijkers and Boonstra 2017, Anshelm *et al* 2018). Similarly, about 4% of the papers are focused on Central America. These papers mainly deal with civil, interstate, and social conflicts. However, unlike Europe, civil and interstate conflicts are mainly about recent developments (Castro-Nunez *et al* 2017, Hunsberger *et al* 2018). Finally, the literature focused on North America mainly deals with crime (Goin *et al* 2017, Sommer *et al* 2018) and political conflicts (He *et al* 2017, Walker and Hipel 2017).

Overall, the analysis of geographic focus is in line with claims in the literature regarding the biased research focus on conflict-ridden areas of the world (Adams *et al* 2018). This raises concerns about the 'streetlight effect', the type of bias in research that occurs when researchers are disproportionately

Figure 2. Different types of pathways. Note that the width of flows is proportional to the frequency of connections between two columns.
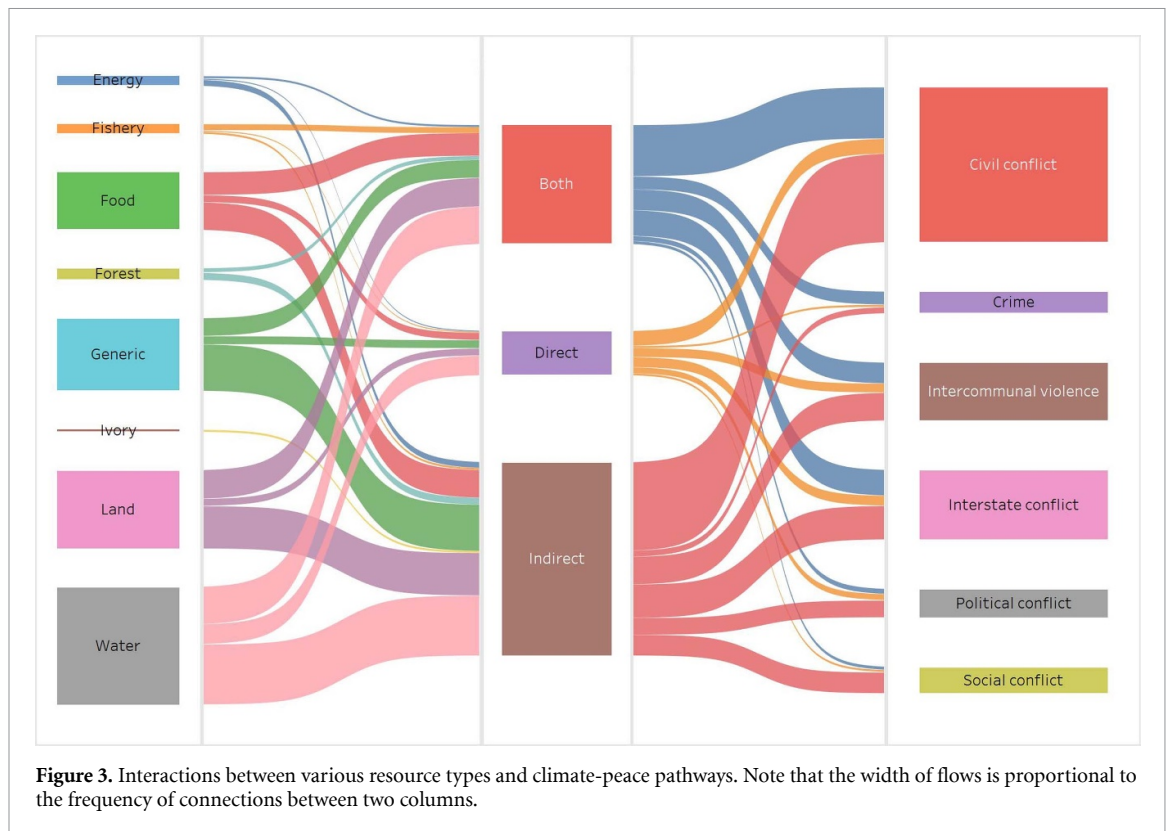
drawn to particular questions and related variables for convenience rather than relevance and validity construction (Hendrix 2017). Therefore, more research on contexts that have suffered from climatic impacts but without experiences of civil and intra-state conflicts is warranted (Adams *et al* 2018, Koubi 2019). More discussions on contextual factors are provided in section 3.3. According to the ACLED database, there are some regions such as Central America and South America that have experienced numerous conflicts over the past few years. However, research on the nexus in these regions is scarce (with few exceptions such as Colombia). Another noteworthy issue is that existing research is mainly focused on civil and interstate conflicts linked to water stress and extreme temperature; other types of climatic stressors and events undermining peace have not been well studied.

3.2. Different pathways

According to Koubi (2019), climate change can be associated with peace through either direct or indirect pathways. The former occurs through direct psychological/physiological effects of climatic impacts or via direct impacts on scarce resources. In contrast, the latter refers to mechanisms through which climatic impacts may indirectly result in events that undermine peace. For instance, this may occur due to alterations in agricultural yield, diminished livelihood capacities, or large-scale climate-induced displacements (Busby 2018, Koubi 2019).

To build on Koubi's work, here we provide more information on these two pathways and their interactions with climatic factors and resource scarcities. For consistency reasons, we have divided discussions regarding direct and indirect pathways into major categories that are mentioned in previous research (Koubi 2019). Direct pathways are divided into two groups: behavioral effects and those related to resource scarcity. In contrast, indirect effects are divided into two groups: diminished economic and livelihood capacities and migration. It should be noted that various contextual and intervening factors exist that determine if climatic impacts can directly or indirectly lead to events that undermine peace. These will be discussed in section 3.3.

Based on figure 2, most studies have only discussed indirect pathways (~57%). In contrast, about 16% have explored direct pathways only. Also, about 27% have discussed both. Figure 2 shows that indirect effects are dominant in most cases. Extreme temperature events and crime events are, however, exceptions in this regard. This may indicate that extreme temperature events are more likely to lead to conflict through direct pathways. Figure 3 complements figure 2 and shows that, irrespective of the nature of pathways, availability and accessibility of resources play important roles in the nexus. As expected, water resources have received the highest amount of attention (~33%), followed by land (~22%), food (~16%), fishery (~3%), forest (~3%), and energy (~3%).

Figure 3. Interactions between various resource types and climate-peace pathways. Note that the width of flows is proportional to the frequency of connections between two columns.

3.2.1. Direct pathways

3.2.1.1. Behavioral/physiological effects

This pathway is mainly related to how climate change may influence the occurrence of crime through influencing behavioral and physiological factors. Crime is a relatively understudied event, and existing evidence is diverging, preventing generalized statements. Also, impacts are different depending on the geographic context and the type of climatic factor. For extreme temperature, there is evidence suggesting that it increases the incidence of property and violent crimes such as robbery and assaults in Malaysia (Habibullah 2017), Beijing (Hu *et al* 2017), India (Blakeslee and Fishman 2018), Japan (Takahashi 2017), and Taiwan (Yu *et al* 2017). Also, global estimates by Mares and Moffett (2016) show that global warming increases homicide rates. However, there is also contradictory evidence showing that street crime rate declines in Dallas, Texas when temperatures are high, as people stay indoors (White 2017). Also, results of a modeling study in New Zealand show that, although irregular rise in daily temperature increases the assault rate, the impacts of future global warming on the incidence of interpersonal violence remain uncertain (Williams *et al* 2015).

Less evidence has been reported regarding the influence of other forms of climatic factors. A study of California drought showed that, contrary to previous findings about the likelihood of increase in violent crime during drought periods, drought does not increase violent crimes (Goin *et al* 2017). For India, Blakeslee and Fishman (2018) show contrasting

results, indicating that water stress increases property and violent crimes. As for the impacts of storms, there is only one study conducted in Taiwan, indicating that effects vary depending on the intensity and duration of the events. Results show that intense typhoons decrease crime rates while long duration typhoons have the opposite impact (Yu *et al* 2017).

3.2.1.2. Resource scarcity and competition

Climate change can directly influence conflict and violence mechanisms through intensifying competition over resources. In other words, it can cause conflicts through reducing the availability of resources, thereby, inducing a mismatch between supply and demand (Le Billon and Duffy 2018). Recent literature is mainly focused on intercommunal violence and civil and interstate conflicts that can be linked to competition over water and land resources (Ambalam 2015, Mertz *et al* 2016, Ngaruiya and Scheffran 2016, Malamud 2018, Sultana *et al* 2019). The empirical evidence is mainly from Africa, South and Southeast Asia and the Middle East. These are regions that are already resource-strained and lack adequate levels of adaptive capacity. Accordingly, there are also claims that climate is not the sole factor inducing conflicts and other pre-existing conditions, and contextual factors are also important (Koubi 2019).

Resource scarcity is caused by either slow-onset climatic stressors such as water stress and temperature change or rapid-onset stressors such as storms and floods. The existing evidence is mainly related to floods and water stress in arid and semi-arid regions

that have traditionally been vulnerable to hazards, and climate change is expected to exacerbate these vulnerabilities by triggering competition and conflict over the management and allocation of water resources (Albrecht *et al* 2018). In their historical analysis of civil conflicts in China, Lee *et al* (2017) and Li *et al* (2017) demonstrate how droughts and floods have played significant roles in driving civil conflicts by causing shortages in water resources and arable land. The positive effects of droughts on the incidence of conflicts have also been demonstrated using recent data in other contexts. Findings from an econometric model show that decreases in precipitation levels increase the possibility of intercommunal violence at the district level in Ethiopia and Kenya (van Weezel 2019). Evidence on intercommunal violence (between different farmer, pastoralist, and fisherman communities) caused by water stress has also been reported in other studies focusing on African communities (Schilling *et al* 2015, Detges 2017, Okpara *et al* 2017). However, these studies acknowledge that other political and socio-economic factors such as homogeneous economic structure and social and political marginalization also contribute to such violence.

Conflicts over transboundary water resources have been discussed in numerous studies. In fact, future climatic changes are expected to aggravate water scarcity by changes in precipitation patterns and evaporation rates. These, in combination with other factors such as rapid population growth, the increasing diversity of water uses, and conflicting interests, are considered as key issues contributing to tensions and conflicts over shared water resources such as lakes and rivers in many regions of the world (Link *et al* 2016, Mourad and Alshihabi 2016, Rai *et al* 2017). For example, several studies have discussed different conflicts that have occurred in the context of the Lake Chad Basin (Asah 2015, Okpara *et al* 2015). Analysis of the Lake Chad Basin between 1855 and 2005 shows that periods of drought have witnessed militarized inter- and intra-state conflicts over competing claims (Okpara *et al* 2015). This issue has also been studied in the context of Southern and Southeast Asia (e.g. the Indus, Ganges-Brahmaputra, and Mekong Basins), where conflicts over use and management of water resources are frequent (Williams 2018). Here it should be mentioned that the literature also acknowledges that resource scarcities may provide opportunities for promoting peace through cooperation (Rai *et al* 2017). For example, Abrahams and Carr (2017) explain that water scarcity has led different groups and countries to adopt cooperative approaches to manage water resources and foster resilience to drought. What can be learned from the literature is that measures such as developing joint plans and mechanisms that ensure regular risk assessment, co-designing regulatory frameworks, and joint management of resources can contribute to dealing

with transboundary resource conflicts (Abrahams and Carr 2017, Rai *et al* 2017).

In addition to water stress, conflicts may also occur due to temperature increases and associated climatic stressors such as sea-level rise (Price and Elu 2017). For instance, a modeling study based on different SSPs shows that in the absence of political reform and improved governance, future temperature rise can increase violent conflict in sub-Saharan Africa (Witmer *et al* 2017). Elsewhere, it is discussed that melting of glaciers can gravely affect water supply in South Asia and submerge low-lying small island states. Both effects can immediately elevate levels of discomfort and aggressiveness in the affected populations that may result in hostility and violence (Barkdull and Harris 2015).

Rapid-onset climatic stressors such as storms and floods may also cause conflicts and other issues that undermine negative peace through damaging community assets and aggravating resource scarcity (Koubi 2019). The effects, however, may vary depending on the intensity of the disaster and the resilience and adaptive capacity of the disaster-hit area. Mixed results have been reported in the literature about the effects of disasters on conflict onset (Siddiqi 2018, Peters *et al* 2019). While in some cases disasters lead to civil conflict and social unrest, particularly in transitional economies with low and middle incomes and limited social and physical infrastructure, in others social mobilization and cooperation may occur (Ghimire and Ferreira 2016, Peters *et al* 2019). Based on a dataset of civil conflicts in 78 provinces in the Philippines, Eastin (2018) analyzed the impact of storms on the incidence and severity of the country's four largest and longest-running civil conflicts. The article argues that natural disasters significantly increase the incidence and severity of insurgents as well as government attacks, and the intensifying effect is larger for the latter (Eastin 2018). However, another study draws more cautious conclusions on the effects of disasters on conflict onset. Through a multivariate analysis of responses to different randomly selected disaster events, the study finds that destabilizing effects are not consistent across all cases and only about 15% of disasters lead to social conflict and political violence (Nardulli *et al* 2015).

Disasters are also argued to intensify and prolong existing conflicts (Brzoska 2018). For instance, analyzing the impacts of flood-induced displacement on civil conflicts based on data from 126 countries, Ghimire *et al* (2015) found that such displacements do not trigger new conflicts but intensify existing ones and extend their duration. This is explained by the increased pressure on the receiving communities and competition over limited resources (Ghimire *et al* 2015). It is also worth noting that, in addition to disasters influencing conflict dynamics, pre-existing conflicts exacerbate vulnerabilities to disaster shocks by limiting the resources that can be allocated

to planning and preparation and, thereby, diminishing communities' absorption and response capacities. This, in turn, may further increase the duration of conflicts (Ghimire and Ferreira 2016, Brzoska 2018).

At the end of this section it should be noted that several authors have criticized efforts aimed at establishing direct causal relationships between climate change and events that undermine peace, using large-N quantitative approaches, on the grounds that they are mechanistic and fail to consider the complex and multi-dimensional nature of the nexus (De Juan 2015, Buhaug 2016, Okpara *et al* 2016b). For instance, Buhaug (2016) argues that climate change does not cause armed conflicts as societal actors do not use force only because of unpredictable changes in temperature or rainfall. However, the impacts of climate change may influence interaction among these actors, depending on specific contexts and conflict drivers. In another study, he emphasizes the need to consider complex and dynamic interactions that occur over long periods as well as context specificities that involve multiple intervening factors (Buhaug 2015). Several other studies argue that, rather than direct causes and drivers of conflict/violence, environmental changes are only risk factors that influence conflict dynamics. In fact, such dynamics are strongly shaped by social and political contexts, confirming the need to carefully consider the complex and multi-dimensional nature of the nexus (Bretthauer 2015, De Juan 2015, Noonan and Kevlihan 2018, Barnett 2019). The issue of contextual factors will be further discussed in section 3.3.

3.2.2. Indirect pathways

As figure 2 shows, recent literature has mainly discussed the nexus through indirect pathways indicating that datasets and evidence related to the influence of indirect pathways are likely to be more readily available and substantiated. This figure also shows that indirect pathways are mainly caused by water stress, extreme temperature, and floods and lead to civil conflict, interstate conflict, social conflict, and intercommunal violence.

3.2.2.1. Diminished economic and livelihood capacities

Apart from a few studies that have demonstrated that an abundance of agricultural yields contributes to conflict (e.g. Koren 2018), existing evidence is mainly related to how climate change contributes to events that undermine peace through reducing agricultural productivity that may in turn cause unemployment, diminish economic capacity, and/or reduce availability, accessibility, and affordability of essential needs such as food. This indicates that the existing research has mainly focused on conflicts in agricultural communities. Similar to the direct pathways, reported evidence is inconclusive and various contextual and intervening factors are argued to

influence the dynamics of the nexus (Ayana *et al* 2016, Hegre *et al* 2016).

