Review Article

Climate Change Resilience and Adaptation Strategies in Ecologically Fragile Urban Mining Communities: A Review of Existing Research and Practice

Abstract

The growing concern about the changing climate and the need to document its observed impacts have resulted into advances in climate change adaptation practices globally. Despite being among the world's most vulnerable regions, urban mining communities have diverse resources and contribute significantly to the quality of urban climate. The location of urban communities near mining activities has not only attracted urban development in most cities but has also provided these communities with a good opportunity for sustainable ways of living. However, most research on mines seem to have focused on impacts of mining on the environment with little focus on communities' climate change adaptation responses. This review paper attempts to address this inadequacy in research by exploring factors that increase urban communities' resilience and the adaptation strategies they use. The study used an evidence-review strategy involving the collection of information from peer-reviewed articles, books, and reports. A total of 213 documents, which included 122 articles, 60 reports, 31 books and gray literature, were identified with the help of Google Scholar and Web of Science search engines. First, the review paper observes that although the concepts of resilience and adaptive capacity are extensively explored, their meanings still remain unclear due to their multiple interpretations. Second, there seems to be very little consensus on factors that lead to increased resilience and the parameters that should be used to measure progress in becoming more resilient due to multiple interpretations of the resilience concept. Third, very few studies seem to have been conducted to assess progress in becoming more resilient in most urban mining communities. Fourth, there also seems to be a challenge in designing vulnerability and resilience assessment frameworks that are procedurally robust, context-specific and appropriate for decision-making related to adaptation action. This study recommends a need to conduct more comprehensive studies which clearly explore factors that increase resilience and adaptive capacity and those that suggest clear policy options for urban mining communities to supplement the rather limited body of literature in this area.

Keywords: Climate change, vulnerability, resilience, adaptive capacity, fragile environments, policy and practice

1.0 Introduction

"Climate change is said to be one of the most significant, persistent and highly dynamic challenges facing society today" (Birchall and Bonnett, 2020). "The United Nations Framework Convention on Climate Change" (UNFCCC, 2007) "defines climate change as a change in climate which is attributed directly or indirectly to human activity that modifies the composition of the global atmosphere and which is observed over comparable time periods. Scholars agree that the burning of fossil fuels has raised the concentration of greenhouse gases (GHG) in the atmosphere" (Hansen et al., 2012), "resulting in a rise in global average temperatures. With GHG emissions reaching unprecedented levels (Rhodes, 2017), subsequent climate impacts are becoming more pronounced". "The fourth assessment report of the Intergovernmental Panel on Climate Change (IPCC, 2007) also highlights that climate change is still widely recognized as one of the major challenges facing humanity today". CGIAR (2012) and Marin (2010) report that recent scientific evidence also points to the fact that global climatic conditions are changing mostly for the worst. Furthermore, in its fifth assessment report, the IPCC (2014) also reflected on the severity of change by stating that the climate system is warming at alarming rates, causing sea levels to rise, precipitation and weather events to become increasingly variable and glaciers to melt rapidly.

Studies have also predicted that the rapid change in climate, especially in ecologically fragile settings such as extractive industries, is set to alter the delicate balance that exists between man and nature (Behara and Vaswani, 2007). Other scholars fear that the poorest communities, who are dependent on nature-based resources, are likely to suffer the most due to their geographic locations, low incomes and low institutional capacity. They also fear that communities are likely to suffer the most due to their greater reliance on climate-sensitive sectors such as agriculture, where the extent of vulnerability within sectors varies because the communities' adaptability to multiple stresses also differs (Acosta-Michlick

and Espaldon, 2008). A recent online blog post by Van Bronkhorst and Bousquet (2021) observed that climate change can create major strains on a society, especially in fragile settings where governments have limited resources to manage crises and help their populations adapt. The writers contend that the adverse consequences associated with climate change, such as water scarcity, crop failure, food insecurity, economic shocks, migration, and displacement, can aggravate disaster risks. Van Bronkhorst and Bousquet's argument is that climate change can act as a threat multiplier, both in the immediate and long term, by intensifying contestation over scarce resources, reducing economic opportunities and social cohesion, and straining public institutions and trust in the state

"The growth of the mining industry, especially in Zambia, has had a positive impact on the country's economy although mining in developing countries can either be a treasure or a trouble depending mainly on factors such as institutional stability, economic management and overall management of the sector itself" (WB-IFC, 2002). "Other studies also point to the fact that mining plays a critical role in the low-carbon transition and the fulfillment of the UN 2030 Agenda" (Hund et al., 2020) "although it is also a driver of GHG emissions through mineral extraction, energy consumption and by contributing to the loss of forest cover" (Bebbington et al., 2018). "Mining activities are also associated with a broad range of social and environmental risks in mineral producing sites" (L`ebre et al., 2020), "many of which are likely to be aggravated by climate change. For example, extreme weather events and natural hazards can damage infrastructure and lead to the contamination of land and water. Moreover, water availability is likely to decrease as a consequence of climate change and as mining requires large amounts of water, the companies' reluctance to reduce their water consumption is likely to affect local mining communities' access to water" (Phillips, 2016; Odell et al., 2018).

An often neglected fact in countries struggling against poverty is that mining has a significant impact on its immediate surroundings and/or communities (WB-IFC, 2002). To support this argument, studies have found that the extractive industry, by its very nature, has a massive socioecological impact and far-reaching ramifications on both human health and the environment itself if not properly managed (IFC, 2014). Recent studies suggest that the main environmental problems associated with mines in developing countries are usually pollution of air, soil and water, geotechnical issues and land degradation although the contribution from old mining legacy sites have shown to be minor compared to current mining operations (Lindahl, 2014). In Australia, for instance, all mining projects located in sensitive regions must undergo rigorous environmental assessment to ensure the sustainable development of these areas. While the level of assessment does vary from project to project, operators will generally have to demonstrate that their project will either not have a significant impact or, if there will be, that these can be adequately managed (ICMM Report, 2011).

Research on industry perspectives by Ford et al. (2010) found that although climate change is an emerging concern for the mining industry, limited action has been taken to plan for or adapt to prevailing climatic conditions. There is clearly a growing concern about changing weather patterns and climate stability and the effect on the consistency of future food and water supplies. Literature further points to the fact that the mining sector is one of the major emitters of GHGs and furthermore produces fossil energy resources that also significantly contribute to global CO2 emissions. However, despite threats of impending climate change impacts, most research on mine design, planning, and monitoring seems to have focused on the impact of mining activities on the environment and water resources with very little focus on communities' adaptation to the changing weather patterns (Ford et al., 2010). While climate data are one of the facets that are incorporated within mining projects, the changing weather conditions are not always considered, and as such, not much action has been taken to plan for or adapt to these changing climatic conditions (IFC, 2014). Furthermore, although the mining sector does seem to be taking action and playing a part in reducing GHG emissions in certain cases, mitigation alone will not solve the problem (IFC, 2014) if it is not accompanied with adaptation to changing environments.

"Until recently however, scholars and practitioners have mainly debated climate change adaptation as a policy challenge to be addressed by subnational and national governmental bodies (Dolsak and Prakash, 2018). Scholars and practitioners have reflected on the tools mining companies have at their disposal to enhance adaptation, particularly in developing countries, where they could develop new technologies and work towards innovative solutions together with the state in public-private partnerships" (Averchenkova et al., 2016; Nasiritousi et al., 2016). "The writers reveal that recently, companies have started to disclose information about their exposure to, impacts on, and responses to climate dangers" (Goldstein et al., 2019). "Scholars and practitioners argue that such actions exemplify an emerging trend of private adaptation, which refers to the process of adjustment by companies to actual

or expected climate change and its effects through changes in business strategies, operations, practices, and/or investment decisions" (IPCC, 2014). "How the private sector, in particular large national and multi-national companies (MNCs), responds to climate dangers can have both positive and negative societal consequences" (Hannah et al., 2013; UN Global Compact et al., 2015; Averchenkova et al., 2016).

Previous research has also shown that communities, world over, have a great diversity of flora, fauna, and culture, which gives them an advantage for socioecological development. Jha et al. (2021) argue that the geo-ecological conditions, such as the landscape and climate, provide a good opportunity for sustainable livelihoods in some of these communities. The writers observe that communities have used various copping strategies to counter climate change and variability. Nhemachena and Hassan (2010) underscore the fact that adaptation measures help communities develop adaptive capacity and resilience to climate change (Klein et al., 2014). Studies further reveal that communities use both meteorological and traditional knowledge systems to make adaptation decisions (Jiri et al., 2015; Mapira and Mazambara, 2013). These adaptation decisions assist communities to attain better livelihoods in the face of climate change and variability (Dube and Sekhwela, 2007). This also helps communities guard against the effects of increasing temperatures and decreasing rainfall patterns, thereby moderating vulnerability (Hassan and Nhemachena, 2008; Wilhite et al., 2014).

Nevertheless, literature also indicates to the contrary that although it is increasingly becoming evident that mining communities are likely to be the most severely affected by climate change, they are still among the least equipped to cope and adapt to climate change (IFC, 2014). Furthermore, although mining companies world over are said to be pursuing a range of adaptive practices aimed at protecting the value of existing and/or potential assets and creating value through technological innovation and collaborative initiatives (Nelson and Schuchard, 2010), most of these initiatives have focused on physical risks of climate change with no clear understanding of the site-level social risks and opportunities. The study further found that mining companies have not seized the opportunity presented by climate change to collaborate with communities, development agencies, Non-Governmental Organizations (NGOs), and governments on adaptation to enhance their social licenses to operate.

Therefore, while communities around the world are developing adaptation programs, efforts remain largely uncoordinated and inconsistent (Wallace, 2017) because there is often a deficit in local, relevant, and easily accessible research to support the development of adaptation plans (Baker et al., 2012). It is for this reason that the study of climate change impacts on natural and human systems is inadequate in the face of questions about societal capabilities to cope with these impacts in the context of their vulnerability, resilience, and adaptive capacity (Jha et al., 2021). Understanding adaptation to climate change is important in order to develop and implement effective adaptation measures which lead to improved adaptive capacity and resilience at the household level. This is critical as the rate of current climate change and variability may outpace adaptation in many parts of the world (Adger and Barnett, 2009) unless serious consideration is given to local-level adaptation strategies that increase resilience in the short term and increase adaptive capacity for future impacts. This review paper, therefore, explores a wide range of factors that increase resilience and the adaptation strategies used by urban mining communities to adapt to impacts of climate change and variability.

1.1 Rationale and aim

This review paper is designed to conduct a detailed review of literature on factors that increase resilience and the adaptation strategies used by urban mining communities to adapt to harsh environmental conditions which are largely caused by climate change and, to some extent, by the mines. The review paper also explores the status of vulnerability in urban mining communities in order to provide baseline information that can guide adaptation strategies and practices. The review paper specifically looks at existing research and practice in the areas of community resilience, the adaptation strategies employed and the adaptive capacity of urban mining communities to climate change impacts in environments which are deemed ecologically fragile. The review paper examines the following key issues: the status of vulnerability and its relationship with resilience; the meaning of community resilience and adaptive capacity and how the terms are used in the research field and in policy circles; core factors that promote resilience in urban mining communities; the nature of emerging practice and how this can be enhanced in different contexts; how policy and practice promote climate change resilience in urban mining communities; and the roles of different stakeholders in supporting this cause.