Several historical analyses focused on China and Europe demonstrate how temperature fluctuations, floods, and water stress have indirectly triggered inter- and intra-state conflicts. Such climatic changes can lead to decreased agricultural production, poor harvest, and spikes in food prices. Without diverse subsistence and livelihood options, a society will face economic and food security challenges that can lead to wars, famines and epidemics (Lee *et al* 2017). The historical evidence shows that climatic pressures and agricultural shrinkage have often been intensified when coupled with significant population increase (Su *et al* 2016, Lee *et al* 2017). For instance, Su *et al* (2016) show how food security challenges caused by the coupling of extreme temperature and water stress, and population growth of the nomadic groups have led to civil conflicts and intercommunal violence in Northern China between 206BC to AD906.

Recent findings from different contexts, particularly those reliant on rain-fed agriculture, are also in line with the historical evidence (Ambalam 2015, Jun 2017, Iqbal *et al* 2018, Tubi and Feitelson 2019). A global analysis shows that temperature fluctuations result in significant variability in crop yields, thereby causing/prolonging civil conflicts by fueling the desire to dominate other groups and gain control over areas with high potential crop yields (Ang and Gupta 2018). Investigating linkages between droughts and rebel violence in developing countries using a quantitative model based on game theory, Bagozzi *et al* (2017) found that drought is a strong predictor of rebel-perpetuated atrocities against civilians in rural agricultural areas that largely rely on agriculture for food and income. Another study relying on climatic data and a set of socio-economic control variables (for the period 1993–2003) shows that, in Indonesia, temperature increases during the main rice growing season leads to the scarcity of rice, a staple food in the country (Caruso *et al* 2016). Consequently, in many provinces, intercommunal violence occurs due to food scarcity. In the neighboring country, the Philippines, Crost *et al* (2018) examined the effects of rainfall fluctuation on agricultural production and civil conflicts and found that wetter wet seasons and drier dry seasons generate negative impacts on agriculture production and consequently increase civil conflict, particularly in provinces where rice production is dominant. As climate change alters seasonal variation in rainfall, the article suggests that this will negatively influence ongoing civil conflict in the Philippines and probably spark new ones in Southeast Asian countries. This seems particularly the case in countries whose population is heavily dependent on rice for subsistence. However, as previously noted, potential impacts of other factors should not be overlooked. For instance, using spatial analysis to examine the association between various events

(i.e. civil conflicts and intercommunal violence) and environmental stressors (water stress and vegetation cover change) in Eastern Africa, Ayana *et al* (2016) found that precipitation and availability of fodder are only weakly correlated with conflict events and other intervening factors and stressors should also be examined to better understand the dynamics of conflict in the region. This indicates that only focusing on conflict onset and incidence is not enough and detailed examination of different intervening factors, and long-term analysis of the impacts of climate change on conflict are needed to better understand dynamics of conflict.

Limited empirical evidence has been reported regarding indirect pathways that occur through impacts on non-farming livelihood options and/or result in events other than civil conflict and intercommunal violence. In the context of Lake Chad, Okpara *et al* (2016a) explain that environmental stressors have decreased fish catch levels, irrigation water resources, and pasture quality. Coupled with other factors such as weak socio-cultural and political institutions and high taxes, these environmental stressors have diminished livelihood capacities of local fishermen, pastoralists, and farmers. As a result, crime rates and civil and social conflicts have increased. Increase of social conflicts due to rainfall shocks has also been reported in a study conducted in India (Sarsons 2015). This study, however, shows that such social conflicts occur even though availability of alternative irrigation options minimizes the economic impacts of drought. This, again, indicates the complexity of the nexus and the need to consider other intervening factors.

Finally, indirect pathways may also increase other forms of crime, such as gender-based violence. In Bangladesh, extreme weather events destroy crops, assets, and livelihoods, which exacerbate pre-existing vulnerability. To reduce household expenses as a means of coping with these negative impacts, families marry off their young daughters or live in crowded shelters, exposing their daughters to harassment and sexual violence (Ahmed *et al* 2019).

3.2.2.2. Migration

About 37% of the reviewed papers discussed issues related to migration, indicating that migration is likely to lead to events that undermine peace. While migration has mainly been discussed in terms of internal displacement, some studies have also focused on refugee movements. In either case, the dynamics of the processes are complex and may be influenced by different factors such as the type of climatic stressor, the past experiences of the migrants, and the nature of support mechanisms to alleviate the impacts of migration (Koubi *et al* 2018, Koubi 2019). It is argued that migration can lead to conflict under certain circumstances. For instance, it may lead to an increase in crime rates in the absence of

humanitarian support to reduce the socio-economic pressures on migrants. It may also lead to conflict by causing tensions through increasing competition over scarce resources in the host communities (Koubi 2019). Conflicts may also arise when migrants are perceived as a threat to national security, and barriers are built to prevent their movement (Nishimura 2015).

Given the above-mentioned complexities, the evidence reported in the literature on how migration may undermine peace is not always conclusive. However, negative impacts of migration have been highlighted in several studies. A survey in Kenya shows that migration can lead to conflicts, particularly between existing residents and the migrants, due to increased competition over already scarce resources that are going to be further strained in the future due to climatic pressures (Linke *et al* 2018b). Similarly, in Nigeria, Akinyemi and Olaniyan (2017) show that during periods of low rainfall and prolonged drought, grass and water become scarce, driving the cattle herdsmen in the North to migrate to the South where agricultural communities are located. This migratory adaptation then leads to conflict between these groups over access to water, encroachment of farms and grazing areas, and damage to crops and theft of cattle. Similar patterns have been reported in other contexts like Darfur (Bromwich 2018). While reported evidence is mainly related to intercommunal violence and civil and social conflicts, migration may also lead to political and inter-state conflicts. For instance, with climate change intensifying floods and droughts, the climate-induced displacement from Bangladesh to India will likely increase, escalating existing ethnic and religious tensions between the two countries (Alvarez 2017).

Despite such cases of migration leading to or intensifying conflicts, there are several studies arguing that only under certain conditions climatic stressors play important roles. For instance, this has been extensively discussed in the context of the ongoing civil conflict in Syria. Some argue that severe drought has been a major factor contributing to the onset of the conflict. It has damaged the agricultural sector, causing significant loss of livelihoods and triggering massive migrations to the periphery of cities. The migrants' failure to become integrated into the urban economy has, in turn, aggravated the social conflicts and led to the onset of the civil conflict (Kelley *et al* 2015, Hayden 2018, Ide 2018). However, other studies emphasize that the process is more complicated and non-linear. Azmeh (2016) argues that oft-cited conflict drivers, such as population growth, rising inequality, climate change, and unemployment, only offer a partial understanding of the conflict. He contends that the socio-economic and political discontent that pushed people to stage protests are rooted in the failure of the Syrian government to meet the twin demands of building national institutions

and redistributing political and economic power. Similarly, other studies show that climate change-migration nexus does not lead to conflicts in all contexts (Weinthal *et al* 2015, Byravan and Rajan 2017). Appropriate dispute resolution resources and mechanisms and adaptation strategies and policies that incorporate migration and address socio-economic and psychological needs of the migrants can mitigate the security issues and conflicts stemming from migration (Bhavnani and Lacina 2015, Nishimura 2015, Nine 2016, Cattaneo and Bosetti 2017).

3.3. Major contextual factors and their influence on the climate-peace dynamics

Interactions between climate change and peace are often mediated by various contextual and intervening factors. Our review showed that such factors have been discussed in about 68% of the literature, indicating an increasing acknowledgement of the complex and non-linear nature of the nexus. Generally, these factors can be divided into three major categories, namely, political/institutional, economic and social. While factors related to these three categories are not isolated from each other, here we present them separately for simplicity.

3.3.1. Political/institutional

Major factors related to policies and institutions are political instability (Malamud 2018), poor governance (Kelley *et al* 2015), weak and insufficient institutions (Weiss 2015), fragile state-citizen relations and lack of democratic and inclusive governance (Ghimire and Ferreira 2016, Detges 2017), political marginalization of some groups (Nishimura 2015), lack of governmental ability to coordinate activities of different actors (Staff 2017), lack of adaptation plans and mechanisms to enhance adaptive capacity (Ayana *et al* 2016), lack of policies for crime prevention (Goin *et al* 2017), lack of trust between countries (Rai *et al* 2017), lack of agreements and treaties between neighboring countries or lack of mechanisms to enforce them (Williams 2018), and history of past conflicts (Noonan and Kevlihan 2018). For example, poor governance and political marginalization are argued to be major factors contributing to the Syrian civil conflict (Kelley *et al* 2015, Azmeh 2016). In Kenya, Ngaruiya and Scheffran (2016) discuss that natural resource regulations and governance arrangements are crucial in solving resource conflicts. Another study focusing on 23 African countries argues that drought cannot influence political violence unless it intersects with social and political marginalization (Detges 2017). The article suggests that state-citizen relationships can determine the vulnerability of people to extreme climate events such as drought. Ultimately, 'political exclusion exacerbates climate-related hardships and can thus give rise to social tensions and grievance in the wake of drought' (ibid, p 95).

3.3.2. Economic

Regarding the economy and economic development, important contextual factors such as poverty (Ghimire and Ferreira 2016), employment level (Habibullah 2017), homogeneous livelihood structure dependent on agriculture or ecosystem services (Tubi and Feitelson 2019), economic inequality and inequitable distribution of resources (Bell and Keys 2018), land tenure security (De Juan 2015), and access to infrastructure services (Detges 2016, Muller *et al* 2016) have been identified.

Poverty and lack of access to resources are frequently mentioned as major pre-existing conditions that aggravate vulnerability to climatic impacts and can foment conflict (Ghimire and Ferreira 2016, Hegre *et al* 2016, Abrahams 2019). Homogenous livelihood structures dependent on agriculture are also recurring contextual factors in the reviewed literature. Such structures are more vulnerable to climatic impacts and can lead to unemployment and subsistence insecurity, thereby causing conflicts and violence. For example, the Bedouin groups in Israel are argued to be directly impacted by climate change as their livelihood is closely related to precipitation. This drives them into intercommunal violence with farming communities to gain access to resources (Tubi and Feitelson 2019). This shows the significance of social protection and planning mechanisms in diversifying the economic structure of households and communities. Other noteworthy factors are availability and equitable distribution of resources and infrastructure, the lack of which may lead to or aggravate conflicts (Scott and Smith 2017). Analyzing the nexus between water stress and armed conflicts in sub-Saharan Africa, Detges (2016) demonstrates that regional differences in the availability and access to key infrastructures such as road networks and water infrastructure influence the risk of incidence of civil conflict and intercommunal violence.

3.3.3. Social

Contextual social factors mentioned in the literature are related to demographic changes (Alfani and Grada 2018), ethnic tensions (Schleussner *et al* 2016), social capital (Cattaneo and Bosetti 2017), and level of education (Bretthauer 2015). Studies focused on historical as well as recent events have highlighted the importance of population growth for increasing the likelihood of conflicts over scarce resources (Alfani and Grada 2018, Farinosi *et al* 2018). Moreover, in the context of competition over scarce resources, migration, and climate-induced disasters, conflict and violence are more likely in areas with pre-existing ethnic tensions (Schleussner *et al* 2016, Tubi and Feitelson 2019). Evidence of heightened tensions and conflicts in ethnically fractionalized locations, following climate-induced disasters and/or displacements, has been reported in the literature (Schleussner *et al* 2016, Peregrine 2019, Weesie 2019). Closely linked

to ethnic fractionalization is the issue of social capital. Related factors such as trust, solidarity, and shared interests are believed to contribute to preventing the outbreak of violence in the face of adverse events induced by climate change (Malamud 2018, Barnett 2019). Finally, level of education can be a defining factor of the climate-peace nexus dynamics. Bretthauer (2015) explains that high levels of tertiary education in combination, with other socio-economic and institutional factors such as low levels of poverty, diversified livelihood strategies, lack of ethnic fractionalization, and strong intuitions, can contribute to minimizing conflicts (Bretthauer 2015).

4. Conclusions

Climate change is increasingly recognized as a threat multiplier and linked to security risks. The main aim of this review was to gain a better understanding of the underlying mechanisms of the nexus between climate change and peace. We examined how different climatic stressors such as extreme temperature, floods, sea level rise, storms, and water stress are linked with various events related to peace, such as civil conflict, crime, intercommunal violence, interstate conflict, political conflict, and social conflict through direct and indirect pathways.

Results show that research on this nexus is unbalanced in terms of geographic coverage and addressing different climatic stressors and events that undermine peace. In line with the findings from previous studies that considered literature since the 1990s (Hendrix 2017, Adams *et al* 2018, Koubi 2019), it was found that the literature in our review is also mainly focused on some conflict-ridden regions located in Asia and Africa. A noteworthy finding is that, in the past few years, there has been an increasing focus on Asia, which contrasts with previous studies that show an African focus in the literature (Busby and Krishnan 2017, Hendrix 2017, Adams *et al* 2018). While previous studies have examined evidence since early 1990s and/or 2000s, in this study only research published since 2015 was included. This shows that previous research has been successful in highlighting the need to focus on Asia. Despite this, more work on other regions is also needed. Indeed, to reduce the streetlight effect more research is needed in regions where climatic stressors do not coincide with conflict. This may also allow one to gain a better understanding of conflict dynamics. In fact, the existing research is mainly focused on conflict onset and incidence and more research is needed to further probe how climate change and other intervening factors may affect conflict dynamics. Another new finding is that even in some conflict-ridden areas such as South America evidence is scarce, warranting further research. Regarding climatic stressors and events that may undermine negative peace, the literature is dominated by evidence regarding civil and/or interstate conflicts linked with water stress and/or extreme temperature. The nexus has a multi-dimensional nature and other climatic stressors and events related to negative peace should be further explored in future research. Also, most of the reviewed articles focus on the implications of individual climatic factors on peace, and there is a lack of research on the combined effects of multiple factors.

Climate change and peace interact in either direct or indirect pathways, but the evidence on the pathways is divergent and inconclusive because interactions are complex and hard to disentangle. Indirect pathways, which occur via reduced livelihood capacities and/or massive climate-induced human displacements, dominate the literature. These pathways are mainly discussed in relation to agricultural and pastoralist communities. Future climatic impacts are likely to affect the livelihood options of different other groups and professions and this should be further studied. It was discussed that indirect pathways may occur due to migration. Our analysis showed that migration-related evidence mainly refers to cases on internal displacement and issues related to refugee movements are relatively less discussed. Future research should pay more attention to the impacts of refugee movements and also examine if such impacts are different from those of internal displacement.

Direct pathways, in contrast, happen through direct psychological/physiological effects of climatic impacts or via competition over scarce resources, with water and land as the most frequently discussed in the literature. Surprisingly, very limited evidence has been reported on energy resources. This could be partly due to relatively fewer conflicts over energy resources and limited modeling studies on the potential impacts of climate change on the availability of energy resources across the world.

Overall, evidence about the existence of direct and indirect linkages between climate change and events that undermine peace remains contested and equivocal. Many studies have argued that climate change does not necessarily lead to events that undermine peace and the nexus is mediated by multiple contextual socio-economic, political, and institutional factors that can make some places ripe for conflict and violence. These studies confirm the complexity of the nexus, raising caution over simplified interpretations of its linkages and overstated impact of climate change on peace (Buhaug 2015, Selby *et al* 2017). Several political/institutional, economic, and social factors bridge climate change to peace. Some of these factors are political instability, weak institutions, poor governance, lack of adaptation plans, poverty, homogeneous livelihood structures, socio-economic inequality, ethnic fractionalization, and lack of social capital. However, while these factors are frequently mentioned in the literature, there is still a lack of knowledge about their relative

importance. Further, there is still limited understanding of how the interplay between them and climatic factors affects the dynamics of the nexus. In particular, there is a lack of knowledge about the impacts of different future climatic scenarios on the nature of interactions between climatic and contextual factors. More research is needed to fill this gap. Also, further research into locations that are frequently hit by climate-induced stressors and disasters but do not experience conflicts is needed to better understand contextual factors that contribute to maintaining peaceful conditions. This will also help minimize the streetlight effect that was mentioned earlier and may lead to limited understanding of the underlying dynamic and complex interactions that govern and regulate the nexus between climate and peace. One important issue is that many of these contextual factors are underlying elements of adaptive capacity. This indicates the importance of developing appropriate plans to enhance adaptation and adaptive capacity through various measures such as improving governance mechanisms, empowering low-income groups, and diversifying livelihood options. In fact, there is now a good consensus that adaptation to climate change is essential for maintaining peace (Buhaug 2015, Jun 2017, Schweizer 2019). There are also some modeling studies aiming to estimate the consequences of inaction and/or maladaptation. For instance, using SSPs that provide an integrated framework to examine the combined effects of different future climate change and socio-economic scenarios, Hegre *et al* (2016) found that scenarios with higher levels of mitigation and adaptation challenges are linked to higher levels of future armed conflict. In fact, as the global climate change persists, critical thresholds and tipping points might be surpassed not only in developing countries, but also in developed ones that until now have rarely experienced conflicts induced by climatic impacts. This can aggravate existing vulnerabilities and have significant repercussions for global peace and security. Therefore, further research is also needed to better understand the dynamics of the nexus under different future climate scenarios and positive peace conditions that enable the creation and maintenance of peaceful societies.