The findings of this review paper are expected to increase awareness on the progress of resilience and the adaptation strategies employed by urban mining communities to adapt to environmentally unfriendly conditions. The results will show which adaptation strategies provide more resilience and attract further attention of planners and policymakers in the adaptation action. The results are also aimed at contributing additional information to the existing body of literature in this area. This review paper is organized in such a way that the next section explains the methodology used. This is followed by the section for results, which includes an overview of literature, a bibliographic analysis and a detailed results of literature review on climate change vulnerability, resilience, adaptation strategies and adaptive capacity. Finally, the review paper wraps it up with the section on discussion and conclusion, which highlights a detailed discussion of results, gaps in literature and their implications and finally the conclusion.

2.0 Methodology

This review paper employed a cross sectional design, which utilized document reviews covering local and international contexts. In order to identify existing literature available elsewhere in the areas of community resilience, adaptation strategies and adaptive capacity, efforts were made to trace as many documents as possible. Keywords such as 'climate vulnerability,' 'climate resilience,' 'climate adaptation,' 'adaptive capacity,' and 'mining and climate change,' were employed to look for these documents and the results were recorded. Documents containing these keywords were then manually searched for any information related to the emerging issues of climate resilience, vulnerability and adaptation strategies used in urban mining communities.

Thus, a qualitative literature review was conducted, which involved collection of relevant information from peer-reviewed articles, books, reports and gray literature. A total of 213 documents, which included 122 articles, 60 reports and 31 books and gray literature were identified with the help of mainly Google Scholar and Web of Science search engines and included in the review (see Figure 1). The review paper focused on a detailed literature search of factors that enhance resilience and the adaptation strategies used by urban mining communities to adapt to climate change impacts. The thematic synthesis of documents collected resulted in a wide-ranging array of findings and gaps in literature relating to climate change resilience and the capacity of urban mining communities to adapt to climate change impacts.

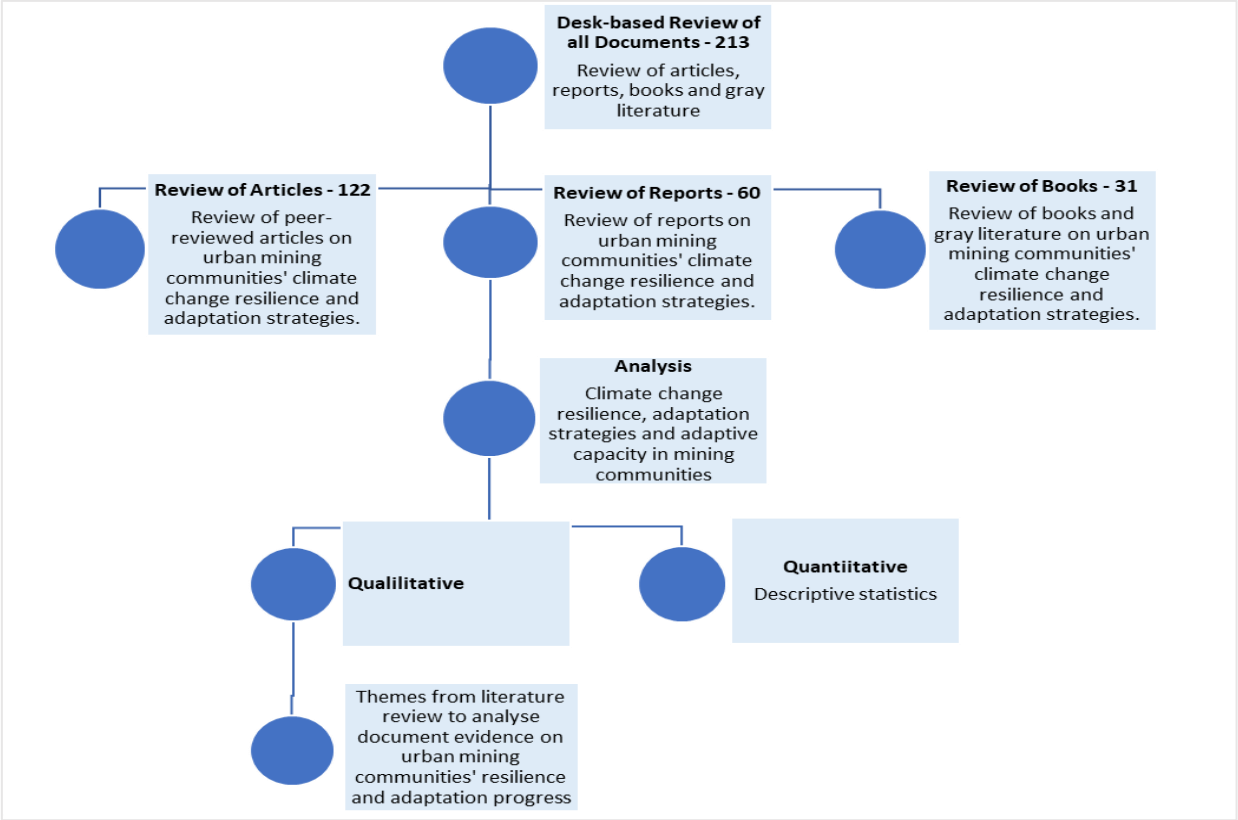

Figure 1: Data selection and review process

The initial search was conducted in October 2021 using Google Scholar and Web of Science search engines. The abstracts and conclusions of the documents retrieved during this initial search were scrutinized and all papers dealing with climate resilience, adaptation strategies and adaptive capacity, especially in urban mining communities, were picked for detailed analysis. While scrutinizing the selected papers, it was also found necessary to include, in the search string, other relevant terms such as 'mining and climate change adaptation' in urban mining communities. Therefore, an updated literature search which included those new terms was carried out later in November 2021. The abstracts and conclusions of the newly added papers were also scrutinized and any papers that dealt with climate resilience, vulnerability and adaptation strategies in urban mining communities, were selected for further review.

During the literature review process, the alert functions of Google Scholar and Web of Science were also activated so as to include any recently published documents in the same area. Other relevant information on adaptation measures and responses in urban mining companies and local communities was collected through a comprehensive content examination of the papers selected. The author also took advantage of being a member of the research gate and from time to time asked for permission from the research gate members to download and use some of their published papers in the area of climate resilience, vulnerability and adaptation.

3.0 Results

3.1 Overview of the literature

In this section, the author offers results from the literature reviewed. He first focuses on contextualizing vulnerability in order to provide baseline information that can guide adaptation strategies and practice. Then the author moves on to present climate change resilience, factors that characterize it and the existing policy on climate change resilience. Adaptation and factors that characterize it are presented next followed by adaptation response using community-based adaptation (CBA) approaches as well as response from mining companies. The author finally presents adaptive capacity, its characterizing factors and the measures used for assessing it.

The papers reviewed can be categorized into four major groups in relation to their focus on climate change vulnerability, resilience, adaptation strategies and adaptive capacity. The larger chunk of papers reviewed relate to both climate change vulnerability, resilience and adaptation strategies used in other urban communities while only a few are focused on climate change vulnerability, resilience and adaptation responses and practices in urban mining communities. In terms of the type of papers, the larger chunk of the documents analyzed are research papers, a few review articles while the rest are books, reports and gray literature. As regards to research methods, the author shares views with Sharifi (2020) who equally identified three major categories of research methods. These include, among others, social science methods, science methods, and economic methods. Most of the social science methods frequently used include review of literature, document analysis, case studies, grounded participatory research, and questionnaire while a few are in science methods. From the papers reviewed, it seems obvious that the social science methods are leading, followed by science methods.

3.2 Bibliographic analysis

The graph below (Figure 2) shows the number of papers identified and selected for review by focusing on the year of publication.

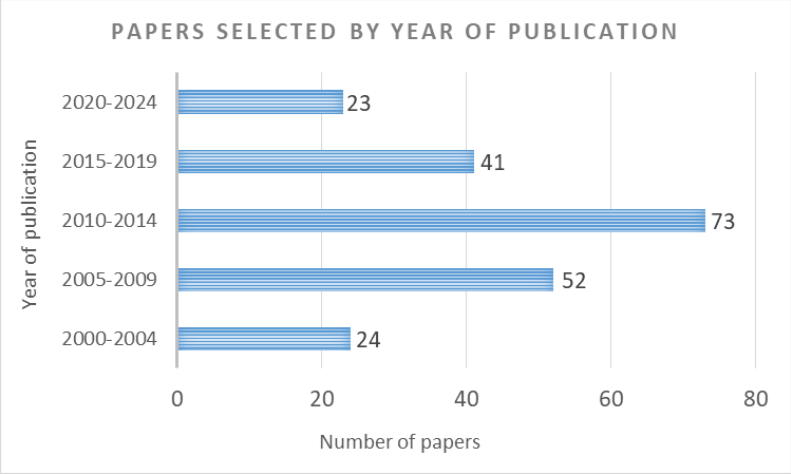

Figure 2 showing number of selected papers by year of publication

Figure 2 indicates that 24 of the papers reviewed were published between 2000 and 2004 while 52 were published between 2005 and 2009. The bulk of reviewed papers adding to 73 were published between 2010 and 2014 while 41 were published between 2015 and 2019. The rest of the 23 papers reviewed were published from 2020 going forward. Thus, the trend shows that the majority of papers reviewed were published at least within the last ten years or so.

The next graph (Figure 3) shows the distribution of selected papers for review by focusing on keywords or themes.

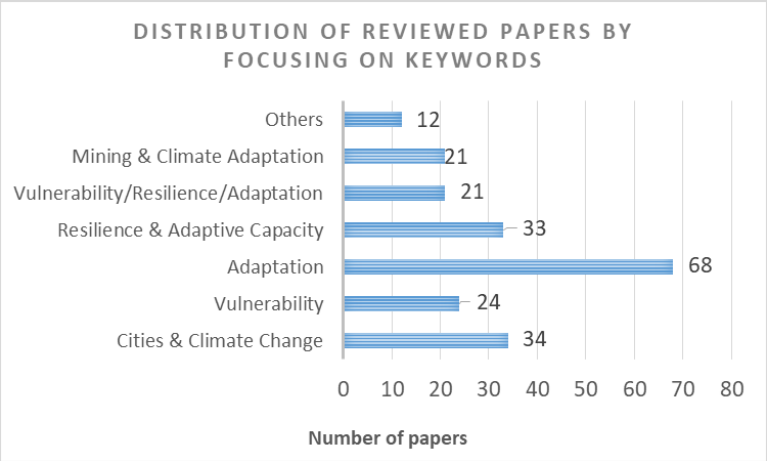

Figure 3 showing distribution of selected papers by keywords

Figure 3 indicates that reviewed papers focusing on cities and climate change were 34 while those on vulnerability were 24. Papers focusing on adaptation topped the list with 68 while those on resilience and adaptive capacity were 33. Papers which had a combination of vulnerability, resilience and adaptation themes were 21 while those focusing on mining and adaptation were 21. The rest of the papers (others) were 12. Thus, the trend shows that the majority of papers reviewed were those focusing on adaptation and resilience while those focusing on mining and adaptation and other themes were the least.

3.3 Climate change vulnerability

3.3.1 Contextualizing vulnerability

Understanding climate change vulnerability as one of the central concepts for this study is of paramount importance. As such, the fourth assessment report of the IPCC (2007) defines climate change vulnerability as "*the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes*". From this definition, vulnerability can therefore be understood to be a function of four elements namely character, magnitude, and rate of climate change and variability. It must be noted that in the period ranging from 2001 to 2014, the definition of vulnerability in the IPCC reports had remained the same except for the word 'or' which was substituted by 'and' in the definition of the 2007 IPCC report. Füssel and Klein (2006) explain that this was done so in order to consider sensitivity and lack of adaptability as both factors of vulnerability as opposed to being alternative definitions. Therefore, any vulnerability assessment based on this explanation considers exposure, sensitivity and adaptive capacity as indicators of vulnerability.

Therefore, determining appropriate adaptive responses requires ongoing assessment of a community's vulnerability and its capacity to adapt to climate change (Birchall and MacDonald, 2020). All the three factors of vulnerability (character, magnitude and rate of climate change and variation) form the equation, which is the rate and degree of climate change, sensitivity and adaptive capacity. In view of this, Birchall and MacDonald observed that in the case of southern Africa, all the three factors made a worrying scenario which suggested that the impact of climate change for the sub-region would be severe. These concepts seem to have originated from the fields of food security and disaster risk reduction. Ragab and Prudhomme (2002) report that in recent past, vulnerability has emerged as a dominant concept into climate change research most likely because there has been an increase in climate change-related incidences and activities.

Previous research as reported by Baker et al. (2012) indicates that vulnerability to climate change is not entirely determined by climate change impacts per se but that it is also largely determined by various non-climate-related elements such as socioeconomic factors, demographic shifts and trends, and access to resources. The writers contend that in developing countries, for example, pressure on land resulting from rapid urbanization often leads to the development of vulnerable spaces such as flood-prone areas, with the poorest of the population living in these locations. Rosenzweig et al. (2011) add that climate change impacts also tend to have a greater effect on vulnerable populations such as the elderly or those with low incomes. The writers argue that inequalities, among socioeconomic groups, are projected to become even more pronounced as climate change progresses.

It is argued that poverty, gender, ethnicity, and age have all been documented as some of the factors that affect vulnerability of urban populations to climate risks (Tyler and Moench, 2012). The writers argue that when these social elements are combined with the physical processes of climate change, they can cause various secondary effects such as displacement of vulnerable populations (Carter et al., 2015). In addition to this, the IPCC (2014) observes that populations that do not seem to have the resources to cope with climate change impacts are likely to experience higher exposure to extreme weather events. The writers contend that this is especially true for poor populations in developing countries and for remote locations such as the Arctic. This is so because the Arctic communities are often located in isolated areas with limited seasonal accessibility where they experience greater social, health, and economic disparities, as compared to communities living in more populated regions. These disparities, coupled with the dependency on the environment, make Arctic communities more vulnerable to climate change impacts (Larsen et al., 2014).

A study conducted by Jha et al. (2017) observed that the vulnerability of socioecological systems often results from natural disasters and unsustainable use of available resources. This means that any impact on one component of an ecosystem also changes the stability of associated components (Obrist, 2006). Overall, instabilities in socioecological systems can lead to poverty, marginalization, and exclusion (Barnett, 2001) and also can modify the flow of services (Parmesan and Yohe, 2003). Therefore, an ability to cope with instabilities is considered to be a crucial element in the continuous evolution of resource use patterns and human settlements (Jha et al., 2017). However, it is argued that additional anthropogenic pressure on resources can upset the natural balance (FAO, 2002) and create vulnerability in the socioecological system (Pandey and Jha, 2011).

Therefore, Dumaru (2010) is of the view that analyzing climate vulnerability involves identifying both the threat and the resilience in exploiting opportunities and in recovering from the negative effects of climate change. This focus on vulnerability and resilience can complement other areas of development by providing a framework for studying long-term climate changes and greater uncertainty levels. The writer reports that a CBA pilot-project on Druadrua Island, Fiji, showcased how climate adaptation was integrated into an existing community structure where participatory decision-making led to responses to observed climatic changes. Regrettably however, not all these responses were sustainable and the pilot-project highlighted how vulnerability and resilience analysis can identify and prevent maladaptive practices alongside revealing new long-term strategies. Eriksen and Naess (2003) have also identified three examples of groups of factors that affect vulnerability as indicated in Table 1.

Table 1 showing examples of factors that influence climate change vulnerability

Category	**Examples**
Institutional factors	Informal skills, traditional knowledge, formal education, skills and technology, informal networks, formal security networks, strength of local institutions
Economic factors	Labor, health, access to natural resources, access to communal natural resources, access to alternative economic opportunities
Ecological factors	Hazardous environments, degraded environments, high dependence on climate-sensitive sectors and natural resources, communal lands and resources

Source: Eriksen and Næss, 2003

3.3.2 Linking vulnerability to resilience

Climate adaptation is aimed at decreasing vulnerability and strengthening resilience to impacts of climate change. For this reason, the relationship between vulnerability and resilience requires clarification. Resilience is often defined as the opposite side of vulnerability (Adger, 2000; IPCC, 2001), while scholars like Gallopin (2006) object by arguing that the opposite side of vulnerability goes beyond resilience and could best be described with the term robustness. In any case, both vulnerability and resilience are determined by the response of a system to hazard exposure, which refers to internal properties of a system, and to the interaction of changes within the system (Gallopin, 2006; Miller et al., 2010). Therefore, resilience is nonetheless closely related to vulnerability because highly vulnerable communities dispose of poor adaptive capacity and are likely to be less resilient. For this reason, although vulnerability and resilience will not be understood as perfect opposites, they will still be

considered to be located on different ends of a spectrum that describes a state's relationship to exposure to perturbations (Nett, 2015).

The relationship between vulnerability and resilience is also explained by Gallopin (2006) using socioecological systems. Janssen et al. (2006) add that these domains differ in conceptual structure and resilience is only seen to be weakly correlated with vulnerability. Scholars have also made attempts to assess vulnerability together with the resilience of socioecological systems in order to establish the relationships between them. Exposure, as one of the three dimensions of vulnerability, is the potential impact of climate change (Ebi et al., 2006) and is almost equal for a system and for either vulnerability or resilience. The IPCC (2007) reports that the impact of exposure relies on its scale, system sensitivity, and adaptive capacity where sensitivity is understood as the degree of exposure, which varies at spatial and temporal scale (Pandey and Jha, 2011).

Therefore, in addition to considering the ability to cope with instabilities to be a crucial element in the continuous development of resource use patterns and human settlements (Jha et al., 2017), resilience and adaptive capacity together have also been found to provide a mechanism that associates biophysical climate sensitivity with socioeconomic factors that reduce or increase the impacts of climatic changes (Malone, 2009). Studies have shown that a resilient community is able to manage risks to reduce their effects and/or to recover rapidly from any negative impacts (CARE International, 2009) while a high adaptive capacity reduces communities' vulnerability to any climatic change and enhances their resilience to carry on with climatic changes (ACCRA, 2010). Scholars further argue that understanding vulnerability causes will support the examination of policy options for addressing its underlying causes rather than just its symptoms while understanding the resilience and adaptive capacity concepts will give guidance on where to channel resources to build on existing strengths (EEA, 2012; 2017).

Twigger-Ross et al. (2015) give a clear distinction between vulnerability and resilience by stating that resilience is about drawing on and building capabilities and should not end in reproducing social vulnerabilities while resilience, as bounce-back, is not adequate to sustain longer-term management of climate change. The writers recognize that communities' social vulnerability to climate change impacts is not merely the opposite side of resilience. They argue that a lack of national strategy to support community resilience makes it less probable that climate vulnerability areas are prioritized and targeted. They further say that the most vulnerable areas may be the least probable to develop community-driven resilience actions, which could cause problems in future if they were affected by climate change.

Therefore, due to the diversity of definitions of both vulnerability and resilience, their shared connection becomes highly contested. So, a practical approach then is to view resilience and vulnerability as two discrete but overlapping concepts with a negative association. According to Welle et al. (2014), this negative association implies that systems with high resilience will usually show low vulnerability and vice versa. A report by Twigger-Ross et al. (2015) underscores that the scarcity of evaluations and different interpretations of issues around resilience means that understanding the main causes of community resilience is not straightforward although evidence seems to point to the importance of 1) framing plans broadly to include actions that respond to a community's wide-ranging priorities and those that nurture skills, understanding and ownership of climate change responses; 2) existing capabilities within a community to inform policy on resilience; 3) support from the community and voluntary organizations to play a mediatory role in providing guidance for new partnerships aimed at building community resilience, and supporting skills and knowledge sharing (Twigger-Ross et al., 2015).

3.4 Climate change resilience

3.4.1 Understanding resilience

In order to evaluate and clearly understand climate resilience in practice, there is need for a better and clear definition of the term. Different scholars and organizations have defined resilience in slightly different ways. CARE International (2009: 6) defines resilience as "*the ability of a community to resist, absorb, and recover from the effects of hazards in a timely and efficient manner, preserving or restoring its essential basic structures, functions and identity*." The work of Mitchell (2013) views resilience as "*the ability of socioecological systems to absorb and recover from climatic shocks and stresses, whilst positively adapting and transforming their structures and means for living in the face of long-term change and uncertainty*". USAID defines resilience as "*the ability of people, households, communities, countries and systems to mitigate, adapt to and recover from shocks and stresses in a manner that reduces chronic vulnerability and facilitates inclusive growth*" (Sagara, 2018: 1). All the definitions

above seem to describe the same relationship among three elements that form the basis of a resilience measurement framework, which are resilience capacities, shocks and stresses, and the wellbeing of communities or sociological systems.

However, literature shows that resilience as a word has a long history with varying and complex meanings (Wilson, 2012 in Steiner and Markantoni, 2014; Olsson et al., 2015). In the context of socioecological systems, resilience is understood by interdisciplinary scientists as the ability of human communities to withstand external distresses to their infrastructure, such as climate variability or social, economic or political upheaval, and to recover from such distresses (Olsson et al., 2015). It is argued that the resilience concept has considerably evolved over time although different interpretations of what is meant by resilience still cause misunderstanding among scholars and practitioners (Walker et al., 2004). The writers argue that a system's resilience needs to be understood in terms of the characteristics that govern the system's dynamics. Three related characteristics of socioecological systems namely resilience, adaptability and transformability, must determine their future trajectories. They argue that resilience has four components identified as latitude, resistance, precariousness, and Panarchy. Walker et al. further add that adaptability is the capacity of actors in the system to influence resilience while transformability is the capacity to create a fundamentally new system when ecological, economic, or social structures make the existing system untenable (Walker et al., 2004).