Data availability statement

All data that support the findings of this study are included within the article (and any supplementary files).

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Full Text Article

Farming amidst climate change: The contextual vulnerability of farmers in Cotabato, Philippines

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Abstract

This research investigated the contexts of farmers in Cotabato, Southern Philippines, and the various aspects of their vulnerability to climate change. The response of the government to address the climate vulnerability of farming communities was also examined. A mixed-methods approach that included document analysis, surveys, interviews, and focused group discussions was used to gather the data for the study. Salient themes from qualitative data were discussed side by side with the results generated from quantitative data. The different aspects of contextual vulnerability investigated—the nature of farming itself, population age groups, education, income, multiple deprivations, farm assets, farming practice, and limited government response—work together to characterize the vulnerabilities of farmers. They also exacerbate, compound, and reify each other. The susceptibilities and multiple deprivations of farmer households through limited formal education, poverty, and lack of social support challenge their adaptation and resilience to climate change. Farmers remain vulnerable to the impacts of climate change despite the existence of a government plan that recognizes their plight. A holistic view of these vulnerabilities is highly recommended in drafting programs and optimal solutions for the issues related to climate change.

Introduction

Over the years, climate change has had vast impacts and consequences in the Philippines. A 2019 Global Index Report covering a 20-year period (1998-2018) identified the Philippines as one of the top ten countries most affected by climate change. In fact, the country has the most number of extreme events recorded during this period (Eckstein et al., 2020).

Extreme weather condition has been identified as the country's main risk. In fact, the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA, 2022) reported that there are more tropical cyclones entering the Philippine area of responsibility than anywhere else in the world, with an average of 20 cyclones in a year. Moreover, typhoons in the Philippines are also becoming more unpredictable and intense in recent years (Board, 2021). Climate change is also severely felt throughout the country through high temperatures and long droughts. In 2015-2016, the country recorded the most severe El Niño drought that lasted for 18 months (Sutton et al., 2019). The disaster affected the agriculture sector the most.

The long spate of drought in 2015-2016 had a significant impact on Cotabato Province in Southern Philippines which is composed of many farming communities. Food scarcity

brought about by the intense drought prompted some hungry farmers to leave their farmlands and go to the city to protest and demand food and aid, ending up in chaos (Macas, 2016). Taking this into consideration, The Asia Foundation (2017) has reported that climate change can add to or exacerbate conflicts and tensions in the Philippines. This is because climate change exposes people's vulnerabilities that can create tensions (Koubi, 2019).

The International Panel on Climate Change (IPCC) recognizes the multiplier effects of climate change, which adds to the burden of people living in poverty (Olsson et al., 2014). The extent of these effects vary across communities as well as the government's capacity to respond to climate-related problems. These effects are likely to impact the agriculture sector due to its heavy dependence on weather conditions (Koubi, 2019).

Vulnerability is framed in two different ways in literature—outcome vulnerability and contextual vulnerability (O'Brien et al., 2007; Okpura et al., 2016). The vulnerability of Cotabato farmers within the outcome vulnerability framework has already been explored in other studies (e.g., Gomez, 2015). However, there is a dearth of research focusing on their contextual vulnerability.

An understanding of contextual vulnerability of farmers is vital in providing the needed support and assistance to systematically respond to the effects of climate change. In lieu of the importance of contextual vulnerability assessment, this paper focuses on the local situation and experiences of Cotabato farmers to understand their vulnerability which, at one point in time, resulted in a climate change-induced conflict. It also aims to examine the response of the local government to address the climate vulnerability of farming communities.

Contextual vulnerability is far less visible in scientific and policy discourses (O'Brien et al., 2007). Addressing this aspect is intended to contribute to more comprehensive adaptation policies and appropriate programs for farmers not only in response to climate change but to other forms of hazards that occur in the province.

Relevant Literature

Knowledge and discourse on climate change vulnerability have been framed in two significant complementary ways—as an outcome and contextual vulnerability (O'Brien et al., 2007, Okpura et al., 2016). Outcome vulnerability is referred to as "endpoint" vulnerability. This vulnerability framework focuses on vulnerability interpretation on estimates of potential climate change impacts, considering possible adaptive responses (Okpura et al., 2016). Its orientation is toward the quantification of biophysical vulnerability in relation to the level of susceptibility that takes place after adaptation (Hopkins, 2015). Just like any other framework, this type of assessment is challenged by quantification problems because as a latent variable, vulnerability cannot be directly measured (Ziervogel & Downing, 2004). Also, a wide-scale model conceals a variety of contextual conditions (O'Loughlin et al., 2012). As Adger and Vincent (2005) emphasize, "the contextual nature of the vulnerability, the difficulties of validating indicators, and considerations of timescale provide challenges to the development of robust indicators." For these reasons, contextual vulnerability considerations are becoming central, especially in climate conflict scholarship and gaining traction in science and policy debates.

Contextual vulnerability is grounded on the human security framework that nature and society are inseparable aspects of the same context. In a contextual framework, vulnerability is interpreted as the current susceptibility to climate change and variability that occurs in the context of social, cultural, technological, institutional, political, and economic processes of change (O'Brien et al., 2007). These contexts can compound the individuals' and communities' level of exposure to climate change that results in risks.

Contextual vulnerability assessments explore why some groups, like the farmers of Cotabato province, are more affected by climate change than others. This type of vulnerability assessment is believed to reveal the complex nuances of vulnerability. O'Brien et al. (2007) posit that this complexity can possibly drive a transformative process for better governance, resilience, and adaptability, and can be a driver of more socially focused policies and adaptation initiatives (Okpura et al., 2016).

The entry point in contextual vulnerability analysis is the current climatic, biophysical, and contextual conditions driving vulnerability including social, economic, political, and institutional structures and dynamics. Methods employed by studies within the contextual vulnerability framework include longitudinal and cross-sectional surveys, household surveys, quantitative/qualitative case studies, and context-specific indicator approaches (Okpura et al., 2016).

Conceptual Framework

Vulnerability is the degree to which a system is susceptible to or unable to cope with the adverse effects of climate change, including climate variability and extremes (IPCC, 2007). Social vulnerability includes factors that weaken the community's ability to prevent human suffering and financial loss in the event of a disaster.

Climate Variability

Conditions resulting from climate change have intense and serious consequences to the socio-economic activities of farming households. Disruptions in livelihood result in lost income that exacerbates poverty (Herrera et al., 2018).

Frequency Exposure

Human activities such as economic enterprises are exposed to climate variability and hazards on a periodic basis (e.g. drought, flooding, tropical cyclones). Such exposures may result in adverse impacts that exceed the coping capacities of communities, particularly when there are underlying social factors that enhance vulnerability (Preston et al., 2009).

Vulnerable Age Group

Climate change can interact with demography in exacerbating its impacts. The most affected are usually the most vulnerable groups (Allen et al., 2018) like children and adolescents in developing countries who are considered the most at-risk to disasters (Bartlett, 2008).

Education Vulnerability

Education positively contributes to demographic and health outcomes (Gakidou et al., 2010). Educated individuals are more capable and empowered to be more prepared and adaptive to disasters because they have more access to information, technology, and resources (Muttarak & Lutz, 2014).

Income Vulnerability

Climate change increases the income vulnerability of small farmers who are highly reliant on farm income (Jalal et al., 2021). Insufficient financial capital and low income constrain families from recovering or bouncing back from climate shocks and other disasters (Cutter et al., 2003).

Multiple Poverty

The vulnerability of poor communities is generally superimposed on existing vulnerabilities (Ecosystems Division et al., 2002). The combinations of deprivations result in a

multiplicity of burdens that act together to keep a household poor (Alkire & Santos, 2010). Multiple forms of poverty experienced by farmer households expose them to more environmental risks and make it more difficult for them to cope with the impacts of climate change.

Farm Ownership

Farm ownership enables farmers to combine a set of physical resources and farm tenure to carry out strategies to adapt to climate change (Defiesta & Rapera, 2014). It gives owners the right to build farm infrastructure, which non-farm owners cannot simply do (Eakin & Bojorquez-Tapia, 2008).

Farm Size

Marginal farm size is associated with the vulnerability of farmers (Gomez, 2015) as gains from improved technical efficiency is much higher on large than on small farms (Lowder et al., 2016).

Crop Diversification

Crop diversification distributes risks across different crops, making failure recovery easier. Low occupational diversification exposes farmers to the risks of climate change (Abera & Tesema, 2019). Diversity in crops is associated with success in achieving livelihood security under improving economic conditions as well as with livelihood distress, such as a lack of funds to restore agricultural production in deteriorating conditions (Ellis, 1998).

Government action

Existing institutional and governance networks to deploy resources are essential while any existing socio-political barriers may impede successful adaptation to climate change (Hulme et al., 2007; Lorenzoni et al., 2007).

Materials and Methods

Study Site

This study was conducted in Cotabato, a landlocked province in Mindanao, an archipelago in Southern Philippines having a Type III climate. Cotabato is the largest among the four provinces comprising Region XII or the SOCCSKSARGEN region. The province has 17 municipalities and one city clustered into three districts. This study covered Kidapawan City and 16 out of the 17 municipalities in the province. The municipality of Banisilan was excluded due to accessibility concerns. Collection of survey and interview data began in September 2018 and was completed in March 2019.

Research Method

A mixed methods research approach, specifically the convergent parallel design, was used in this study. In a convergent parallel design, quantitative and qualitative data are collected concurrently in one phase. This study simultaneously collected survey and interview data. This procedure was used to confirm, cross-validate, or corroborate findings. Table 1 summarizes the methodology used in this study.

Desktop research and analysis of existing reports and publications were done to gather data about demographic, economic, agricultural, and climate profile of Cotabato Province. The Philippine Statistics Authority (PSA) portal was explored to obtain links to online sources of data relevant to the study. The provincial field personnel of PSA and the Bureau of Agricultural Statistics (BAS) were interviewed to validate and gather details on some data accessed online.

The National and Local Climate Change Action Plans (NCCAP/LCCAP) were also reviewed. Separate focused group discussions and follow-up interviews with personnel of Cotabato provincial government offices of the Disaster Risk Reduction Management (DRRM), Department of Agriculture (DA), and the Provincial Planning Office (PPO) were likewise conducted. Discussion topics included climate change, impacts of climate change-related disasters as well as climate-related government policies and programs for farmers.

The survey was part of a bigger study funded by the Commission on Higher Education (CHED). Information gathered through surveys included households' socio-demographic profiles, social contexts such as economic condition and farm assets, and their practices with regards to climate change. Respondents also completed the slightly modified Multiple Poverty Index (MPI) questionnaire developed by the Oxford Poverty and Human Development Initiative (OPHI) (Olsson et al., 2010). Trained enumerators implemented the survey. When needed, they assisted respondents by reading the questions aloud and writing the responses in the questionnaire.

Simultaneous with the survey, one-on-one interviews were conducted with five household members in each of the identified barangays. The interview participants were different from the survey respondents. They were asked to provide elaborate responses on some items included in the survey questionnaire and detailed descriptions of households' experiences with climate variability and change, their socio-economic conditions, and farming experiences and concerns.

Table 1. Summary of data collected, method used, sources, and analysis.

Data Collected	Data gathering method	Source	Data analysis
Population, agriculture, and climate profile of Cotabato	Desktop research and document review	Existing reports and publications	Descriptive and Test of Relationship
	Interviews	Provincial personnel of Philippine Statistics Authority (PSA) and Bureau of Agricultural Statistics (BAS)	
Socio-economic vulnerability of farmers and their farming practices	Survey	1,526 Farmer Households from 32 barangays	
	Interviews	Provincial Office Personnel (Cotabato Provincial Planning Office, Disaster Risk Reduction and Management [DRRM], Department of Agriculture [DA])	Thematic Transcript/ Document Analysis
Government climate change actions	FGD and interviews	Provincial Office Personnel	
	Review of documents	Intended Nationally Determined Contributions (INDC), National Climate Change Action Plan (NCCAP), Local Climate Change Action Plan (LCCAP)	

Respondents and Sampling Procedure

A target of 1,065 households equally divided among three clusters (Table 2) out of a total of 320,567 households in Cotabato was initially considered as a sample. The total number of households was taken from the latest available census data (2015) and the

sample size was computed at 95% confidence level and 3% margin of error. The actual sample size however, reached 1,526 households, as more respondents volunteered during the survey. This resulted in a higher confidence level, a narrower confidence interval and a more precise estimate of population characteristics.

Multi-stage sampling was used, starting with the selection of at most two barangays to represent each municipality. The selection of barangays was intended to be random. However, during actual data gathering, some mayors or their representatives advised against visiting certain barangays, primarily for security reasons. Respondents' permission to participate in the survey or interview was also crucial for data gathering. Thus, the inclusion of household samples in identified barangays was largely based on their availability and willingness to participate. Under these conditions, one barangay was selected from Kidapawan City and from the municipality of Alamada; two barangays were selected from each of the 15 other municipalities, for a total of 32 barangays.

Interview respondents were selected by purposive sampling. Household members with at least ten years of farming experience in the barangay were the main criterion in the selection. An elderly household member was specially targeted during the conduct of interviews as they had more experience with local climate variability and how farming changed over time. In most cases, family members present at the time of the survey or interview altogether provided the information for the study.

Table 2. Distribution of sample by legislative district with clustered municipalities.

District (Municipalities)	Household Population	Target Sample Size (at 95%, CI = 5)	Actual Sample (99%, CI = 3.3)	Percentage
1 (Alamada, Aleosan, Libungan, Midsayap, Pikit)	106444	355	509	33.35
2 (Antipas, Arakan, Kidapawan, Magpet, Makilala)	106501	355	524	34.38
3 (Carmen, Kabacan, Matalam, Mlang, Tulunan)	107622	355	493	32.30
Total	320,567	1065	1526	100.00

Data Analysis

Quantitative analysis was done using descriptive summaries such as frequencies, percentages, and means. Data from survey are represented visually using graphs and tables to illustrate trends, and generalizability whenever necessary was shown using some inferential statistics such as the chi-square test.

Qualitative data from interview of farmer households was processed using NVivo 12. Salient themes and nodes that came out of the process included climate variability, climatic events and hazards, changes in farming patterns, impacts of changing weather patterns and other hazards, knowledge of climate change, local government assistance, other vulnerabilities, reliance on farming for income, and social impact of climate change.

Data presentation for the study made use of side-by-side comparison merged data analysis strategy as described by Bian (2018). Quantitative and qualitative analyses were intended to complement each other to provide an elaborate perspective on the vulnerabilities of farmers. When juxtaposed with each other, they can provide in-depth portrayal of how these vulnerabilities interact with climate change impacts.

Results

Vulnerability of Farming to Climate Risks

The climate type of Cotabato province was originally Type IV, along with all other provinces in the SOCCSKSARGEN Region (Coronas' Modified Classification of Climate 1951-2003). Climate Type IV is characterized by rainfall which is evenly distributed throughout the year. This climate type greatly favored the farming activities of the province. The even distribution of rainfall in a year sustained the water needs of its farm areas which mostly are non-irrigated.