The work of Sagara (2018) sees the emergence of climate resilience as a means for addressing the increasing intricacy and scale of risk in humanitarian and development spheres. However, the scholar argues that the ability to develop strategies and programs that enhance resilience requires robust quantification and analysis methodologies. Against this backdrop, Welle et al. (2014) report the adoption of a practice-oriented explanation of central pillars of resilience which constitutes the basis for evaluating and monitoring climate resilience. Mitchell (2013)'s work further underscores the fact that climate resilience is therefore a combination of absorptive, adaptive and transformative capacities, which can be delimited according to the way they respond to climatic shocks and stresses. These capacities are explained in some detail below:

- *Absorptive capacity*: "*the ability of a system to prepare for, mitigate or recover from the impacts of negative events using predetermined coping responses in order to preserve and restore essential basic structures and functions*" (e.g. human life, housing, productive assets) (Béné et al., 2012, Cutter et al., 2008).
- *Adaptive capacity*: "*the ability of a system to adjust, modify or change its characteristics and actions in order to better respond to existing and anticipated future climatic shocks and stresses and to take advantage of opportunities*" (Béné et al., 2012, Brooks, 2003, IPCC, 2012).
- *Transformative capacity*: "*the ability of a system to fundamentally change its characteristics and actions when the existing conditions become untenable in the face of climatic shocks and stresses*" (Béné et al., 2012; Walker et al., 2004).

Welle et al. (2014)'s work takes a slightly different viewpoint by contending that although distinguishing the three capacities is useful for the purpose of analysis, in reality they fall along a continuum and jointly facilitate different types of responses that range from a low to a high degree of structural change. The writers' argument is that climate resilience relies on the combination of all the three capacities as different types and intensities of climatic shocks and stresses require different responses. Thus, a social-ecological system with a high level of absorptive capacity but practically no adaptive and transformative capacities in existence cannot be said to be resilient. A good example for such a system would be a farmer's village, whose occupants are fully insured against weather but are not willing to modify their planting behavior or diversify their sources of income amidst increasing water scarcity.

Literature further indicates that a resilient community is able to manage risks to reduce their effects and/or to quickly recover from any negative impacts, resulting into a similar or more improved state than before. Research shows that there are strong connections between resilience and adaptive capacity and as a result resilience also varies greatly for different groups within a community (CARE International, 2009). CARE International argues that resilience can take the form of social resilience (social networks, social capital, and institutional support), or economic resilience (access to financial assistance, available infrastructure and access to technologies, and livelihood diversification). Pelling (2010)'s work reinforces CARE International's arguments by stating that the development and support of these facets can help communities cope during climatic shocks and stresses. He continues to say that while adaptation

promotes the development of resilience, it can also extend beyond this form of system maintenance to include elements of transition as well as transformation.

It is clear from the forgoing that the term resilience denotes different things to different people. However, from a theoretical viewpoint, there are substantial variations in how the term is understood and applied and the renewed interest in the term is a result of several processes undertaken. The term however is seen to be a valuable and unifying concept through which many disciplines and policy realms can relate to one another. Bahadur et al. (2010)'s work reviews that one of the most useful mappings of the resilience concept comes from delineating 16 different conceptualizations of the term ranging from the psychological, social and ecological to the economic. Bahadur et al confess that there seems to have been very little attempt to scrutinize the literature to study how scholars could derive a workable approach to the complexity of the resilience concept. The writers argue that what can be seen now is the adoption of a term that is diverse in meaning. Perhaps more worryingly is the observation that there is also often a lack of awareness among most scholars that such a multiplicity of explanations of the same concept exists. Operationalization of the term is of great significance as different ways in which scholars understand the term may have different implications and may eventually lead to different indicators of the resilience systems.

3.4.2 Community resilience factors and measurement

A study by Anokye and Asuah (2016) reiterates that the absence of a universally agreed resilience measurement tool makes the concept of resilience difficult and subjective (Steiner and Markantoni, 2014; Kulig et al., 2008) in the sense that parameters used by some scholars are seen as outcomes by others. In addition, the scholars argue that differentiation in a set of cultural, locational and policy context makes direct application of the normative perspectives inappropriate because local settings and socioeconomic characteristics are essential in obtaining desired results (Steiner and Markantoni, 2014). As a result, a mixed-method analytical framework is required (Magis, 2010). Magis' study borrowed the three resilience parameters used by Matarrita-Cascante and Trejos (2013) as a tool for measurement because the study measured similar objectives in a different setting. Thus, the reason for justifying the need for the chosen measurement parameters is that the study was focused on measuring the ability of mining communities in Obuasi to cope with and recover (Olsson et al., 2015; Steiner and Markantoni, 2014) after the on-going stress (Magis, 2010).

Local ownership of resources is known to place the community in a better condition in light of changing circumstances (Matarrita-Cascante and Trejos, 2013) because it facilitates economic benefits such as increased multiplier effect, and reduced leakages (Adger et al., 2005). It also facilitates non-economic benefits such as increased control over decision-making, sense of inclusion and responsibility. Matarrita-Cascante and Trejos (2013) argue that the importance of citizen involvement in community decision-making is much highlighted in literature. It is argued that such participation ensures the mobilization of resources towards problem-solving (Magis, 2010). Furthermore, organizational capacity, particularly in the context of resource dependent communities, is critical given the contribution which local knowledge and citizen input provide when designing and implementing policies that define natural resource usage, control, and distribution (Matarrita-Cascante and Trejos, 2013). The work of Kulig et al. (2008) highlights the presence of visionary leaders and supporters; access to resources and others with influence, community-minded, and knowledgeable about local resources, as some of the characteristics identified as leading to resilience at the community level. The writers argue that these, in addition to institutional adaptability, are critical for the community to receive economic and non-economic benefits, given how regulations and policies can define or redefine resource access, control, and usage (Kulig et al., 2008; Matarrita-Cascante and Trejos, 2013).

However, previous research has shown that due to the multiplicity of interpretations of the resilience theory, however, there is still little or no consensus on factors that lead to increased climate resilience and the parameters that should be used to measure progress in becoming more resilient. Nevertheless, the vulnerability-resilience indicators model (VRIM) as reported by (Moss et al., 2001; Brenkert and Malone, 2005; Malone and Brenkert, 2008), identifies 17 factors (as listed in Table 2) that together assess the resilience of a society. The model represents both managed and unmanaged land, economic activities that are natural-resource intensive, and socioeconomic characteristics. The VRIM model has been used by various researchers, scholars and practitioners to compare 160 countries (Moss et al. 2001, Malone and Brenkert in press a), to evaluate adaptive capacity at temperature increases of 1.5°C and 4.5°C (Yohe

et al., 2006a, b), to analyze India and Indian states under current conditions (Brenkert and Malone, 2005) and future scenarios (Malone and Brenkert, 2008), and to examine resilience in Mexico and Mexican states (Ibarrarán et al).

Table 2 showing sectors and variables used in the VRIM

Sectoral Indicators	Proxy Variables	Proxy For
Food security	Cereals production/crop land area	Degree of modernization in the agriculture sector; access of farmers to inputs to buffer against climate change and variability
	Protein consumption/capita	Access of a population to agricultural markets and other mechanisms to compensate for shortfalls in production
Water resource sensitivity	Renewable supply and inflow of water	Supply of water from internal renewable resources and inflow from rivers divided by withdrawals to meet current or projected needs
Settlement/ infrastructure sensitivity	Population at flood risk from sea level rise	Potential extent of disruptions from sea level rises
	Population without access to clean water	Access of a population to basic services to buffer against climate change and variability
	Population without access to sanitation	
Human health sensitivity	Completed fertility	Composite of conditions that affect human health including nutrition, exposure to disease risk and access to health services
	Life expectancy	
Ecosystem sensitivity	Percent of land managed	Degree of human intrusion into the natural landscape and land fragmentation
	Fertilizer use/cropland area	Nitrogen/phosphorus loading of ecosystems and stresses from pollution
Human and civic resources	Dependency ratio	Social and economic resources available for adaptation after meeting other present needs
	Literacy	Human capital and adaptability of labor force
Economic capacity	GDP (market)/capita	Distribution of access to markets, technology, and other resources useful for adaptation
	An income equity measure	Realization of the potential contribution of all people

Source: Brenkert and Malone, 2005

3.4.3 Resilience in mining communities

As alluded to in the previous section, the concept of resilience has been developed with the purpose of managing and responding to community crises. Resilient communities are said to be those that can absorb and/or adapt quickly to change and crisis. Callaghan and Colton (2008)'s work reviews that the success of building a resilient community hinges on strong leadership with clear and open communication. Community Conservation Resilience Alliance Initiative (CCRAI) (2020) project in Chile reiterates that communities' resilience and their ability to continue managing and conserving their local environment could be significantly improved by policies meant to empower them by encouraging self-determination, strengthening cultures and reviving traditional ways of relating to nature. They argue that ecosystem recovery, forest regeneration and sustainable agriculture are among the key priorities. CCRAI emphasized the importance of strengthening institutions that evaluate and monitor environmental impacts. The report also suggests that local energy generation projects should be developed in collaboration with communities, in order to support them with financial resources and institutions, and to take advantage of the communities' existing decision-making structures. These projects would benefit from communities' interest in getting involved in projects that would help address their own problems.

A study conducted by Nasdian et al. (2020), using an emic and etic approach to explore community resilience and food insecurity in South Kalimantan, found that the pattern of community resilience in the

two communities under study was in the form of social movements classified as social adaptation, and agricultural land recovery and the changing agricultural commodities as a form of ecological adaptation. The study observed that the process of community resilience in the two communities was at the level of recovery towards a stable community condition, not yet at the transformation stage. Community capability is the most influential factor on the degree of community resilience so that the handling of food insecurity based on community resilience should be done by coming up with strategies for increasing community capabilities.

Another study conducted by Kanakis (2018), on mining community resilience, reported that the resilience of mining communities is subject to many factors among which are economic market trends and the lifecycle of the resource being mined (Black, 2005). Callaghan and Colton (2008) argue that sustainable development requires consideration of the actions needed at a local level that are seen to contribute to or hinder community resilience. The work of Kanakis (2018) concluded that factors that influence general community wellbeing reflected the six forms of community capital and highlighted the interconnectedness of relationships between the different forms of community capital. The study indicated that social capital components played a key role in resident's discernments of the community's wellbeing. It was observed that mining activity was perceived to have various impacts on local mining communities. Kanakis' study showed that although participants reported positive impacts, they more consistently identified negative impacts of mining activity on community wellbeing. Again, social capital components were recognized as playing a key role in residents' perceptions of the mining industry and the negative impacts of mining activity. Due to these reports of social capital components being a key determinant of community wellbeing, the study has suggested that these factors need to be considered within sustainable community development approaches.

Pfefferbaum et al. (2013)'s study used communities advancing resilience toolkit (CART) as a publicly available theory-based and evidence-informed community intervention to increase community resilience by bringing stakeholders together to address community issues in a process that would include assessment, feedback, planning, and action. Tools used in the study included a field-tested community resilience survey and other assessment and analytical instruments. Pfefferbaum reports that the CART process encouraged public engagement in problem-solving and the development and use of local assets to address community needs. The CART process also recognized and identified four interrelated domains that contributed to community resilience and these were connection and caring, resources, transformative potential, and disaster management. The study observed that the primary value of CART was to contribute to community participation, communication, self-awareness, cooperation, and critical reflection and its ability to stimulate analysis, collaboration, skill-building, resource sharing, and purposeful action.

A study by Kuir-Ayius (2016) was focused on building community resilience in mine impacted communities in Papua New Guinea. The study investigated relevant models of community resilience from the literature and how policy functions could be related to these models. The study also developed a way of quantifying the impact of mining on health service delivery and the building of resilience in these communities. However, the investigation showed a number of discrepancies in the levels of resilience in these communities, which varied with the stages of mining. It was observed that both the beginning and post-mine closure stages demonstrated significantly low levels of community resilience as compared to the operational phase. Findings from the research indicated a lack of access to health services resulting from a range of factors which included but not limited to insufficient finances, weak sector governance, and the need for infrastructure and transport.

Matlaba et al. (2021)'s study, which was based on resilience perception of a mining town in eastern Amazonia, used theories as a conceptual orientation for the development of a resilience scale for measuring resilience at the community level in a large-scale mining. This approach allowed for the evaluation of resilience perception using 26 interview statements derived from six resilience theories. The multivariate analysis method used found that the perception level of community resilience among residents was reasonable. The interviewees pointed out one positive and five negative factors that influenced the level of resilience to be moderate but could have been improved with more economic diversification and infrastructure, and less inequality in access to services and involvement in decision-making. The most considered relevant themes were problems caused by mining in the municipality, quality of life issues dealing with change after the arrival of mining, and economic problems.

Another study by Wasylycia-Leis et al. (2014) revealed that despite recent efforts by government to regulate the industry, the mining industry continued to generate press and pulse disturbances that

impacted the resilience of the community. Operating from the view that resilience depends largely on the management capacity of stakeholders, the study identified three ways to improve mining governance in Itabira. First, they observed that there is a need for local government to have more power in dealing with the corporation. Concurrent with this power, however, the municipality had to demonstrate ownership over its fate ideally through the creation of a sustainability plan. Finally, all key parties had to demonstrate commitment to cooperation in resolving outstanding disturbances even when these fell outside the regulatory approval process. The study observed that while Itabira would remain a mining town for the foreseeable future, actions taken then to address challenges would only strengthen community wellbeing and sustainability going forward.

3.4.4 Resilience policy and practice

As illustrated in the previous sections, the resilience concept is still being used in various disciplines and it has tremendously gained a lot of prominence in the area of policy. Scholars recognize that many programs that want to build climate and disaster resilience provide demonstrated examples of the resilience concept (Nelson, Adger and Brown, 2007; Ensor, 2011). The writers argue that with the increased understanding of the relationship between disaster risk and climate change, a lot of effort seems to have been made to invest in incorporating a variety of methodologies aimed at building more resilience. This seems to have taken several forms such as through mainstreaming disaster risk reduction into development programs; convergence of climate change adaptation and disaster risk reduction; and the reframing of development through a climate lens. A recent example of an approach aimed at contributing towards building resilience is said to be the climate smart disaster risk management (CSDRM), which is trying to bring together climate change, disaster risk management and development. At the policy level, the United Kingdom (UK)'s humanitarian emergency response review (HERR, 2011) and DfID's response to the review (DfID, 2011) provide insightful examples. It is argued that despite the inclusion of the term resilience in these and many other important policy and program documents, it is still not clear, among many scholars, what the concept really means in approach, policy and practice.

Satterthwaite (2008) says what is required now in order to address climate change is competent and accountable urban governments which integrate adaptation measures in an all-inclusive manner. Satterthwaite says several measures need only slight modifications to existing practices such as building codes, land subdivision regulation, land-use management and infrastructure standards, which can build resilience without high costs over time. Tanner et al. (2009) adds that building policies can help increase energy efficiency, and waste policies can reduce CO2 emissions. In the final analysis, there is need for transparency, accountability, participation and inclusion during the implementation of such policies in order to ensure good governance for adaptation.

It is important that any effort to understand what a resilient system looks like is as clear as possible in order to avoid misconceptions (Adger, Lorenzoni and O'Brien, 2009). This includes, among other things, being historically knowledgeable; taking into account the political economy of a given situation; and taking into consideration the role of natural resources and natural resource management in local livelihood systems. It also includes taking into account the crucial role of people's discernments and the importance of climate change adaptation; different viewpoints of risk; the role of formal and informal governance mechanisms at different levels; the understanding of the conflict dynamics at play; the role of indigenous coping mechanisms; and the role of culture in disaster risk (Harris, 2011). Bahadur et al (2010: 19) are of the view that taking a position that integrated policies and programs is one way of operationalizing the characteristics of resilience provides latitude to examine the value of existing programs which have attempted to bring on board a variety of sectors and approaches.

Zambia's National Climate Change Response Strategy (NCCRS) (2010) has identified "*agriculture, food security, fisheries, water, forestry, wildlife, health, mining, tourism, human settlements, and physical infrastructure" as priority sectors for adaptation based on their economic vulnerability and national development priorities"* (GRZ-NAPA, 2007; GRZ-NCCRS, 2010). Priority projects presented in the NCCRS and National Adaptation Program of Action (NAPA) (2007) include "*improving the Zambia Meteorological Department (ZMD)'s early warning system to facilitate timely dissemination of weather information so as to enhance preparedness; promoting better land and critical habitat management; diversifying crops and livestock to improve nutrition and food security; promoting alternative sources of livelihood to reduce vulnerability to climate change and vulnerability; enhancing water management to withstand erratic rains through water harvesting, water conservation, and small-scale irrigation;*

renovating and rehabilitating existing health infrastructure; and climate-proofing sanitation in urban areas" (GRZ-NAPA, 2007; GRZ-NCCRS, 2010).

Priority challenges and constraints for addressing vulnerability and increasing resilience data, research, and capacity needs include "*carrying out climate change data collection and monitoring; improving training for policymakers and other relevant stakeholders on tools for developing climate scenarios and analyzing vulnerability; improving inter-ministerial and inter-institutional coordination to facilitate implementation and mainstreaming of cross-cutting environmental and climate change programs, plans, and policies; increasing public awareness on climate change and its potential impacts on social and economic development, livelihoods, and ecosystems; and developing clear and specific legal and policy frameworks for climate change to help direct adaptation planning*" (GRZ-NCCRS, 2010).

Studies highlighting governance and institutions also represent another view of urban resilience. Literature on urban resilience seems to focus on questions of how different types of institutional arrangements affect the resilience of local environments. The literature also focuses on how resilience thinking can influence the development of better governance instruments for enhancing adaptation to climate change such as new types of social contracts and CBA efforts (Avis, 2016). The writer highlights how resilience principles, such as adaptive management, can be used to promote sustainability in highly developed coastal zones. Governance studies also show which characteristics of urban governance can increase climate resilience while reducing vulnerability of urban citizens who are most at risk to climate change impacts. Avis says some of the many characteristics of urban governance that are identified as promoting resilience include: polycentricity, transparency and accountability, flexibility, and inclusiveness. But instead of identifying a single 'best practice' arrangement, the governance literature advocates for varied methodologies, arguing that effective institutional arrangements take many forms.

Twigger-Ross et al. (2015) report that the policy focus in the UK currently in relation to community resilience, for example, is generally on direct shocks resulting from extreme weather events, rather than longer-term pressures. This explains why the policy places emphasis on emergency planning and the role of the community linked to other institutions in supporting responses. The writers reiterate that other areas of policy are directed towards tackling indirect shocks and stresses relating to climate change but they are framed as climate change mitigation rather than as supporting community resilience.

3.5 Climate change adaptation

3.5.1 Understanding adaptation

The IPCC (2014) defines adaptation as "*the process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects*." McCarthy et al. (2001) describe climate change adaptation as "*actions targeted at the vulnerable system in response to actual or expected climate stimuli or their effects with the objective of moderating harm from climate change or exploiting opportunities*." The writers argue that climate change adaptation is an urgent, yet insufficiently funded priority for poor communities who are already exposed to existing climatic and non-climatic stresses. The main societal response alternatives for reducing climate-related risks are mitigation and adaptation to climate change (McCarthy et al., 2001). However, our interest, in this review paper, is in responses pertaining to climate change adaptation and community resilience to socioecological impacts of climate change.

Literature shows that adaptation is not a new concept because in the past societies repetitively adapted to climatic changes through migration, modifications in agricultural practices, and in shelter. It is further observed that communities in southern Africa have always adapted to climate change by making preparations based on their resources and their traditional knowledge accumulated through experience of past weather patterns. They have also reacted to and recovered from climate extremes such as floods, droughts and hurricanes (Armitage and Plummer, 2010). However, the writers argue that because climate change comes with new threats and new uncertainties, communities' past experience alone can no longer be used to guide or predict future events. Furthermore, while African farmers have developed several adaptation alternatives aimed at coping to current and future climatic changes, such adaptation will not be sufficient for future changes of climate (IPCC, 2007). This realization seems to have led to the need to develop alternative climate adaptation methodologies that are in tandem with present realities and

futuristic. It is for this reason, therefore, that a focus on communities' response to changing climatic conditions requires a thorough understanding of the adaptation concept.

Smit and Wandel (2006) argue that the adaptation concept reoccurs throughout a diverse range of fields; both within the natural and social sciences. In particular, anthropology, ecology and natural hazards have developed considerable amounts of literature which demonstrate the greatest influence on climate change research. The writers argue that probably the most extensive use of the concept is borrowed from disaster risk reduction where people and their families are molded and constrained by social, political and economic forces which determine their capacity to adapt to climate change disturbances (Klein et al., 2003; Schipper and Burton, 2008). In view of this, research into climate adaptation is focused on 1) decreasing *vulnerability*, 2) increasing *resilience* to climate change impacts, and 3) increasing *capacity* to cope with climate change impacts (Schipper and Burton, 2008).

Birchall and Bonnett (2020)'s study reviews that adaptation in practice is further illustrated through the difficulties of defining its basic goals. Engle (2011) points out that one goal of adaptation is to increase adaptive capacity in order to manage or reduce risk while a second goal is to increase resilience to climate change (Nelson et al., 2010). A third goal is to reduce vulnerability to impacts of climate change (Yamin et al., 2005). It is argued that the origins of these three goals are from a varied array of disciplines such as ecology, human geography, sustainability science, risk management, and development, and they all seem to have come together under the umbrella of adaptation research (Goldman et al., 2018). Smit and Wandel (2006) explain that these adaptation goals are all interconnected. De Coninck et al. (2018) point out that a system with a high adaptive capacity should be less vulnerable to harm, and more resilient and able to cope with risk. The writers echo that the residents of the Pacific Islands, for example, have strengthened their adaptive capacity and reduced vulnerability by developing systems to share resources and labor, which has helped communities prepare for and recover from drought and cyclones.

CBA as an approach for adaptation attempts to address the local definition of adaptation to support an all-inclusive view of climate adaptation. Building from this origin of the adaptation concept, the development community has become an important partner for the climate community by sharing knowledge and expertise based on previous experiences. Thus, the goals of the climate and development communities often overlap as unsustainable development is not only the underlying cause of climate change but also the cause of development pathways which determine the degree to which populations are susceptible to a changing climate (Huq et al., 2006). A study by Singh et al. (2021) reviews that although cities may increase risk, they may also provide chances for innovation. Sigh et al. illustrate this by stating that Indian cities, for example, seem to face an urgent imperative to adapt to current and projected climate change impacts despite being located at the crossroads of extensive urbanization, unequal development, and high climate vulnerability. Araos et al. (2016) argue that while a global valuation of urban adaptation found no examples of municipal government adaptation being reported, Indian cities are increasingly reporting various planned and autonomous actions that have adaptation co-benefits.