However, in recent years, Kidapawan City, together with 16 of the 17 municipalities, was reclassified to climate Type III (see Figure 1). According to the Cotabato PPO only the municipality of Arakan and some of the elevated portions of Magpet, Makilala, Tulunan, and Kidapawan City remained totally classified as Type IV climate. The reclassification of almost all parts of Cotabato to climate Type III indicates that seasons in the province are currently no longer very pronounced. Among the four provinces in the SOCCSKSARGEN, only Cotabato was reclassified to Climate Type III, indicating a more drastic change in climate experienced in this part of the region.
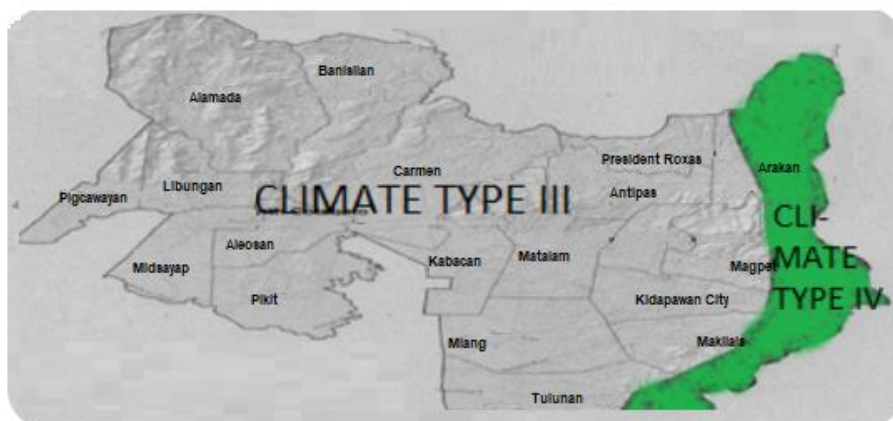

Figure 1. Climate type classification of Cotabato municipalities.
(Source: Cotabato Provincial Planning Office)

Under the mid-range scenario, the projected increase from historical observed mean temperature in Cotabato was 1.0 to 1.3 by 2020 and 2.1 to 2.5 by 2050 (PAGASA, 2011). This projected mean temperature increase in Cotabato Province is higher than in other provinces and in the whole country. Under the medium emission range scenario, average temperature in the Philippines is estimated to increase annually by 0.9°C to 1.1°C in the 2020s and 1.8°C to 2.2°C in the 2050s (PAGASA, n.d.).

Climate variability in the province was highly noted among interview respondents. They particularly indicated the erratic, unpredictable weather pattern. The unpredictable weather condition renders farmers vulnerable as their traditional knowledge of seasonal calendar no longer applies. The planting season has shifted and no longer coincides with the farmers' usual schedule. This has a significant impact on farming activities, especially of farmers in non-irrigated areas who engage in seasonal crops such as rice and corn.

In previous years, planting was synchronized with the rainy season to sustain crop water requirements. Harvesting was done on dry months to facilitate easy transport of produce and sun-drying activities. The long years of farmers' exposure to predictable weather patterns enabled them to create a definite seasonal calendar for rice and corn crops. The changes in weather patterns have disrupted the established seasonal calendar. According

to interview respondents, current farming condition is hard because their calendar no longer applies. The season becomes dry during the expected months of rain for the planting season. Rain arrives unsuspectedly during harvest season and causes damage to crops. Farmers lament the damage to crops because of long droughts and heavy rains especially if planting involved borrowed capital with interest. In the study of Galang (2020), the borrowing incidence is 56.57% among palay households and 30.52% among corn farmer households in the Philippines. Some farmers choose not to "gamble" with planting for fear that their households would suffer more if the borrowed capital cannot be recovered in the event of crop failure.

Climate change presents dire consequences among farmers of Cotabato Province as agricultural production and the number of cropping seasons can be significantly reduced. In non-irrigated areas, rice farming was reduced to one cropping per year (Digal & Balgos, 2017). Table 3 reflects the reduction in rainfed rice and corn crop yields. The year 2014 is used as baseline, being the year prior to the 2015-2016 drought.

Table 3. Rice and corn area and production in Cotabato Province, 2014-2019.

Year	Irrigated rice		Rainfed rice		Corn	
	Area (ha)	Production (MT)	Area (ha)	Production (MT)	Area (ha)	Production (MT)
2014 (Baseline)	93,600	418,669	35,852	111,360	130,699	414,630
2015	91,561	377,350	34,045	97,735	125,695	369,766
2016	83,517	348,735	28,881	85,222	108,820	317,336
2017	93,011	402,130	32,857	98,108	111,946	343,070
2018	93,620	419,615	33,510	104,344	113,022	355,917
2019	93,054	385,328	30,493	82,409	109,160	294,569
Average	91,394	391,971	32,606	96,530	116,557	349,215

During the five-year period, rainfed rice and corn crops were not able to recover and match the 2014 production in area and volume. Rainfed rice production area was reduced by 14.9% and yield by 25.9% in 2019 against the baseline. On the other hand, from 2014 to 2019, corn production area was reduced by 16.5%, while yield was reduced by 29.0%. Irrigated crop yields were also significantly reduced during the 2016 drought. In times of drought, limited water source results in constraints and rationing of irrigation services to farmers. Irrigated areas are also subjected to pest damage when surrounding non-irrigated farmlands are abandoned or left unproductive due to insufficient rainfall.

Table 3 also shows that rice production is significantly lower in rainfed than irrigated areas during the five-year period (2.96 MT·ha^{-1} and , 4.29 MT·ha^{-1} respectively). The majority of the farms in Cotabato Province are rainfed-dependent. Among the survey respondents, 58.3% work in rain-fed farm areas (Figure 2). Of the areas planted with various crops in the province, only 22.3% are irrigated as of 2019 (PSA, 2020b). These irrigation facilities are restricted to rice only. As of December 2015, only 29.94% of the estimated irrigable area in Cotabato province, the lowest in Region XII, was reported to be serviced by an irrigation system (National Irrigation Administration-Region XII, 2015). A National Economic and Development Authority (NEDA, 2017) report also indicated a reduction in the number of irrigated areas in the SOCCSKSARGEN Region between 2014 and 2015. In Cotabato, this downward trend continued as of 2019. The reduction in irrigated areas is partly due to the damages in irrigation facilities, which interview respondents attribute to strong rains, poor

management, and the rice field owners' failure to pay for the irrigation fees resulting in poor maintenance. The use of water pump is not an economical option for farmers as it requires extra fuel because the water table in Cotabato areas such as Mlang is too deep (Digal & Balgos, 2017).
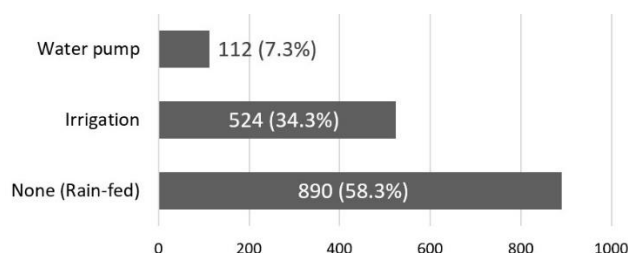

Figure 2. Water resource of household respondents (n=1526).

Farmers have expressed that groundwater is becoming insufficient. The extreme heat has also caused groundwater to easily evaporate. According to them, even with a week's worth of rain, the soil easily dries up and the water dissipates in just four or five days because of extreme heat. In Kidapawan City, dry spells reduced the water production from spring sources by 15-20% (Cadelina-Manar, 2020). Natural forests that can hold water under the soil are absent in most areas where the research team visited. Patches of trees and shrubs that are present in some farm and residential areas are objectively not enough to hold water in the ground.

Aside from physical impacts, the farmers' labor patterns have also shifted following changes in the climate. Extreme warm conditions have made farming activities difficult and unbearable for farmers. Observed data for Cotabato in the last decade shows daily high temperature averages ranging from 30.9°C to 32.3°C and the corresponding heat index is usually above 37°C. This condition is directly felt by farmers and the unbearable heat results to reduced farm hours. According to interview participants, this has forced them to significantly shorten on-farm engagements to at most half a day, with workers taking a break between 10AM to 3PM.

Socio-economic Impact of Climate Variability

Figure 3 shows the socio-economic impacts of climate variability to farmer respondents. Low agricultural production was identified by about 74.8% of survey respondents. Interview participants elaborated that this is due to the decline in planting activities, crop damage, or decline in quality of the crops produced due to insufficient rainfall, unexpected heavy rains, and/or extreme heat.
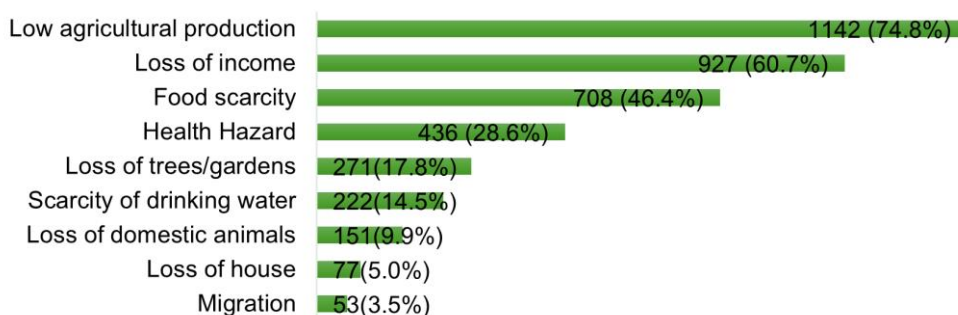

Figure 3. Socio-economic impacts of climate change to respondents.
(multiple response item, n=1526)

The low production naturally leads to loss of income. This is the second most impactful effect of climate change identified by 60.7% of survey respondents. Interview respondents also associated loss of income to the increasing expenses in farming. They emphasize the present difficulties in tending a farm such as the decline in soil quality; hence the need for fertilizers as well as increase in pests that need to be controlled. Farm inputs have also become expensive especially because of the pressing need to choose seeds that can better survive the weather. Moreover, irregular rainfall and extreme heat cause ground water to dissipate quickly that necessitates farmers to outsource water to feed the plants. This results to additional expenses for outsourcing water using water pumps in increasing frequency among some farmers. Poor marketability of low-quality farm produce due to unfavorable weather is another source of income loss to farmer respondents.

Extreme heat also limits the work input of farm owners and forces them to hire help, which adds up to their expenses. On the other hand, there is a significant number of farm workers whose main incomes are derived from farm labor. Lack of rainfall and drought events significantly reduce or even totally cut their income during times when agricultural activities are minimized or even halted. Moreover, even when labor is available, on-farm engagement is also reduced because workers cannot bear the heat of the sun and consequently, lose their income. According to interview respondents, the limited capacity of laborers during extreme conditions eventually led some farm owners to mechanize farm activities. This shift to technology is claimed to be efficient and beneficial to farm owners but impacts the income of farm laborers.

The limited production and income contribute to the scarcity of food in farmer households. Scarcity of safe drinking water during long droughts was also reported as well as health hazards mostly associated with extreme temperatures. There was also a loss of trees/gardens, domestic animals, and even the loss of houses to floods. The climatic events that occurred in the province also caused the migration of some relatives to other places.

Farmers' Exposure to Climate Hazards

The frequency of climatic events experienced in Cotabato exacerbate farmers' vulnerability.   Figure 4 shows the hazards experienced in the past years as recalled by survey respondents.   Among the climatic hazards, a large majority (79%) has recalled drought, and many respondents also experienced pests (59%) and floods (37%). Interview respondents also indicated that the frequency of climatic events in the province increased in recent years. For example, according to them, drought used to happen around once in every ten years but has occurred more frequently in recent years. Confirming this observation are various sources reporting droughts happening in the Philippines in 1911, 1958, 1968, 1972-73, 1982-83, 1986-87, 1997-1998, 2010, 2015-2016, 2019 (Flores, 2019; Israel & Briones, 2013; "Remarkable drought in the Philippines", 1913; van Huysen, 2015). Cotabato Province is affected by the recent droughts that hit the Philippines. In addition to climatic events, respondents mentioned to have experienced other hazards such as epidemics or health concerns (4%) and armed conflict (13%).

The intensity of climatic events occurring in the province has also increased according to interview respondents. Most recalled the intense droughts in 2016 that caused massive damage to their lives. A strong wind was considered as second most damaging calamity especially to permanent crops such as rubber and banana. Almost all affected farmers considered a massive effect of this calamity because replanting permanent crops means longer years to wait before income can again be realized. Pests and landslides emerged as the third most damaging calamity to farmers. In 2016 alone, rats famished due to the long droughts which consequently destroyed PhP 84.5 million (about $1.66 million) worth of crops in Cotabato (Cervantes, 2016). Climate change is expected to alter pest and disease outbreaks (Harvey et al., 2014).
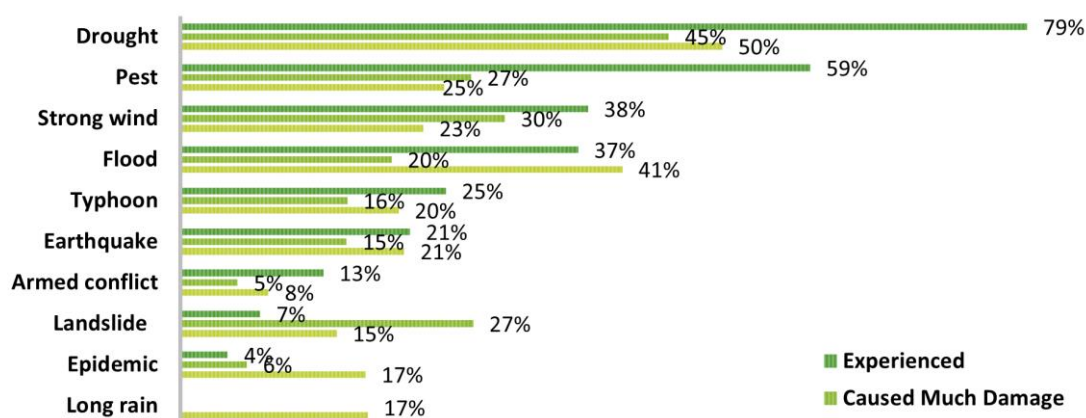
Figure 4. Percentage of respondents according to experienced hazards recalled, caused massive damage, and expected to recur (multiple response item, n=1526).

Landslide has a massive effect on farmers because eroded lands are lost forever, which leaves affected farmers totally landless. Cotabato is highly exposed to rain-induced and ground-shaking-induced landslides. The erosion problem in the province has reached alarming levels. According to Cotabato PPO, over the past 10 to 15 years, 23% percent of the land area in Cotabato has been severely eroded. Only 11.4% remains stable from erosion.

The province is also most exposed to earthquakes. Further, the level of exposure of the agriculture sector in 17 of its 18 municipalities/cities is high. Table 4 shows the number of municipalities in Cotabato province with population and agriculture exposed to different levels of hazards.

Table 4. Number of municipalities in Cotabato exposed to different levels of hazards (n=18).

Hazard	To Population			To Agriculture		
	Level of Exposure			Level of Exposure		
	Low	Medium	High	Low	Medium	High
Flood	9	3	6	10	0	6
Landslide	17	1	0	17	1	0
Earthquake	1	1	16	1	0	17
Liquefaction	11	2	5	11	2	5

Source: Cotabato Enhanced DRR/CCA Enhanced Provincial Framework Plan, 2013-2019

Drought was also perceived by survey respondents as having the most chance of recurring followed by floods, landslides, typhoons, and long rains. Farmers in the province feel more vulnerable due to the recurrence of calamities before fully recovering from the previous one. This has a major impact on the social conditions of farmers, which is another aspect of the farmers' vulnerability.

Social Vulnerability of Cotabato Province

Social vulnerability refers to the susceptibility of the community to adverse conditions such as the effects of climate variability and extremes. It includes factors that weaken the community's ability to prevent human suffering and financial loss in the event of a disaster.

In the case of Cotabato, the age group and education of the province population are some sources of its social vulnerability.