A study by Jiri et al. (2017) found that farmers used indigenous knowledge to adapt to climate change impacts and by diversifying across crops and risk management options. Farmers generally varied their agricultural practices by utilizing activities that were less sensitive to drought and those that took full advantage of benefits derived from climatic conditions. Farmers, for example, planned their planting and inputs based on their best estimates of the cropping season, and in this way they reduced their risk exposure by varying their ways of living. Nevertheless, the writers admit that effective management of droughts in climate risk-prone areas requires modifying livelihood approaches and income generating alternatives within and outside agriculture, especially into income generating alternatives through non-farm enterprises and employment opportunities.

However, there seems to be little consensus on what counts as effective adaptation in practice. One probable reason may be that most of the initiatives proposed and planned are rarely implemented (Bierbaum et al., 2013; Mimura et al., 2014). Obstacles that regularly hinder adaptation efforts may include insufficient resources, prohibitive policies, conflicting priorities for action, and uncertainty about future climate changes (Moser and Ekstrom, 2010; Biesbroek et al., 2013). Adaptation efforts are molded by exceptional combinations of localized situations such as politics, funding, motivation, power dynamics, and cultural values. It is argued that initiatives entrenched in one community can produce different outcomes in another community. It can also be difficult to differentiate climate adaptation from related activities such as reducing risk to environmental disasters or alleviating poverty, which renders successful adaptation efforts complicated and ineffective. The IPCC, for example, claims that integrating

climate adaptation into sustainable development strategies will result in win-win solutions (Roy et al., 2018). While efforts to mainstream climate adaptation may appear efficient, actions that address present development issues may conflict with actions that address future climatic risks or vice versa (Barnett and O'Neill, 2010; Roy et al., 2018).

A study by Owen (2020) highlights the difficulties associated with defining adaptation, delineating its objectives, and demonstrating progress towards meeting those goals. Owen argues that the multiplicity of overlapping measurement instruments, situations, and meanings can be overwhelming. However, Schipper and Langston (2015) emphasize that these difficulties should not at all paralyze action. Scholars and practitioners can still work with the diversities embedded in adaptation by making their assumptions, values, and perceptions of progress clear and harmonizing those notions with other ways of knowing and understanding. In the following section, this review paper gives examples of some of the adaptation initiatives that have been implemented and gives selected contexts of how effective this has been documented. The analysis seems to offers some explanation on what characterizes adaptation practices, offers some observed examples of effectiveness, and identifies emerging research gaps.

3.5.2 Adaptation measures and effectiveness

Available literature shows that a number of studies have been conducted to measure adaptation and assess its effectiveness in addressing the impacts of climate change in urban communities. Owen (2020)'s study, in particular, has demonstrated the effectiveness of some of the implemented adaptation practices by outlining the following indicators, which are based on progresses in resilience, vulnerability, capacity, and/or preparedness:

a) Minimizing risk to impacts of climate change;
b) Augmenting social relations and community welfare;
c) Improving ecosystem health, environmental quality, and natural resources;
d) Improving household incomes and access to economic resources; and
e) Strengthening institutional connections, policies, and governance practices.

The study observed that more than ¾ of cases showed effectiveness across a number of indicators. The writer observed that the majority of cases showed effectiveness by decreasing risk to impacts of climate change. This was followed by cases that demonstrated improvements in social relationships and community welfare. Improvement in ecosystem health, environmental quality, and natural resources was third followed by an increase in household incomes and access to economic resources. The least of the cases demonstrated strengthening of institutional links, policies and governance practices.

Owen (2020) observed further that the activities that often times showed risk reduction had to do with water resources availability from new reservoirs and irrigation systems, more efficient use of water, and rainwater harvesting. Indicators of improvements in social relationships and community welfare included improved cooperation, sharing of resources or increased access to resources associated with human welfare. Indicators for improving ecosystem health, environmental quality, and natural resources included reduced land degradation, improvement in soil and water quality, restoration of ecosystem functions, and enhancement in biodiversity. Owen's study found ecosystem-based adaptations and policies to be the most common for tackling ecological issues such as erosion control, environmental restoration and conservation, adaptive and fisheries management. Indicators for improving household incomes and access to economic resources included making changes to agricultural, aqua cultural or livestock practices and livelihood diversification. Lastly, indicators for strengthening institutional links, policies, and governance practices included creation of new partnerships, improved institutional connections, conflict resolution and management, enhanced local involvement and independence, and change in government structures.

Li et al. (2018)'s study also found that subsidies for water reservoirs and storage from the Beijing government helped farmers minimize their exposure to effects associated with extreme temperatures. This was also demonstrated by Eakin et al. (2015)'s study which found that an early warning system in Chile alerted potato producers to protect their crops from potential pest hazards and disease outbreak. Another study by Sterrett (2011) showed how structural adaptations led to increases in food security for village households, increased access to safe and clean drinking water, decreased women's daily workloads, and reduced the number of lives lost during a cyclone. Sterrett underscored enlargement of water storages, solar-powered water pump installations, establishment of a plant nursery, and building of an emergency shelter as some of the adaptations undertaken. Other practices which played a considerable

role in improving social relationships included cooperative development practices and financial incentives. Jacobi et al. (2013)'s study also observed that in Bolivia, local agricultural cooperatives provided farmers access to information and physical resources to enable them to shift from monoculture farming to agroforestry involving cocoa trees. This adaptation created better working conditions and led to increased levels of self-organization among farmers.

Ryan and Elsner (2016)'s study also observed that sand dam rainwater harvesting systems helped vegetation recover more quickly after periods of drought in Kenya. Lubchenco et al. (2016)'s case demonstrated how a fishery on the western coast of the United States implemented co-management procedures that decreased the risk of overfishing seven ground fish species. In Brazil, Oviedo et al. (2015) reported that a community-based fishing management structure was implemented in two aquatic reserves in the Amazon Basin. It was found that freshwater fish populations increased tremendously resulting in increased household incomes over a five-year period. In the Philippines, Furoc-Paelmo et al. (2018) illustrated how the introduction of a rubber-based agroforestry system improved household incomes in two farming areas. In St. Vincent and the Grenadines; a network of institutions and community organizers, was strengthened through efforts to fund and build a solar-powered desalination plant to increase local freshwater availability and future water security (Jaja et al., 2017).

3.5.3 Adaptation response using CBA

It is argued that in order to have a spatial planning model and to develop urban physical aspects that are adaptive to climate calamities takes the readiness of the human aspect. It also depends on how urban communities respond to climate-related calamities that are a danger to their socioeconomic welfare (Wijaya and Luthfi, 2021). Therefore, the writers' argument is that using CBA, urban communities can be encouraged to be more adaptive and responsive because they are the ones who are severely affected by these climate-related calamities, particularly the poorest communities. Chishakwe et al. (2012 describe CBA as a form of adaptation whose aim is to decrease climate change risks to the world's poorest communities by allowing them to also participate in the practices and planning of adaptation initiatives. It adds to current methodologies to adaptation by highlighting the social, political, and economic drivers of vulnerability, and the needs of vulnerable communities. Chishakwe et al. (2012) add that CBA is a bottom-up approach that places the community at the centre of determining how to respond to climate change impacts. The approach emphasizes community involvement that builds on the main concerns, knowledge and capabilities of local people. These include, among other things, the development and transference of technology aimed at improving adaptive capability and the ascertaining of community susceptibility through assessments of threats that communities may face. The writers contend that CBA can also use the opportunities and experiences provided by non-climate initiatives that have enabled these communities to deal with other stresses. By so doing, non-climate initiatives have also established capacity, institutions and models which can be used by communities to deal with a range of stresses with minimum external support.

CBA seems to have developed from the bringing together of climate change and development in order to advance community-driven climate change adaptation. It is a bottom-up approach because the community is the subject of projects including competence development and technology transfer; and also being the main entity to implement adaptation (Sekine et al., 2009). CBA uses participatory approaches to gather existing indigenous knowledge and coping strategies and to identify new adaptive measures (Prowse and Scott, 2008). In so doing, vulnerability and resilience assessments not only address scientific knowledge of climate change impacts but also diverse factors such as poverty, social capital and indigenous knowledge (Sekine et al., 2009). CBA also advocates adaptive decision-making in light of climate uncertainty. As clarified by Bharwani et al. (2005), this shift "addresses the need to support strategic and operational decision-making on climate risk management and adaptation. Key concepts are the need to reduce decision uncertainty, the value of climate information and understanding actual decision processes".

CBA also tackles the traditional top-down adaptation approach partly because almost 85 percent of all priority projects identified by the National Adaptation Programs of Action (NAPAs) pay little or no attention to local institutions (Agrawal et al., 2009). CBA targets local communities and institutions with the aim of feeding into higher-levels; a goal which is realized with varying degrees of success within CBNRM. It puts poverty-reduction and empowerment at its core with the aim of enabling communities to take action themselves based on their own decision-making processes. However, while CBA is a

relatively new approach, it is based on certain established principles borrowed from other development fields (Huq and Reid, 2007).

Sekine et al. (2009) explain that for people in the third world, introducing technologies that do not translate into short-term benefits tends to be risky and to avoid such a situation, trust in the local government and within the community are necessary. Moreover, it is argued that the community is the one which defines its own vulnerability and resilience after all the necessary scientific information is provided. In this respect, CBA combines scientific projections from a number of sources such as climate change models, seasonal forecasts, remote-sensing, and satellite pictures together with traditional knowledge about trends and patterns experienced by communities (Reid et al., 2010). This is particularly appropriate for areas where there is inadequate historical data about climate trends and where traditional knowledge can inform regional scientific studies.

Reid et al. (2009 report that there are many studies and reports that illustrate the accuracy of traditional knowledge of climate change. Whilst communities can map out changes of climate in their local setting, there may exist little knowledge of the global drivers and effects of climate change. CBA often employs co-learning methodologies, taking into consideration both traditional and external scientific knowledge about climate change (Reid et al., 2009). The use of forecasting for agriculture or disaster risk reduction, in particular, requires trust in the forecasts based upon the accuracy and payoffs of different strategies; taking many years to gradually shift practices (Bharwani et al., 2005). Reid et al. (2009) have identified 11 examples of participatory tools used by CBA approaches as shown in Table 3.