Vulnerable Age Group

Cotabato Province has a population of 1,490,698 in the 2020 census—the highest among the four provinces in the SOCCSKSARGEN Region (PSA, 2021). Its annual population growth rate is 1.64%, which is highest among the provinces in the region and higher than the national population growth rate of 1.63%.

Children and adolescents in developing countries are considered the most at-risk to disasters (Bartlett, 2008). Children and adolescents (up to 19 years old) constitute 43% of the total population in Cotabato Province with children in the age group of five to nine years old having the highest percentage (PSA, 2022). Children, particularly, if living in poor conditions are most vulnerable to the resulting health risks from climate change and lower exposure to health consequences (World Health Organization, 2021). They are also dependent on their parents or guardians for needs, provisions, and decisions. As such, their welfare is largely contingent upon the adults' capacity to respond to their needs.

The elderly (65 years old and above), which is also another vulnerable group, form 7.7% of the population. The low percentage can be attributed to the high birth rate; hence, the surge in the young populace, as well as low life expectancy in the province. Based on the 2015 census, the life expectancy of males in Cotabato Province is only 62.27 years (PSA, 2020b). This is lower than the national life expectancy of 68.72 years (PSA, 2020b) and significantly lower than the world average life expectancy of 72.6 years (Roser et al., 2019). On the other hand, the female life expectancy is 72.58 years, which is also lower than the national life expectancy of 74.74 years. The low life expectancy has implications for the health status of farmers in the province which was also highlighted by the interview participants of this study.

Census data show the percentage of the population in the vulnerable age groups constitutes more than half of Cotabato's population. Combined, the youth and old age dependency ratio as defined by the United Nations (2007) shows that for every 100 actual or potential working population, 61 dependents share the income.

Education Vulnerability

In the 2015 census (Figure 5), a large percentage (3.2%+6%+41%=50.2%) of Cotabato's population aged 5 years old and above have not stepped beyond the elementary level. Estimates show that about 35% of the population aged 15 years and above did not go beyond elementary education. College graduates constitute only 7.2% of the population. As such, a large number of Cotabato farmers are potentially vulnerable to the impacts of climate change based on their level of education.
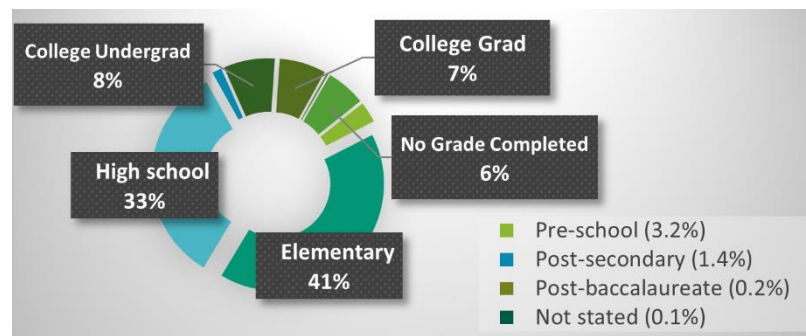

Figure 5. Distribution by educational attainment in Cotabato Province 2015 census of population (Source: PSA, 2020b).

Socio-economic Vulnerability of Farmer Households

Social conditions significantly affect the degree to which farmer households are affected by climate change and their ability to cope with the impacts of climate change. The multiple poverty, low formal education, limited farm assets, and constrained farming practice of farmers can compound the challenges posed by climate change and vice versa.

Table 5. Household size and dependency rate among survey respondents (n=1420 responses).

Household Size	Frequency	Percent
3 Below	357	25.1
4 - 6	827	58.2
7 - 9	202	14.2
10 Above	34	2.4
Standard deviation: 1.92		
Average number of working household member: 1.5		
Average number of non-working household member: 3.3		
Average household dependency rate: 67%		

Household Size and Income Sources

Table 5 shows that the majority (58.2%) of households in the survey have four to six members. The average household size is 4.8 and the average number of earning members per household is only 1.5. The household dependency rate of 67% was computed by dividing the number of non-earning household members by the total. Larger households require more food and other basic needs, which strain the household's ability to cope with climate shocks. This is exacerbated by the condition that most of the family members are economically dependent, and the primary source of earning family members is unstable. Table 6 shows that the main source of income among earning family members is contingent on farming activities (57.1%) and the availability of labor/service contract jobs.

Table 6. Primary source of income among earning household members (n=1547 responses).

Source of Income	Frequency	Percent
Farming	883	57.1
Farm labor	144	9.3
Service labor (ex. carpentry)	133	8.6
Vending	101	6.5
Tenured employment (ex. teaching)	82	5.3
Contractual employment (Ex. guard)	64	4.1
Rubber tapping	56	3.6
Barangay local government unit work (ex. Citizen Armed Force Geographical Unit)	26	1.7
Domestic employment (ex. helper)	22	1.4
Work outside Philippines	18	1.2
Others (business, livestock)	18	1.2

Economic Condition

Economic condition is a significant factor in understanding the capabilities of a household. Households can have difficulties adapting to climate change if they do not have sufficient income to sustain their needs.

The majority (66%) of the farming households indicated a meager monthly family income of PhP 5,000 (about $98) or below (see Figure 6). The average income during the survey is PhP 6,002.00 (about $118) for households of about five members on the average. Results of the 2018 Family Income and Expenditure Survey (FIES) indicated that the economic threshold for a Filipino family with five members is PhP 10,727 (about $210) per month (PSA, 2019). The average income of household respondents is far below the poverty line which is why about 74% of households surveyed indicated they are experiencing bad economic conditions with 34% of them stating that it is very bad.

Of 1145 households who provided complete data on financial status, only 86 (7.5%) have earnings falling within the range of what they consider sufficient. Figure 6 illustrates that most respondents (69%) indicated that they needed a monthly income ranging from PhP 7,501 to PhP 20,000 (about $147 to $392) to sufficiently sustain the needs of their households. On average, farming households indicated a monthly income of PhP 13,952.00 (about $274) to be economically sufficient. The farmers' actual average earnings only constitute half of what they need. Farmers, therefore, need to be facilitated to at least double their present earnings to meet their needs.
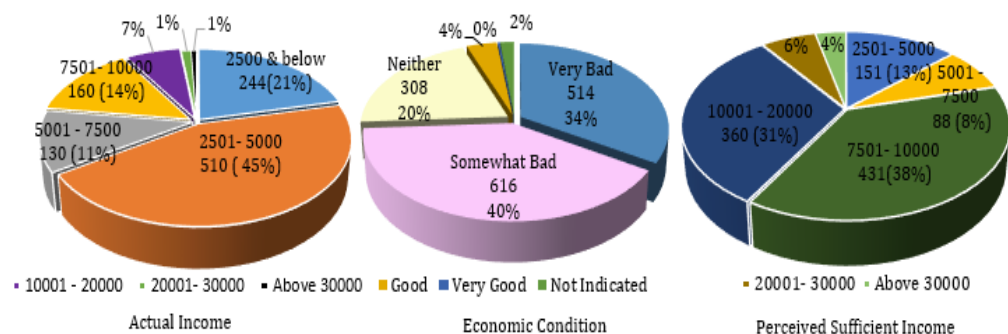

Figure 6. Economic condition of household respondents.

Multiple Poverty

The Multiple Poverty Index (MPI) used to identify indicators of poverty among farmer households corroborates the census data. The MPI is an international measure of acute multidimensional poverty which reveals combinations of deprivations. Table 7 reveals the incidence of deprivation on each indicator in the sample households.

The global MPI computation (OPHI, 2010) was followed to capture multiple deprivations in the following indicators: education, health, and living standards. Results in Figure 7 show that 45% of farming households are multidimensionally poor. These households experience combinations of deprivations that result in a multiplicity of burdens acting together to keep a household poor (Alkire & Santos, 2010). The highest deprivations among multidimensionally poor households were in the realm of living standards in mobility assets (98%), clean cooking fuel (94%), and safe house type (82%). Schooling deprivation is higher among multidimensionally poor farmer households at 64%. It can continue to plague these households as 33% of them revealed that there are school-aged children in their households not attending schools for Grades 1 to 8. Malnutrition is also high at 34% with a mortality

incidence of 13% in these households. Although this study failed to include chronic illnesses in the survey as part of health indicators, it was revealed in the interviews that health problems such as renal failure, diabetes, and hypertension severely exacerbate the vulnerability of many farming households primarily because of health expenditures and living constraints.

Table 7. Incidence of deprivation among farmer households (HHs) (n=1526).

Dimension	Indicator	Deprived if…	% Deprived
Education	Schooling	No HH member has completed at least 6 yrs. of school*	39.3
	School attendance	School-aged child in the HH is not attending school in Grades 1 to 8	18.1
Health	Mortality	Any child has died in the family	10.2
	Nutrition	Any adult or child is malnourished	18.1
Standard of living	Electricity	The HH has no electricity*	13.6
	Water	The HH does not have access to clean drinking water within a 30-minute walk*	13.6
	House type	The HH has soil or sand floor/house made of light materials	66.0
	Sanitation	The HH has no clean toilet or shared with other HHs*	17.6
	Fuel	The HH does not use clean cooking fuel (The HH cooks with wood or charcoal)	95.6
	Assets	The HH does not own communication and mobility assets*	95.8

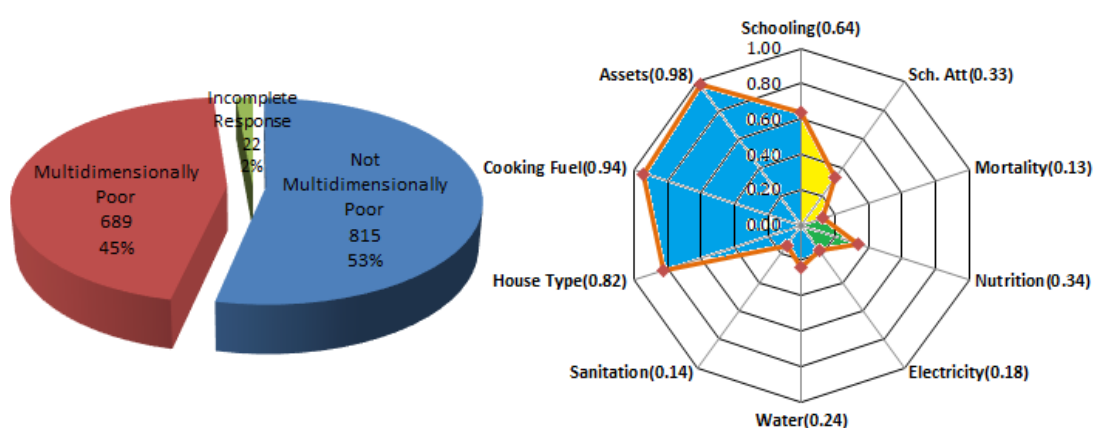*These indicators were worded positively in the survey questionnaire

Figure 7. MPI classification of household respondents (n=1 526) and interaction of MPI indicators among multi-dimensionally poor households (n=689).

Farm Ownership and Size

Table 8 shows that only 49% of the households own farms they themselves cultivate with land areas ranging from one-fourth to 20 hectares. Farm ownership enables farmers to combine a set of physical resources and farm tenure to carry out strategies to adapt to climate change (Defiesta & Rapera, 2014). It also provides them extra privileges. Several government projects are contingent on farm ownership rendering a large percentage of farmer households as not eligible beneficiaries. For example, assistance in the form of distribution of crop seedlings by the Department of Agriculture were available to farm owners only.

Table 8. Tenureship and farm areas owned or cultivated by respondents (n=1526 households).

Land tenureship			Farm areas owned/cultivated				
Category	n	%	Mean	s.d.	Min (ha)	Max (ha)	Mode/ Median
Owner	746	49.0	2.5	2.3	¼	20.0	2.0
Lessee	79	5.0	1.7	1.3	¼	7.0	1.0
Lessor	27	2.0	1.5	0.8	¼	3.0	2.0
Tenant	348	23.0	1.9	1.4	¼	10.0	2.0
Worker	326	21.0	--	--	--	--	--

About 5% are amortizing owners or lessees of the land they cultivate with areas up to seven hectares. As non-owners of land, lessees are bound to their contract with landowners and hence, their options are constrained. Some of these households are financially capable but unable to own land, especially inherited land because ownership was not properly transferred. Also, farm owners who are financially constrained are only willing to temporarily lease the area. About 2% of the households had all their farm areas on lease with areas ranging from ¼ to three hectares. According to respondents, farmlands are temporarily leased for various and/or compounded money needs such as school expenses, hospitalization, or to finance a family member's application for work abroad.

About 23% of the households are tenants or maintainers who constitute respondents under tenancy farming—the second largest group in the survey. These farmers do not own the land, but for an agreed period permanently tend the farm of some landowners. A significant population of farmers (21%) consists of farm laborers or harvesters. Because farm labor is not permanently available, laborers do not have fixed work and income. They mostly live according to day-to-day income; their survival depends on getting work for the day. Combined, 44% of the respondents are totally landless and work as tenants or laborers. The income of farmer households leaves them incapable to own and maintain farms.

The average farm size cultivated by respondents is 1.77 hectares, with owners cultivating significantly bigger farmlands than lessees and lessors. According to the Department of Agriculture Provincial Office, some government projects are also tied to farm size because the efficiency of farm equipment and other inputs cannot be maximized when farm areas are small.

Farming Practice: Mono-cropping Versus Crop Diversification

Table 9 shows the crop area allotment of respondents. Temporary crops such as rice and corn dominate their farm produce (45.1%+18.7%=63.8%) with an average area of 1.49 hectares for rice and 1.34 hectares for corn. Most farm areas in Cotabato are planted with temporary crops (PSA, 2020a). Many of the interviewed households see these short-term crops as their only option because they only need to wait about three months before harvest, and the family can already have money and food. Smallholder farmers are living on

subsistence and cannot afford to wait several years before realizing an income as required in permanent crops such as rubber and coconut or longer cropping seasons such as in banana and sugar cane.

Crop diversification or mixed cropping distributes risks across different crops, making failure recovery easier as compared to concentrating capital on a single crop. However, Table 10 shows that only 24.9% of the respondents with land tillage (owner, lessee, and tenants) indicated diversifying crops. A large majority 75.1% engaged in mono-cropping.

Table 9. Area allotment for crops by farmer respondents.

Crops*	Frequency	Percent	Average Size (ha)
Rice	688	45.1	1.49
Corn	285	18.7	1.34
Rubber	283	18.6	2.14
Coconut	219	14.4	1.76
Sugarcane	37	2.4	1.54
Banana	101	6.6	2.19
None	326	21.4	

*Multiple response item

Land size is a significant factor in the farmers' decision whether to maintain mono-cropping or diversify. Owners of small farmlands concentrate their limited area on a single crop. In Table 10, 82.4% of respondents with areas of less than 3 hectares do not diversify crops. The practice of crop diversification becomes more frequent as farm area increases that is, 54.5% among farmers with areas between three to five hectares and 93.2% among farmers with more than five hectares. The chi-square test shows a significant relationship between farm size and crop diversification (χ^2= 227.4, p < .001).

Owners of larger farmlands have more capital and area to invest in a variety of crops. They can as well diversify into long-term crops such as rubber as they have the financial means to sustain family needs during the waiting period for major crops to become productive. This reveals that the practice of crop diversification is not just a matter of farmers' willingness and agency to do so. It is heavily constrained by its financial and physical resources. These constraints need to be addressed to make farmers adapt well to climate change.

Table 10. Farming practice of farmer respondents with land tillage (n=1173 households).

Farm Size	Monocropping		Diversified Cropping		
	n	%	n	%	Total
Below 3 Ha	827	82.4	177	17.6	1004
3 To 5 Ha	50	45.5	60	54.5	110
Above 5 Ha	4	6.8	55	93.2	59
Total	881	75.1	292	24.9	1173

Chi Square Value = 227.4***   df = 2   Probability <.001

Government Actions to Address Climate Change

Agriculture is recognized as a key sector in climate change initiatives as embodied in the Climate Change Law (2009) and Intended Nationally Determined Contributions (INDC, 2015) of the Philippines in the Paris Agreement.