Table 3 showing examples of participatory tools used by CBAs

Participatory Tools	**Uses**
Mental models	• Drivers and effects of climate change
Seasonal calendars	• Seasonality and links with livelihoods can be combined with timelines to show perceived changes in seasonality
Timelines	• Hazards and events trends in climate (i.e. temperature and rainfall)
Community mapping and modeling	• Resources • Types and causes of risks and threats • Extent of vulnerable areas • Vulnerable households and individuals • Planning DRR/CC adaptation measures
Transect walks	• Vulnerability/risks • Land-use • Resources
Ranking	• Vulnerabilities and hazards • Coping and DRR strategies (i.e. water management, crop varieties)
Dream maps and drawings	• Vision of community or farm and how to achieve measures
Theatre, poems and songs	• Awareness raising of risks and risk reduction measures • Advocacy
Participatory videos	• Awareness raising • Farmer to farmer communication • Advocacy
Stakeholder analysis	• Institutions, relationships, power
Key informant discussions	• In-depth discussion of vulnerability • Livelihood sources

Source: Reid et al., 2009

3.5.4 Adaptation response from mining companies

Communities near urban mineral producing cites are regularly under pressure from several stressors, with mining being one such stressor. For example, most of Zambia's Copperbelt mines operate in areas characterized by high social inequality, food insecurity and water stress. The local urban communities are often not satisfied with the provision of basic services and infrastructure in the region. In addition, these local urban communities report that they suffer from environmental disturbances arising from noise, air

and water pollution caused largely by mine operations and have experienced relocations. In such contexts, climate change can act as a risk multiplier by exacerbating the already existing social and environmental impacts and increase the risks of tensions and conflicts between the mine owners and the communities. For instance, increasing water stress linked to climate change could intensify competition over water between the mines and the local communities in the future if nothing is done.

A study by Gustafsson et al. (2021) identified three main types of adaptation responses to climate risks which are institutional, infrastructural, and community-oriented. Out of these types of responses, community-oriented responses have so far received little attention among researchers, signifying limited interest in this area. The writers classify community-oriented responses to climate risks into activities that primarily or partially promote community resilience. Such responses can support communities to diversify their agricultural practices or setting up irrigation systems or water storage infrastructure to enable communities to have access to continuous supply of water (Sovacool and Linn´er, 2016). There is also increasing awareness that community-oriented responses are necessary to ensure that private adaptation actions do not harm local communities (UN Global Compact et al., 2015). This is perhaps the more reason why most large transnational companies, particularly in the mining sector, engage in some sort of corporate social responsibility (CSR) projects that focus on improving community resilience as climate hazards become irresistible (Gustafsson, 2018; Haslam, 2021).

Eriksen et al. (2021)'s study revealed that 26 percent of the companies reported that they conducted adaptation initiatives that sought to increase the adaptive capacity of indigenous communities. However, it was observed that companies often reported isolated cases of CSR projects which were aimed at increasing community resilience. When asked about the need to consider the climate impacts on indigenous communities as an integrated strategy, most company representatives argued that if companies improved their own climate resilience, this would have positive impacts on host communities. Eriksen et al. further report that even if company representatives claimed that their adaptation initiatives had a positive impact on the community because they reduced the risks, companies still disregarded the well-known tradeoffs and risks for unintended consequences associated with adaptation interventions. The study reported that although companies had started to address the impacts of climate change on their operations, responses did not usually address the vulnerabilities of indigenous communities.

UN Global Compact et al. (2015) reports that one of the most significant concerns for indigenous communities was access to water. This meant that a more meaningful way of disclosing information and involving stakeholders was by incorporating climate hazards into current participatory water management initiatives. For instance, in Colombia, South 32 formed a community climate action model (CCAM) to manage water utilization in a clear and participatory way (Kunz et al., 2017). It is argued that through these approaches, indigenous communities were able to share information about their needs, assess community strategies, and reach agreements with mining companies on how to share their scarce water resources. However, Odell (2021) argues that while such collaborative initiatives may create opportunities for community influence, such close interactions with companies might also lead to internal conflicts and fragmentation among indigenous communities. Thus, while most of the mining companies had started to outline risks to core business undertakings, accountability and information disclosure and participation of indigenous communities tended to be weak.

Gustafsson et al. (2021)'s study raises significant issues about the societal effects of private adaptation. The study suggests that companies adapt to climate hazards in order to reinforce business resilience while taking little obligation to develop societal resilience. The writers argue that this has ramifications for the affected communities and weakens the significance of further thought on how private adaptation mediations affect climate vulnerability (Dolsak and Prakash, 2018; Eriksen et al. 2021; Purdon and Thornton, 2019; Sovacool and Linnér, 2016) in the mining sector. It is argued that mining activities place immense pressure on water supplies and livelihood assets, and contaminate the environment (Bebbington and Bury, 2009; L`ebre et al., 2020), and these impacts are likely to be aggravated by climate change. Such overlapping impacts have, however, largely been overlooked in scholarly and policy debates about mining governance (Odell et al., 2018). The study sheds light on the importance of augmenting community participation in the design and implementation of private adaptation, in order to avoid inequitable consequences of private adaptation initiatives. Odell et al.'s study recommends a need for systematic analyses of the concrete impacts of private adaptation strategies on local communities, both in the context of mining and in other issue areas.

The work of Loechel et al. (2013) reveals that effective climate change adaptation in mining communities is reliant on action by both local authorities and mining operations. This view is supported

by Ford et al. (2011)'s study which reveals that recent studies on Canadian mining industry indicated that despite being aware of current impacts from climate change and reported actions to adapt, the sector was not undertaking long term adaptation planning. Ford et al. argue that the key obstacles to taking action were reported as uncertainty about future climate conditions and the cost of adaptation measures. Most of the response to impacts of climate change was focused on mitigation rather than adaptation measures. Lack of knowledge about climate forecasts and probable impacts were reported as the main constraining factors to the industry's knowledge about climate risks. Another study by Loechel et al. (2013) suggests that because of the role the mining industry plays in the economy, its ability to influence regional communities, and the vulnerability of both industry and communities to climate risks, there is need to clearly understand the respective capabilities of the industry and local councils to adapt to climate change.

Nevertheless, a study by Gustafsson et al. (2021) reiterated the fact that although most of the mining companies do respond to climate risks, there are still a number of significant gaps that are left unattended to when it came to community involvement and ensuring that they also benefited from such initiatives. The study observed that these inadequacies were partially as a result of weaknesses in government and pressure groups such as civil society organizations which are mandated to force the mining companies to address climate risks in a beneficial way. The study also found that mining activities seemed to place huge pressure on water supplies and livelihood assets, and often times polluted the environment (Bebbington and Bury, 2009; L`ebre et al., 2020). The writers argue that such overlapping impacts have, however, largely been overlooked in scholarly and policy debates about mining governance (Odell et al., 2018). Odell et al. recommend the importance of increasing the involvement of communities in the planning and execution of private adaptation in order to avoid unequal effects of private adaptation initiatives. The study further suggested that there was a need for systematic analyses of the actual impacts of private adaptation strategies on local communities, both in the context of mining and in other areas.

3.6 Adaptive capacity

3.6.1 Understanding adaptive capacity

The final core concept of climate change adaptation is that of adaptive capacity. The IPCC defines adaptive capacity as "*the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences*" (IPCC, 2007: 869). This definition is also intended to apply to physical and social systems. In this study, the term 'adaptive' has been used to mean any response that increases a community's probability of survival from climate change impacts. A distinction is made between coping mechanisms and adaptive strategies. Coping mechanisms are used to mean a bundle of short-term responses to situations that threaten livelihood systems, and they often take the form of emergency responses in abnormal seasons while adaptive strategies are the ways in which individuals, households, and communities change their productive activities and modify local rules and institutions to secure livelihoods. The two kinds of responses may overlap over time, and coping mechanisms may develop into adaptive strategies over time.

Adaptive capacity is one of the main factors that influence the vulnerability of regions to climate change (Adger et al., 2005, 2007; Park et al., 2012a, b). The concept has been of interest to many researchers within the last decade (Smit and Wandel, 2006; Engle, 2011; Engle and Lemos, 2010; Glaas et al., 2010; Juhola et al., 2012a, b). "*Adaptive capacity is the capability of the system to protect socio-ecological systems from changes or perturbation*" (Pandey and Jha, 2011). It involves enhancement or modification in systems, even without change. Adaptive capacity can also include reactions of the system that alter its sensitivity to perturbation (Gallopin, 2006). In adaptive capacity assessments, the focus is on societal aspects, such as technology, infrastructure and knowledge that are driven by public and economic policy, thus making it of interest to decision-makers (Adger et al., 2007). The use of assessment results in decision making is important, given that adaptive capacity, as part of a vulnerability assessment, has the most relevance to policy making in the field of climate adaptation (Engle, 2011).

Adaptive capacity does not refer to short-term coping strategies, which are themselves adaptation alternatives, but involves continuous and permanent change in the system. To highlight this subtle difference, the IPCC (2007) defines the coping range as "*the variation in climatic stimuli that a system can absorb without producing significant impacts*". As such, there is an implied limit to coping which

may be well addressed within existing natural resource management. What makes the capacity to adjust unique is that it is permanent and requires a change in the system rather than pushing the limits of the current system.

3.6.2 Adaptive capacity measures and indicators

In most cases, adaptive capacity is generalized without clear indicators. It is reliant on a number of social, economic, political, technological and institutional factors such as varying in weight depending on the scale of analysis (Vincent, 2007). The link between these indicators changes at the national level when the focus goes to the community level. Acknowledging this uncertainty and complexity, a useful framework is the Local Adaptive Capacity Framework (LACF) developed by the Africa Climate Change Resilience Alliance (ACCRA), which outlines the main determinants of adaptive capacity. This is made up of the asset base of a community, institutions and entitlements, knowledge and information, innovation and governance (ACCRA, 2010).

The IPCC (2007) also identifies "*economic wealth, technology, information and skills, infrastructure, institutions and equity*" as the principal determinants of adaptive capacity. Others include "*social capital and good governance as additional key components*" (Adger, 2003; Jones et al., 2010). Much of the focus in the measurement of adaptive capacity has been at the national level, with a heavy emphasis on assets and capitals. With the notable exception is the National Adaptive Capacity Framework (NACF), which focuses purely on a function-based approach (WRI, 2009). Important elements of local adaptive capacity include "*access to and control over natural, human, social, physical and financial resources as well as knowledge co-production, learning and collaboration*". CARE international (2010) has identified five examples of types of resources that affect adaptive capacity as shown in Table 4.

Table 4 showing examples of resources that affect adaptive capacity

Resources	Description
Human resources	Knowledge of climate risks, conservation agriculture skills, good health to enable labor
Social resources	Women's savings and loans groups, farmer-based organizations, traditional welfare and social support institutions
Physical resources	Irrigation infrastructure, seed and grain storage facilities
Natural resources	Reliable water sources, productive land, vegetation and trees
Financial resources	Micro-insurance, possible diversified income sources

Source: CARE International, 2010

Rayner and Malone (2000a) contend that the resilience of societies and activities is an excellent umbrella concept for those factors that mediate between geophysical conditions and events, on the one hand, and human abilities to cope with, take advantage of, or adapt to those conditions and events, on the other hand. The writers argue that "*resilience is a composite concept, incorporating environmental, social, economic, political, demographic, cultural, gender and psychological factors, in describing the capacity to adapt to climate change impacts*". This conceptualization draws attention to the amplifiers of the impacts of climate change and points towards characteristics of certain groups, institutions and places. It also emphasizes the degree to which the risks of climate catastrophe can be cushioned by adaptive actions that are or can be brought within the reach of vulnerable populations.