The scope of the Climate Change Act of 2009 is comprehensive. Through it, the Office of the President has mandated the creation of the Climate Change Commission (CCC, 2016). The CCC is tasked to oversee policymaking regarding climate change, create programs and action plans, and apply monitoring and evaluation. One key output of the CCC is the creation of the National Climate Change Action Plan (NCCAP). The NCCAP outlines national frameworks, strategies, and policies in climate change mitigation and adaptation. It highlights the significance of Cotabato as a prime food producer in Mindanao and recognizes the susceptibility of the province to the impacts of climate change, particularly the increasing frequency of droughts. The NCCAP serves as the basis for the Local Climate Change Action Plan (LCCAP) developed by the provincial government and cascaded down to the municipalities and barangays.

The LCCAP of the Cotabato Province focuses on three sectors: power, education, and the cluster of agriculture, fishery, and livestock. Within the agricultural sector, there are 13 planned programs; all of which are under the auspices of the Department of Agriculture in the province.   These are shown in Table 11.

The Cotabato Province LCCAP intends to build the resilience of its agriculture sector primarily through the diversification of crops, which is apparent in the 13 planned programs it constitutes. Of the 13 programs, six involve crop diversification (from rice and corn), four on agroforestry, two on organic farming, and one on crop production and protection.

Further, four of the six programs on crop diversification are concerned with the distribution of planting inputs such as 1.) high-value crops, which include rubber, coconut, and coffee; 2.) abaca; 3.) fruit trees; and 4.) root crops. The other two are intended to strengthen high-value crop production through the establishment of high-value crop demo farms and the provision of salt fertilizers for coconut.

However, this study has shown that many of the farmers are unable to participate in crop diversification, not for a lack of willingness but because of constraints in their decisions. The LCCAP, for its part, has not considered other aspects, contexts, and vulnerabilities of farmers that inhibit them from coping and adapting to climate change. Because many of the projects including those of the DA are linked with land ownership, many farmers are not able to partake in the government adaptation projects.

More importantly, the LCCAP only focuses on crops and making crops resilient. Plans that take into consideration the social conditions of farmers are absent in the document. Deprivations in the context of farming communities are not recognized. Many farmers are therefore excluded from the local policies and government programs. They are left to fend for themselves during times of disaster and amid climate change. As such, they are further marginalized and exposed to climate risks.

Gaps in Policies and Implementation

Philippine policies and laws attempt a comprehensive task at defining the Philippine actions towards climate change mitigation and adaptation in the agriculture sector. The NCCAP, for example, includes plans of action for food security, water sufficiency, human security, and capacity development that directly impact Filipino farmers. However, a few gaps in the already established policies and laws were highlighted based on document reviews and discussions with Disaster Risk Reduction Management, Planning and Development, and the Department of Agriculture in the province.

Table 11. Cotabato Province Local Climate Change Action Plan (2017-2019) programs for agriculture sector.

1. High-Value Crops Development Program, which includes distribution of planting inputs such as rubber, oil palm, coconut, cacao, coffee, banana varieties, bamboo, and forest trees

2. Creation of the Amas Agro-forest Nursery that is intended to produce as well as disperse fruit tree seedlings that are ready to be planted

3. Procurement of forest tree seedlings from the Cotabato Provincial Forest Eco-tourism Park (CPFEP) in Amas and their dispersal

4. Maintenance of the CPFEP

5. Development of High Value Crops Demo Farm for oil palm, cacao, coconut, rubber, and coffee

6. Coconut Fertilization Project, which includes the provision of salt fertilizer to coconut farmers

7. Cotabato Abaca Development Project, which involves the provision of abaca planting materials to farmers

8. Techno Demo sa *Organikong Pagsasaka sa MRF* (Organic farming program)

9. Provincial Root Crops Production Program, which involves the production and distribution of planting materials for root crops

10. Vegetable Production and Seed Dispersal Program

11. Crop Creation Program, which includes providing trainings on crop production and protection from diseases and pests; and provision of crop protection supplies and materials including environmentally-friendly biological control agents

12. Trainings on agro-forestry and intercropping

13. Development of organic farms, which also includes training farmers on how to produce healthy and safe crops

The jurisdiction, responsibilities, and scope of the Climate Change Commission remain unclear. Corollary to this, the delineation of responsibilities and the model for synergies are undefined and are also unclear. The thematic approach of the NCCAP and LCCAP also sacrifices responsibility-taking for each government agency. Climate change policies and programs must be implemented across multiple government agencies and sectors, and effective coordination is necessary to ensure that actions are aligned and mutually reinforcing. Interviews with provincial agencies involved in climate change indicated the problem of interagency coordination and jurisdiction in program implementations.

The NCCAP does not prescribe specific climate change activities. Specific activities and programs that can tackle the capacity and resilience of farmers are meant to be offered by the LCCAP and addressed through needs-based projects. There is however a disjoint between national policies and how they are conceptualized on the ground. For example, the NCCAP emphasizes social protection mechanisms, but this is lacking in the LCCAP. The 2019 LCCAP of the province only focuses on three key sectors and does not yet cover the extent and comprehensiveness of the NCCAP. Also, the programs and policies focus only on the crops and not necessarily on the social lives of farmers.

There is also an issue with implementation capacity. Effective implementation of climate change policies requires strong institutional capacity, including personnel and adequate systems for monitoring and evaluation. In the context of Cotabato Province, there is still a lack of capacity to address climate change mitigation and adaptation, particularly within the context of farming communities. For example, the province does not have enough physical,

financial, and human resources. The province is still less effective when it comes to scientific assessments. The provision of early warning systems is also limited to certain municipalities only. As reflected in the interviews with the officials of the Cotabato Province, there is a need to strengthen capacities in knowledge management and establish a comprehensive database to enhance the province's overall capacity to address climate change. A work in progress is the SOCCSKSARGEN Regional Geographic Information Network (SOXRGIN) Geoportal. Informed decision making is important since many of the proposed policies and programs are yet to materialize.

Lastly, the programs and policies mostly focus on the crops and making crops resilient, not necessarily on the social lives of farmers. Mitigation in the Philippines is concentrated on Land Use, Land Use Change, and Forestry (LULUCF). There is also a high consideration for high-value crops which does not benefit the majority who are smallholders or landless farm workers.

Discussion

Climate change is a pressing threat in the lives of Cotabato farmers because of their contextual vulnerability to climate change. This vulnerability manifests itself in social, economic, and structural ways.

First, the livelihoods of farmers are at stake because of the dependency of their crops on the weather. The observed changes in climate brought with it disruptions in their livelihoods such as loss of reliability of their previously established and held-on seasonal calendars as well as the destruction of crops and crop failures. The previous climate permitted as much as three planting seasons for rice and corn in one cropping year (Gerpacio et al., 2004). These crops, according to the PSA (2020a), occupy the largest production area in the province. Seasonal calendar guided farming activities in the province and farmers are heavily reliant on it. Disruptions in livelihood result in loss of income that exacerbates poverty (Herrera et al., 2018).

Second, there is a high percentage of vulnerable groups in the population of Cotabato. These vulnerable groups consist of the aged and young populations who are dependent on adults for their needs, sustenance, and decision-making. The presence of many vulnerable groups in the population and in the households has implications on overall productivity and can put a strain to resources as they may require additional support.

Third, the vulnerability in the province is tied to education. Education capacitates people and gives them tools to cope and adapt (Muttarak & Lutz, 2014). However, based on the census, a large percentage of people in Cotabato lacks education. This is also true among the farmers surveyed for this research.

Fourth, farmers maintain big households with a high dependency rate. The income of the farmers is not enough to sustain the needs of their households, much less for non-basic expenditures. In fact, according to the farmers themselves, they need twice as much of what they presently earn to be able to live sufficiently. However, the main source of earning family members in most households is contingent on farming activities and the availability of service contract jobs. The lack of financial capital limits families from recovering or bouncing back from climate shocks and other disasters (Cutter, et al., 2003).

Fifth, using the Multiple Poverty Index, deprivations among Cotabato Province farmers are revealed to be multidimensional which result in a multiplicity of burdens that act together to keep a household poor (Alkire & Santos, 2010). The multiple forms of poverty experienced by farmer households expose them to more environmental risks and make them

more difficult to cope with the impacts of climate change. Multiple deprivations are difficult to manage, especially with the constraints on the financial resources of farmers. When climate change and disasters coincide with these deprivations, families further sink into poverty and are unable to recover and challenge adaptation and resilience to climate change.

Sixth, farm assets are unequally distributed among farmers in Cotabato Province. A large percentage of households do not own farmlands. People who do not own lands such as lessees, tenants and maintainers, and laborers are particularly vulnerable because they cannot make long-term decisions on farming practices and activities. Laborers are particularly vulnerable because their income is reliant on available jobs. Marginal farm size constrained farmers to take adaptation strategies such as crop diversification.

Seventh, many Cotabato Province farmers practice mono-cropping despite the benefits of crop diversification for climate change adaptation. This is, however, not because of the lack of willingness or information. Rather, constraints in terms of land ownership, land size, and financial capacities are major factors in choosing not to diversify crops. Monocropping is counterproductive in terms of cost-income benefits and its effects on climate change and land degradation (European Commission, 2021).

Lastly, local government policies and programs, largely overlook these contexts and conditions. Government programs tend to focus more on crop resiliency rather than on human lives. Several government programs are also tied with land ownership, thus, excluding the majority who are landless farmers. Furthermore, government actions are focused on crop diversification and seed distribution, which exclude the particular needs of farmers. Hence, farmers remain vulnerable to the impacts of climate change despite the existence of a plan that recognizes their plight.

Conclusion and Recommendation

Cotabato farmers are highly exposed to climate change and other hazards. Climate change is severely felt by farmers through increasing temperatures and erratic weather patterns that had repercussions on their seasonal calendar of farm activities and farm engagements and increased farmers' exposure to health hazards. Farmers' reliance on income from farming engagements with no stable water resources renders them highly vulnerable to the impacts of climate change. The decline in farm and labor engagement was apparent, consequently leading to low income and food scarcity. Their socio-economic conditions such as income and income sources, farm ownership, and farm size limit their capacity to cope with climate change stresses to a large extent. These vulnerabilities are exacerbated by the need for high farm inputs due to climate-induced factors such as a decline in soil quality, the emergence of pests, and the need for seeds that can better survive the weather. The multiple forms of deprivation experienced by farmer households expose them to more environmental risks and make them more difficult to cope especially since a series of calamities come with them having not fully recovered from the previous disasters.

The different aspects of vulnerability investigated—the character of farming itself, population age groups, education, income, multiple deprivations, farm assets, farming practice, and limited government response—work together to characterize the vulnerabilities of farmers. They also exacerbate, compound, and reify each other. For example, the lack of income restricts farm acquisition, resulting in limited access to government programs that are contingent to land ownership.   Hence, the vulnerabilities of farmers can be pictured as a web that produces and reproduces itself.   Their susceptibilities and deprivations through education, poverty and lack of social support challenge their adaptation and resilience to climate change. A holistic view of these vulnerabilities is highly recommended in drafting programs and optimal solutions for the issues related to climate change in Cotabato Province. There

are constraints in government actions that need strong inter-agency coordination, investments in capacity building of government agencies and personnel, and clear provisions of social protection or safety nets for marginalized farmers.

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THE POTENTIAL OF SELF-LEARNING MODULES TO DEVELOP MATHEMATICAL REPRESENTATIONS AND CONNECTIONS IN DISTANCE LEARNING

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ABSTRACT

The use of self-instructional materials was employed among elementary school learners for learning continuity amidst pandemic where face to face instruction is prohibited. In this study, the researchers identified the features of representation and connections in the said instructional materials; the level of help the learning material offered as perceived by the learners; and the experiences of the learners on the use of self-instructional materials. Document analysis was done to 27 self-instructional materials in Mathematics 6 in order to find out the features; survey questionnaire was used to gather data from the grade 6 pupils who served as respondents to assess the level of help the self-instructional materials offer to them; and 10 pupils participated in the interview to account the experiences of the learners on the use of the said materials. The findings revealed that in terms of representation, visual representations were found in the sample activities and exercises in majority of the modules; however, these are seldom found in the assessment section. In terms of connection features, most of the connection features found in the sample activities, exercises and assessments are connections to real life situations. Meanwhile, the pupils consider the representations and connection features of the materials as helpful. The shared experiences of the pupils in the use of the self-instructional materials in Mathematics include: difficulty in learning from the self-instructional materials; lack of guidance in learning from the modules; self-fulfillment in learning; loss of interest in learning/demotivation.

Keyword *Connections, distance learning, experiences, interrupted face to face instruction, representations, self-instructional material or module*.

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1. INTRODUCTION

The recent pandemic is a crisis challenging the education sector to find ways of ensuring learning continuity without the conventional face to face teaching and learning environment. There is firm mandate of the President that face-to-face classes should be prohibited unless the vaccine for Covid 19 is available. In response to this, the Department of Education (DepEd) issued the Memorandum Order No. 012 series of 2020, the Adoption of the Basic Education Learning Continuity Plan for School Year 2020-2021 in the Light of the COVID-19 Public Health Emergency. The memorandum mandates the schools to deploy different learning modalities for learning continuity.

There are many options for learning continuity and online learning, or distance education is one of those. However, in the Philippines, particularly in the rural areas, internet connection is a problem; hence, online class as one of the options, is also challenging for both teachers and learners. Modular approach with the use of the Self-Instructional Learning Materials, is designed for self-instruction to attain learning objectives. It directs learners to

practice information; gain mastery of the concepts with the exercises given following the progression of activities (Nardo, 2017) [1].

It is indeed an acceptable fact that due to the natures of mathematics education, it can be better facilitated through face-to-face classes. Mathematics necessitate learners to have a grasp of what the abstract materials in mathematics are and connect their experiences to such. On the part of the teachers, they need to decompress and unpack the mathematics concepts for the students not to find it difficult to learn. Hence, teachers need to employ various strategies related to action learning and motivation and use motivating tools for learning mathematics (Abramovich, Grinshpan & Milligan, 2019) [2].

The K to 12 Curriculum for Mathematics particularly for the Grade 6 pupils clearly presented the learning standards stated as: "the learner demonstrates understanding and appreciation of key concepts and skills involving numbers and number sense using appropriate technology - in critical thinking, problem solving, reasoning, communicating, making connections, representations, and decisions in real life". In the context of Mathematics learning where demonstrations, illustrations and manipulatives are necessary in order of the learners to grasp the important mathematics processes, what then these instructional materials can do and will do to be able to help elementary school learners learn such processes?

Sejpal (2013) [3] claimed that self-instructional materials are more appropriate for mature learners. However, many schools implement the modular learning approach. In Kidapawan City Division particularly at Amas Central Elementary School, self-instructional learning materials are distributed to leaners. But as widely accepted fact, there is no approach in learning that fits all. There is question as to the potential of these materials to develop mathematical representations and connections among the pupils who are not directly in contact with the teachers for face-to-face instructions or classes. In addition, how do learners view the helpfulness of these materials in their learning?

The researchers noticed that there are limited literature pointing out the use of self-instructional materials in mathematics for elementary learners. With the use of such materials among the elementary pupils, the researcher finds it interesting to find out how these materials help learning mathematics processes. This research is very timely as educators and policy makers are trying their best to ensure that learning continuity is in place in the country. The researcher has not come across studies related to this since the phenomenon is new. This is the first school year where classes are interrupted for this longer length of time and teachers rely on the use of the instructional materials

1.1 Purpose of the Study

The purpose of this study was to explore the potential of the self-instructional materials to develop mathematical representations and connections. It also specifically accounted the perceptions of the pupils as to how helpful the learning materials are; and the experiences and challenges learners encounter while learning mathematics during the interrupted face to face instruction.

1.2 Research Questions

This study asked the following research questions:

1. What are the features of Self-Instructional Modules in Mathematics 6 in terms of visual representations and connections?
2. What is the level of help the Self-Instructional Modules in Math offers for the learners in terms of representations and connections?
3. What are the experiences of the learners while learning mathematics through the self-instructional materials?

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2. METHODOLOGY

This research employed both descriptive quantitative and qualitative research design. For Creswell, Plano Clark, Gutmann, and Hanson (2003) [4], the researchers can employ mixed method when there are research questions which can be better answered with the use of qualitative and quantitative data regardless of what data are largely gathered. It is also helpful when a researcher embeds within a quantitative design a qualitative aspect in the study.

In this study, quantitative design was applied in the research question which ask about the perceptions of the respondents on the extent of help the self-instructional materials in Mathematics offer for the elementary school learners during the interrupted face to face instruction. This can be assessed quantitatively since the respondents

rated the level of help the materials can give in learning mathematics process such as problem solving, reasoning and proof, representation and connections.

On the other hand, descriptive qualitative design was used for the research questions which ask about the experiences learners encountered while learning the self-instructional materials. Document analysis was also part of the qualitative design where the self-instructional materials were studied in terms of the features related to mathematical representations and connections.

3. RESULTS AND DISCUSSION

This section presents the findings of the study regarding the features of representations and connections in the module; the level of help of the module as perceived by the respondents; and the experiences of the pupils while learning the mathematics modules. This also presents the discussion of the findings; the implication for educational practice and future research.

3.1 Representation of the Mathematics 6 Self-Instructional Materials

The analysis of the representation features centered on two (2) aspects: the visual presentation of the concepts or lesson being taught with the use of pictures, illustrations, drawings, and other visuals; and the idiosyncratic presentation which refers to the presentation of concepts in pictures, illustrations, and drawings without number labels on them. The parts of the self-instructional materials being analyzed were categorized into sample activities, exercises and assessments consisting pre-assessment and the post assessment.

All the 27 modules in Grade 6 Mathematics were evaluated. Of these 7 (25.9%) did not use visual or idiosyncratic representations in parts of the modules evaluated. These 7 modules focused on solving routine and non-routine problems involving division without or with any of the other operations of fractions and mixed fractions, multi-step problems involving multiplication and addition or subtraction of decimals, dividing decimals up to 4 decimal places by 0.1, 0.01, and 0.001, differentiating repeating from terminating and non-terminating decimal quotient, solving multi-step problems involving division of decimals and any of the other operations, types of proportion and solving word problems on integer. All these mathematical concepts were presented in texts with no visual representation to facilitate learning.

Moreover, visual representation appeared only in sample activities and exercises part of the module. Under the assessments part, both the visual representations and idiosyncratic representations were not evident. A total of 20 (74.1%) from 27 modules were found to have representational features. Table 3.1 presents the representation features found in these self-instructional materials.

Table 3.1 Frequency of Mathematics 6 Self-Instructional Materials with Representation Features

| Parts of the Self-Instructional Materials | Representations (n=27) | | | | | |
| | Visual | | Idiosyncratic | | Total | |
	f	%	f	%	f	%
Sample Activities	19	70.37	1	3.7	20	74.1
Exercises	7	25.9	0	0	7	25.9
Assessments	0	0	0	0	0	0.0

As shown in the table, the sample activities have the highest percentage of occurrence in terms of visual representations where in 19 (70.37%) of 27 modules have these features. Meanwhile, 7 modules (25.9%) have visual representation in the exercises. All assessments in the 27 modules evaluated were not accompanied by both the visual representations and idiosyncratic representations.

Figure 1 shows a visual representation of one sample activity in the module. The sample word problem is being accompanied by a drawing meant to facilitate students' understanding of the problem context.
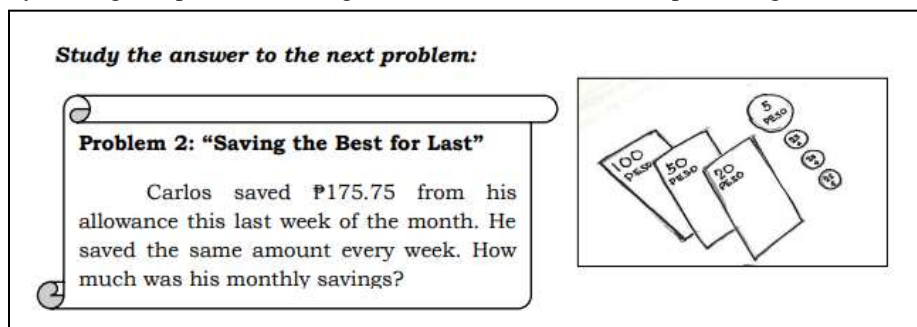
Figure 1. *Sample Visual Representation in the Sample Activities*

Figure 2 shows a sample visual representation from the exercises section of the SIM. In this sample the amount of money in the given problem is being reinforced with the visuals representing the amount of money.

Study the answer to the next problem:

Problem 2: "Saving the Best for Last"

Carlos saved ₱175.75 from his allowance this last week of the month. He saved the same amount every week. How much was his monthly savings?

Figure 2. *Sample Visual Representation in the Exercises*

The idiosyncratic presentation only appeared in 1 module (3.7%). As to the idiosyncratic representation, this is how the representation appears as shown in Figure 3. This is considered as idiosyncratic since the representation is not labelled with the number of fruits as given in the word problem. This, however, appears only in 1 out of 27 modules.

In a basket, there are 10 mangoes, 6 guavas and 8 chicos. What part of the total number of fruits are guavas?

Figure 3. *Sample Idiosyncratic Representation*

3.2 Connection Features of the Mathematics 6 Self-Instructional Materials

Table 3.2 presents the frequency of occurrence of the connection features in the sample activities, exercises, and assessments of self-instructional modules in Mathematics 6. The parameters being used in the evaluation for this feature are the connection to the previous lesson, connection to real-life context, and the connection to different solution strategies.

Table 3.2 Connection Features in the Mathematics 6 Self-Instructional Materials

Parts of the Self-Instructional Materials	Connection Features (n=27)					
	Connection to the previous lesson		Connection to real-life		Connection to different solution strategies	
	f	%	f	%	f	%
Sample Activities	16	59.26	20	74.07	11	40.74
Exercises	7	25.9	16	59.26	10	37.04
Assessments	0	0	15	55.56	0	0

Connection Features in Sample Activities. Connection features was found dominant in the sample activities part of the modules. For the sample activities, 16 modules (59.26%) features connection to previous lesson.

In figure 4, the lesson is about division of decimals. The sample activity shows a connection of the lesson to the previous topics. The material directed the learner to recall the concept about the decimal point; and tell the

learners to use their addition, subtraction, and multiplication knowledge in order to perform the division task during the presentation of the sample activities.

The decimal point allows you to write whole numbers and numbers with a fractional component using a consistent notation. This makes it more meaningful especially when you will be needing it to solve and seek solutions for certain concerns that you might want to address.

On a lighter sense, making operations such as addition, subtraction, multiplication, and division, which are easier and simpler.

Now, to further explain it, here are another examples.

Figure 4. *Sample on Connecting to the Previous Lesson*

Connecting math concepts to real-life is most evident in this part of the module with 20 (74.1%) self-instructional materials able to connect sample activities to real life. To connect to the real-life experiences or real-life context, the sample activities of the material appeared like the sample shown below where the material presents word problem using the numbers in math in a context that is based on the daily activities where the concept can be applied. In sample 5, the word problem is in the context of tiling the floor which is observable by learners and the dimension of the room which is also relatable.

Problem 1:

Engr. Yson planned to tile the floor of his room. Its length is $4\frac{1}{2}$ meters and the width is $3\frac{1}{3}$ meters. What is the floor area of the room?

Area = length x width

Figure 5. *Connecting to the Real-Life Experiences*

Connection to the different solution strategies appear in the sample activities of 16 (59.26%). To show connection to the different solution strategies, the material presents the sample activities this way as shown in sample 6 where the material presented 2 ways to solve the problem in the sample activities.

Activity 1: **Lace for the Blouse**
Read and understand the problem.

Lilia was asked by her mother to buy 10 meters of lace for her blouse and 100 meters of the same lace for the dresses that her mother sew. Each meter costs ₱ 8.45. She made a table to show the data of her problem.

This is how Lilia made it:

	x 10	x 100
₱ 8.45	₱ 84.5	₱ 845

Solution 1:
₱ 8.45 x 10 = ₱ 84.5   She moved the decimal point one place to the right because 10 has only one zero.
So, she paid the cashier ₱ 84.50 for the 10m of lace.

Solution 2:
₱ 8.45 x 100 = ₱ 845   She moved the decimal point two places to the right because 100 has two zeros.
So, she paid the cashier ₱ 845 for the 100 m of lace.

Activity 2: **Puzzle Box**

A number was placed in the main box. Study how the product is written when multiplied by each factor at the top of the column.

	x 0.1	x 0.01
43.7	4.37	0.437

This is how we arrived at the product:
Multiplying by 0.1:
43.7 x 0.1 = 4.37   We moved the decimal point one place to the left because 0.1 has one decimal place.
Multiplying by 0.01:
43.7 x 0.01 = 0.437   We moved the decimal point two places to the left because 0.01 has two decimal places. Take note that we put additional zero to serve as a place holder.

Figure 6. *Sample in the Sample Exercises Showing Connection to Solution Strategies*

Connection Features in Exercises. For the exercises part of the material, connection to the real-life has the highest percentage of appearance as it appears in 16 out of 27 modules (59.26%). The examples below show how the exercises exhibit connection to the previous lesson. In figure 7, the material makes use of the knowledge in the previous lessons (steps in solving the area and how multiplication of decimals is done) for the students to perform the presented exercises.

A. Read the problem and complete the solution:

> Jason has a rectangular dish garden. Its length is 0.75 m and the width is 0.5 m. How many square meters is the area of the garden?

To find the area of the dish garden, we multiply 0.75 by 0.5.
To solve for the 0.75 x 0.5 follow the steps:

1. Multiply the number as you would multiply whole numbers. Regroup if necessary.

$$
\begin{array}{r}
0.75 \\
\times\ \ 0.5 \\
\hline
03\square5
\end{array}
$$

2. Count the number of decimal places in the factors.

```
  0.75  ------- __ decimal places
x  0.5  -------  1 decimal place
  03□5  ------- __ decimal places in all
```

Figure 7. *Sample Exercises that Show Connection to the Previous Lesson*

10 modules are evident of showing connection to the different solution strategies (37.04%). The connection to real-life experiences is also evident some of the self-instructional materials' exercises. For instance, figure 8 presents the connection of the lesson to the real-life situation by presenting a worded problem in the context of buying a drawing book.

1. Abbe bought 2 drawing books at ₱48.50 each and a pad paper at ₱30.75.

If her money was a 200 – peso bill, how much was her change?

Figure 8. *Sample Exercise Connecting the Lesson to the Real-life*

The least is the connection to previous lesson were observed in the exercises of 7 modules (25.9%). To connect the exercises to the different solution strategies, figure 9 shows the different strategies in multiplying decimals based on the given and let the students recall those before the presentation of more exercises by including the "remember this section" to connect the two strategies when solving decimals.

Direction: Fill in the blanks with the correct words to complete the concept you have just learned.

Remember this:

A. To multiply a decimal by 10, and 100
   1. Count the number of _____ in 10, and 100
   2. Move the decimal point to the _____ based on the number of zeros.

B. To multiply a decimal by 0.1, and 0.01:
   1. Count the number of _____ in the tenths and hundredths.
   2. Move the decimal point to the _____ based on the number of decimal places.

Figure 9. *Connecting to Different Strategies*

Connection Features in Assessment. In the assessment part of the module, the only connection feature found is connection with real-life. Fifteen (55.56%) modules connected assessment to real-life applications. Connection to the previous lessons and connections to the different solutions strategies were not observed.

In the assessment, the word problem is presented in the context that is relatable for the leaners.
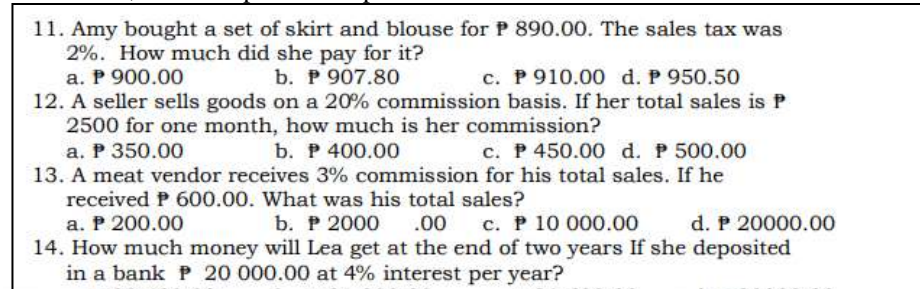

11. Amy bought a set of skirt and blouse for ₱ 890.00. The sales tax was 2%. How much did she pay for it?
    a. ₱ 900.00   b. ₱ 907.80   c. ₱ 910.00 d. ₱ 950.50
12. A seller sells goods on a 20% commission basis. If her total sales is ₱ 2500 for one month, how much is her commission?
    a. ₱ 350.00   b. ₱ 400.00   c. ₱ 450.00 d. ₱ 500.00
13. A meat vendor receives 3% commission for his total sales. If he received ₱ 600.00. What was his total sales?
    a. ₱ 200.00   b. ₱ 2000   .00   c. ₱ 10 000.00   d. ₱ 20000.00
14. How much money will Lea get at the end of two years If she deposited in a bank ₱ 20 000.00 at 4% interest per year?

Figure 10. *Connecting to the Real-life Context*

This study revealed that the representation and connection features are not evident in all self-instructional materials being analyzed for this study. In terms of representation features, only the sample activities and the exercises parts of the material are showed with visuals; however, this does not appear in all modules. Observably, there are pictures presented in some modules, but these are not representations of the concepts or lesson being introduced or being practiced. It is also observed that the assessment sections of the modules do not have representation features. This means, the numbers are given as they are without illustrations for better understanding.

It can be gleaned from the results of the analysis that module developers or writers are not using visuals to supplement the explanation of the concept and to show representations of concepts to help facilitate understanding. Representation is linked to imagination; and thus, when there is representation, learners imagine, construct and retrieve information to aid learning (Lingefjärd & Ghosh, 2016) [5]. In the study of Kaswa (2015) [6], the use of visuals in presenting the lesson is one of the ways in improving the learning of the students.

In terms of connection features, the most prevalent feature is the connection of the concept to real-life context which appear in all parts of the module. This is manifested through the use of contextualized word problems in the sample activities, exercises and assessment. The results imply that the modules are designed in such a way that learners are able to find the usefulness of the lesson for their everyday life. Various types of math tasks are embedded in real context, such as word problems, story problems, math modeling and applications. Doing this in presenting mathematics lessons support the idea of Crooks and Alibali (2014) [7] who pointed out that showing connections in mathematics instruction will facilitate greater understanding as the learner connects or links ideas from one situation to another.

3.3 Level of Help of the Mathematics 6 Modules

This result is based on the perceptions of the Grade 6 pupils. This was also focused on the representations and connections features in the material. Table 3.2 presents the perception of the respondents on the level of help of the self-instructional materials' representation and connection features.

Table 3.3 Level of Help of the Self-Instructional Material as perceived by pupil respondents

Statement	Mean	Interpretation
Representations		
1. I enjoy learning through my modules because of the pictures it shows for me to learn.	3.44	Helpful
2. I can understand the lesson through illustrations.	3.32	Helpful
3. I can understand the lesson through the drawings and pictures.	3.30	Helpful
Connections		
1. I can connect different solution strategies.	3.24	Helpful
2. I can connect my Math lesson to my previous math topics.	3.18	Helpful

3. I can connect a math topic to real-life contexts.	3.08	Helpful

Based on the evaluation of the representation and connection features of the self-instructional materials, there are representation features which may not be completely helpful as they lack the features which may aid student understanding of the concepts. It is emphasized by Fyfe et al (2015) [8] that mathematical concepts introduced through representation should be linked to concrete ideas and that the representation should be directly observable for this to become more understandable and aids learners in comprehending abstract mathematical concepts (Mitchell, Charalambous & Hill, 2014 [9]; Kang & Liu, 2018) [10].

The pupils' perceptions of the help that the mathematics module offered to them particularly the representations and connection features of the modules, showed that the material is helpful. This means, the pupils have oftentimes observed the way presentations and connections in the modules help them in learning. It can be deduced from the result that the module is perceived helpful for the pupils. There are studies which support that the module is helpful for learners while there are also studies which pointed out the disadvantages of using self-instructional materials. The material has to provide the student with full guidance in learning, in the absence of a teacher. The student should not struggle to master content when using self-learning materials of any type. On the negative side for instance, Sejpal (2013) [3] pointed out that the use of modules faces the challenge among younger learners because this is only appropriate only for matured students.

3.4 Experiences of Pupils in Using Mathematics 6 Self-Instructional Materials

The experiences of the pupils in using the mathematics self-instructional materials are presented in Table 3.3 showing the themes, and the core ideas. The themes include difficulty in learning from the self-instructional materials; lack of guidance in learning from the modules; self-fulfillment in learning; loss of interest in learning/demotivation.

Table 3.4 Themes and Core Ideas on the Experiences of Pupils in Using Mathematics 6 Self-Instructional Materials

Themes	Core Ideas
difficulty in learning from the self-instructional materials	• confusion as to what to answer • difficulty in understanding the lesson • some parts of the modules are difficult to learn
lack of guidance in learning from the modules	• inability to answer the modules alone • absence of adults at home to guide in learning
loss of interest in learning/demotivation	• boredom while learning • leaving behind the learning tasks
self-fulfillment in learning	• positive attitude towards learning from the modules

Difficulty in learning from the self-instructional materials. The difficulty in learning from the self-instructional materials is supported by the core ideas like the confusion of the pupils on what to answer in the tasks, activities and tests in the module. As revealed by one of the pupils being interviewed, she has difficulty in learning some parts of the lesson since she is in doubt of whether her answer is correct which is caused by her confusion of the lesson and as to what she will answer.

> *Naguguluhan ako sa kung ano ang isagot ko. Minsan naguguluhan dahil maraming i-solve.* (I am confused on what to answer. I am sometimes confused since I have a lot to solve.) **P2**

> *Maglibog ko sa akong ianswer usahay kay lisodan ko sa module.* (I am confused on what to answer because sometimes, I find the lesson difficult.) **P3**

Similarly, the experience of having difficulty in learning from the instructional materials is manifested with the difficulty the pupils have in understanding some lessons. As shared by the pupils, there are topics which they find difficult to understand.

> *...mahirapan ko sa lesson...mahirapan ko usahay sa kanang integers...ug sa mga problem pud.* (I find the lesson challenging…I find the topic about integers difficult and also those word problems.) P12

Another participant mentioned the topics on the operation involving integers as topics which are difficult for her.

> *Lisudan kaayo ko isaulo...katong sa positive ug negative nga i-add, i-minus, i-times ug i-divide.* (I find it really hard to memorize…the positive and negative…that should be added, subtracted, multiplied and divided.) P11

Related account of Participant 13 further explained the idea that the pupils are having difficulty in understanding their lesson and pointed out that the formula are not understandable.

> *...naay formula dili maintindihan...mas lahi if teacher mag-explain.* (There is a formula I cannot understand… it would be better if my teacher will explain it…) P13

Moreover, the participants also shared that some parts of the modules are difficult to understand. Aside from mentioning topics which are tough for them, Participant 15 elaborated the reasons why she experienced difficulty in learning:

> *Kanang daghan kaayo isulat ug isolve...naay itimes, tapos i-divide pa jud. Daghan answeran…*(There are plenty to write and solve…there are those which should be multiplied and divided…and there are a lot to answer.) P15

Lack of guidance in learning from the modules. The participants also shared that in learning the modules, they lack the guidance of those who are knowledgeable about the lesson so they can seek immediate help. This is explained by the ideas that pupils have inability to answer the modules alone; and some lack the self-directed learning readiness.

The pupils shared that while studying their modules, and they meet some difficulties, they got no one to call for help to explain the concept to them. One of the participants expressed this when ask about how is her learning through the module.

> *Okay lang pero kung mahirapan ako minsan, wala man magtabang sa akoa kay nagaluto man akong mama.* (It is ok but I find it difficult sometimes if no one could help me because my mother is cooking (doing household chores). P3

Similarly, Participant 1 and Participant 14 responded:
> *Ang pag-gamit ng math module ay medyo mahirap dahil ito ay nakasulat lang sa papel at hindi lubos na maunawaan dahil hindi naipapaliwanag ng mabuti sa amin…* (Using the module seems difficulty because it (the lesson) is only written in the paper and this could not be easily understood since there is no one explaining it.) P1

> *Wala koy ganahan sa module. Dili man ko kabalo muanswer kung walay magtudlo sa akoa.* (I do not like the module. I do not know how to answer if nobody will teach me how.) P14

Loss of interest in learning/demotivation. There are pupils who also shared that they loss the interest or they are demotivated to learn from the self-instructional materials. They expressed boredom in answering the modules:

> *Mabored po ako minsan sa pag-answer sa modules. Daghan man gud kaayo nagtapok nga answeran.* (I am sometimes bored in answering the modules since there are a lot to answer.) P16

Other pupils also revealed that they are not answering or they are not doing some parts of the modules. They are selective on what to do and what to answer.

Dili naku answeran ang uban…ang uban lang. (I am not answering other parts of the module. Only some.) **P13**

Self-fulfillment in learning. While other themes generated on the experiences of the pupils are usually on the negative side, there are also positive experiences being shared by the pupils. They shared positive attitude towards learning the module. It is interesting to note, how Participant 1 revealed her realization about modular learning.

Mahirap sa simula…ngunit kung pag-aralan ng Mabuti…hanggang namalayan ko na madali lang pala maintindihan. (It is challenging at first…but if you have to study carefully…then…I realized…it is easy to learn.) **P1**

Ang akong matun-an sa module sa Math kay pwede naku magamit sa tindahan…kanang mga sukli ug magkwenta pila ang gipalit. (What I learned from the module in math can be applied when I calculate the change and the cost of the items sold in our store.) **P13**

The experiences of the pupils in using the Mathematics 6 self-instructional materials are described in the themes such as: difficulty in learning from the self-instructional materials; lack of guidance in learning from the modules; loss of interest in learning/demotivation; and self-fulfillment in learning. It is evident in the result that their difficulty in learning is manifested by instances when they have confusion in understanding the concepts and in doing the learning task required from them; and that some parts of the modules are difficult for them. These observations of the pupils about the modules caused their perceived difficulty. As argued by Graham (2006) [11], with the use of self-instructional materials, learners may be overawed by the learning opportunities that the teachers or learning designers provide.

Furthermore, the lack of guidance in learning from the module is another experience which is also considered as a challenge in modular learning. This means, even if the materials are labelled as self-instruction and is designed for self-learning, it is not a guarantee that the learners are able to learn from it without the need of adult to scaffold in their learning.

The loss of interest in learning is another experience revealed by the pupils which is evidenced by their boredom and with the unanswered parts of the modules. This result implied that there are pupils who are not adapted to modular learning or self-learning. Indeed, as shared by Song and Hill (2007) [12], self-directed learning requires learners to control their own learning since the learning objectives rest on the plans and targets of the learners; hence, this can only succeed if the learners are responsible enough in their own learning.

Interestingly, there are also pupils who revealed their fulfillment in learning the modules. This suggests that while there are those who find modular learning difficult, there are also learners who see the relevance of learning from it as they believed the math topics are helpful in their daily activities. For Khodabandehlou et al. (2012) [13], self-learning is a way to gain skills; it is helping student to learn skills like self-goal setting, management of time and assessing oneself which are all very necessary since these skills are applicable in many circumstances in life.

3.5 Implications for Education Practice

The results of the study have several implications for educational practice. As found out, the modules lack representation and connection features for only some of the modules contain such features. Several literatures have established the necessity of using representations and establishing connections in Math teaching and in learning materials in math since these features can potentially offer various advantages for learners. On this regard, the module developers may check on the modules and may revise its presentations of the topic or learning competencies for learners to find learning easier and more enjoyable.

It was also highlighted in the study that the module is helpful as perceived by the pupil-respondents. Being perceived as helpful does not necessarily mean that the modules offer the necessary help for pupils to learn the concepts. In fact, the results of the interview with the said respondent revealed that they find the difficulty in learning through the modules. This means, there is still a need to review the contents of the modules and modify it for better understanding among the pupils.

The experiences shared by the pupils in learning the module, unfold the most important insight: the learners are struggling to learn and that they need scaffolding. It can be deduced from the responses of the pupils that not all of the topics in the modules are understandable with their own capacity to learn. They need assistance. This means,

the module itself is not fitted to some learners who need teachers and adult to guide in their learning journey. This further implies the need for easy to learn materials which can be determined based on the learning abilities of the learners; the need for immediate assistance when learning difficulty arises; and most importantly, the need to check if the learning tasks are not burdensome for the learners who are not only dealing modules in math but also modules of other subjects by implementing a self-learning plan and schedule.

3.6 Implications for Future Research

One of the limitations of the study is its inability to explore more on the explanation of the results of the quantitative data which reveal that the modules are helpful. It is noticeable the qualitative data on the experiences revealed that pupils find difficulty in learning the modules seem contradictory to their responses that the module is helpful. Future researchers may further investigate on this aspect in qualitative or quantitative method.

Another focus for future research may be to find out other features in the mathematics modules aside from the representation and connection features. Deeper analysis on how these features can be utilized for easier or better mathematics learning among Grade 6 pupils may also be included in the study. However, since the learners expressed their difficulties in learning from their modules, the module developers may develop a new module which is more suitable for the learners particularly those who are under this study.

If time permits, materials being developed for self-learning may be pilot tested for the developers to have better understanding if the material with its content and features, is helpful for the learners or not. This will enable developers of the module to revise the material and make it more helpful for self-directed learning. Moreover, researchers may also assess the impact of the use of modules in mathematics on the academic performance of the learners; and the skills and competencies being acquired or mastered.

4. CONCLUSIONS

The findings of the study pave way to a number of realizations in the researchers' teaching journey amidst the pandemic and that the school authorities may also make this study a springboard or basis for an informed decision making.

As revealed in the study, the contents of the modules do not have enough representations and connection features though these are considered vital in mathematics learning. To mathematics teacher, this served as a wakeup call for checking teaching practices, the learning materials provided to the learners, and the scaffolding initiatives to be taken. Providing printed materials for learning – for pupils to read and to answer is not enough since there is a need to provide them a supplementary material which have been evaluated as to its features and as to its appropriateness for self-learning.

As initially claimed, learning continuity is ensured through the use of modules, and other platforms, the school administrators and the Department of Education may ponder on how these printed materials can have impact to learning. Based on the experiences shared by the pupils, it can be concluded that pupils have varied experiences depending on their abilities and perceptions of their capability to learn. While some claimed to have learned from the module, all of them have common answers- they find some topics/concepts difficult to learn. This may serve as a reminder for mathematics teachers to scaffold the learners who expressed their difficulty in learning. While the pupils in this study perceived the representation and connection features as helpful, they experienced many difficulties in using the module. As earlier presented, there may be parts of the modules to be checked and to be improved to make the representation and connection features more helpful for the learners.

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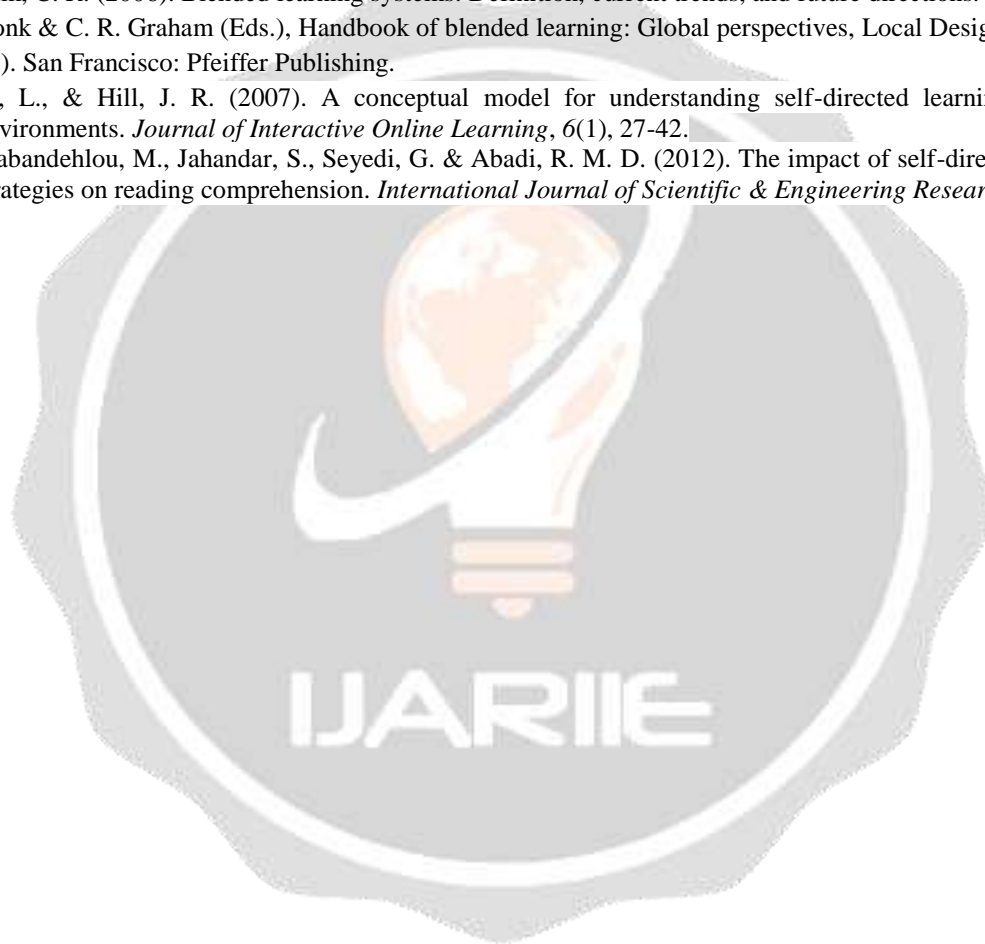
Introducing Lesson Study to the Teachers in Southern Philippines: Foreseen Challenges

Authors   Levi Elipane, Leorence Tandog

Publication date   2014

Description   This paper is an elaboration of the foreseen challenges of implementing Lesson Study as a mathematics teacher professional initiative in Cotabato, a province in the Southern part of the Philippines called Mindanao. The analysis of data based on a phenomenological approach made use of the Anthropological Theory of the Didactics as an analytical tool. Through the utterances of the participants during a 5-hour intervention during a seminar workshop and their responses in interviews and survey questionnaires, it was apparent how 1) leadership; 2) teachers' mindset, and 3) affordances of the national curriculum guidelines were deemed as critical factors in being able to optimally engage in this professional development model that originated from Japan. These findings provide ramifications on how Lesson Study could be implemented by Filipino teachers.

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Research Article

The Application of Enhanced Damath in Learning Operations on Integers and Developing Strategic Thinking

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Abstract: This study examined the effect of using enhanced Damath on learning integer operations and developing strategic thinking. Enhanced Damath is an educational board game which is a Philippine traditional Damath game with a dice modifier. Damath has been used in Philippine schools mainly to improve students' mathematical competency in computing. This research aimed to expand the application of Damath to improve strategic thinking which naturally develops in game playing. A randomized pretest-posttest control group experimental research design with matched subjects was used to gather empirical evidence. The respondents for the experimental group were randomly chosen high school students. The respondents for the control group were randomly chosen matched pairs of the subjects in the experimental group determined based on the school enrolled, grade level, academic performance, sex, and age. Results revealed that playing enhanced Damath significantly improves students' level of knowledge in integers involving single and multiple operations. The game also significantly contributes to the development of students' strategic thinking. Students affirmed the positive effect of enhanced Damath in terms of improved performance and a fun way to learn mathematical skills.

Keywords: Damath; enhanced Damath; integer operations; strategic thinking; experiment