Yohe and Tol (2002), for example, identified eight generalized determinants of adaptive capacity, many of which are societal in character. These include the; "*i) range of available technological options for adaptation; ii) availability of resources and their distribution across populations; iii) structure of critical institutions, the derivative allocation of decision-making authority, and the decision criteria that would be employed; iv) stock of human capital, including education and personal security; v) stock of social capital, including the definition of property rights; vi) system's access to risk-spreading processes; vii) ability of decision-makers to manage information, the processes by which these decision-makers determine which information is credible, and the credibility of the decision-makers themselves; and viii) public's perceived attribution of the source of stress and the significance of exposure to its local manifestations*". Yohe and Toll (2002) argue that the challenge in adaptation research, however, is to design adaptive capacity assessment frameworks (as shown in Figure 4) that are methodologically robust

and context-specific and relevant to those who make decisions related to adaptation action. As an emerging field of study, methodological questions are relevant to ensure quality of research results relevant to climate change adaptation policy (Pittock and Jones, 2000; Malone and Engle, 2011; Roman et al., 2011).

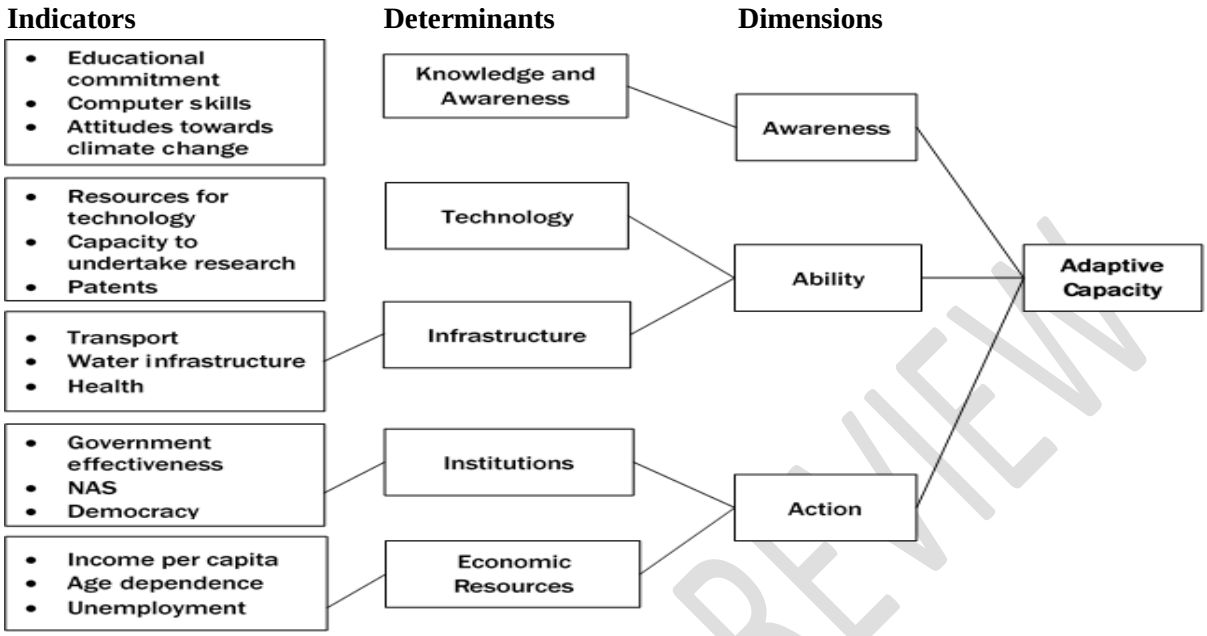

Figure 4: Determinants and dimensions of adaptive capacity
Source: Juhola and Kruse, 2015

Literature indicates that various ways of assessing adaptive capacity of a region have been developed (Engle and Lemos, 2010; Engle, 2011) ranging from indicator-based assessments to stakeholder driven scenario-based assessments (Posey, 2009; Malone and Engle, 2011; Park et al., 2012a,b). The purpose of these studies has been to characterize the capacity of a system to adapt to climate change and to identify recommendations for policy makers on how to increase this capacity and decrease vulnerability and risk. Current approaches for measuring adaptive capacity and their ability to provide reliable and sound information are increasingly being discussed (Hinkel, 2011; Malone and Engle, 2011; Park et al., 2012a,b). For example, Park et al. (2012a,b) developed a standardized, non-contextualized index approach (environmental vulnerability index) and compared the results from this to the results of a participatory assessment (sustainable livelihood analysis). This analysis shows how rankings of relative vulnerability are reliant on the assessment instrument being used.

Birchall and McDonald (2020)'s study reviewed that adaptive measures that support resilience to climate change can take many forms depending on the specific vulnerabilities of a community. They can come in the form of institutional, educational, and behavioral change; and also in the form of early warning and proactive planning information systems. They can also come in the form of physical infrastructure development; integrated natural resources management (INRM); and so on (IPCC, 2014). Harman et al. (2015) discussed three main categories of adaptation to climate change namely planned retreat, accommodation measures, and protective measures. First, planned retreat involves organized withdrawal or regulated restrictions on development in hazardous coastal areas affected by sea level rise, erosion, storm surges, and so on. Second, accommodation measures consist of revised building codes and changes to urban design, allowing populations to continue to develop and live in areas affected by climate change impacts while reducing sensitivity and/or exposure to those impacts. The last are protective measures which can be used to shield coastal communities from the impacts of climate change. These can be implemented through "*hard defenses, such as dikes or sea walls, or soft defenses such as beach nourishment or coastline naturalization*" (Harman et al., 2015).

In another study by Carter et al. (2015), it is argued that increasing green space in developed urban areas is considered a valuable accommodation response, as green spaces can mitigate the urban heat island effect by reradiating less heat than built surfaces and providing cooling through evapotranspiration while also creating attractive spaces within urban centers. The writers argue that as sea levels rise and the

potential severity and frequency of storm surges increases, hard defenses can prevent flooding and reduce coastal erosion. Coastline naturalization can help to protect developed areas from the impacts of climate change (Harman et al., 2015; McDougall, 2017). Thus, scholars conclude that "*the successful implementation of adaptive measures should involve public disclosure at all stages. Open communication with vulnerable populations allows the public to be involved in adaptation planning while also making them aware of any hazards associated with climate change in their community*" (Bulkeley and Tuts, 2013; Harman et al., 2015).

4.0 Discussion and conclusion

4.1 Discussion

The aim of this review paper was to conduct a literature search on factors that increase resilience and the adaptation strategies employed by urban mining communities to adapt to climate change. The review paper has attempted to identify key factors that promote increased resilience in urban mining communities; the nature of emerging practice and how this can be improved in different contexts moving forward. A few other reviewed papers have also written on adaptation responses to climate risks in urban mining communities, including potential barriers to adaptation initiatives, partnerships and additional information needs. The results of this review paper are discussed in line with existing researches on climate change vulnerability, resilience, adaptation strategies and other similar studies of adaptation in mining industry in other countries. In this review paper, a total of 213 documents, which included 122 articles, 60 reports, 31 books and gray literature were screened and selected for inclusion in the study. These were generally documents which contained qualitative information focusing on factors that increase climate resilience and the capacity of urban mining communities to adapt to climate change impacts.

A number of reviewed papers have also attempted to provide factors that increase resilience in urban mining communities while a few others have provided very insightful information on measures and adaptation responses to climate change risks from mining companies and the surrounding local communities. After a thorough review of literature, this review paper has found that the gaps in the literature seem to have been most evident on how measurable community resilience and adaptive capacity are in addressing climate change impacts. Thus, even though most of the reviewed papers have explored resilience and adaptive capacity quite extensively, the concepts still remain unclear (Walker et al., 2004) due to the multiplicity of interpretations scholars have attached to their meanings. There also seems to have been very limited effort to scrutinize the literature to explore further avenues to come up with a workable approach to the concept of resilience. This seems to have been exacerbated by a lack of awareness among scholars that such a multiplicity of interpretations exists (Bahadur et al., 2010). As a result of this complexity and multiplicity of interpretations of the resilience concept, there seems to be little consensus, among scholars, on factors that increase climate resilience and the parameters that should be used in order to measure progress in becoming more resilient.

The review paper has also observed that there are also still fears among some scholars and practitioners that the scarcity of evaluations and different interpretations of issues around climate resilience implies that understanding the main causes of community resilience is not a straightforward exercise. As Twigger-Ross et al. (2015)'s study puts it, evidence seems to point to the importance of 1) outlining plans widely to include practices that address the inclusive priorities of a community and those that nurture skills and ownership of climate change responses; 2) existing capabilities within a community to inform policy on climate resilience; 3) support from the community and voluntary organizations perform mediatory functions to give guidance and insights for new partnerships which are aimed at promoting community resilience, skills and knowledge sharing. The review paper has also noted that very few of the reviewed papers unambiguously assessed factors that increase resilience and adaptive capacity in urban mining communities. Most of the papers reviewed have only discussed community resilience, adaptation strategies and adaptive capacity in the context of other equally fragile communities other than those in the contested urban mining communities.

Discussing the issue of adaptation, Ayers and Forsyth (2009) suggest that any good adaptation practice must consider the immediate and long-term climatic and developmental risks. The scholars contend that there is no need to seek to adapt to likely climatic dangers without, first of all, seeking to know how social and economic trends put people at risk or what they require. The review paper has shown that climate adaptation is not only a result of the scale of change in a particular area but also a

result of the magnitude of the change in the vulnerability and resilience entrenched in each community. The paper has also found that although most of the mining companies respond to climate risks, most mining communities do not benefit from such initiatives because they are not regularly involved. Gustafsson et al. (2021)'s study add that these gaps are partly as a result of ineffective governments and pressures from civil society which are supposed to ensure that mining companies address climate risks in a manner that would help strengthen community resilience through sustainable adaptation practices. The review paper has also found that although some mining companies have put in place measures to evaluate the impact of climate change such as integrating climate risks in water governance and adapting their infrastructure to suit the changing climate, adaptation is still mainly driven by pressures from investors, and not by local regulations. This implies that mining companies do not often engage local mining communities in their adaptation initiatives by collaborating with them in beneficial ways (Ford et al., 2011). This shows how limited adaptation initiatives from mining companies are and the existence of barriers to achieving transformative change in urban mining communities.

Nevertheless, some scholars have suggested that in order to measure climate resilience, a clear definition of resilience and a better understanding of the concept is needed. This is important in order to remove the current misperception caused by the multiplicity of interpretations that the concept usually carries. Other studies have recommended that scientific evaluation of possible changes in climate should be open to CBA in order to integrate various concerns about community vulnerability and development with policy and practice. Studies emphasizing urban governance and institutions (e.g. Avis, 2016), have focused on questions of how different types of institutional arrangements and resilience thinking can affect the resilience of local communities through improved governance mechanisms for promoting adaptation to climate change. The studies considered for this review paper were collected with the help of mainly Google Scholar and Web of Science search engines from a diverse array of peer-reviewed articles, books, reports and gray literature.

4.2 Gaps and implications

The review paper highlights a number of gaps in literature which are critical for future studies in this area. First, the review paper shows that there seems to have been limited attempt to scrutinize the literature to explore other avenues of coming up with an alternative workable approach to the resilience concept. As a result, there is considerable multiplicity in the manner in which the term resilience is understood and applied between and among disciplines, and as such diverse interpretations of the term may have different implications when it comes to policy and action. Second, the review paper reports a lack of consensus on factors that lead to increased resilience or progress in becoming more resilient due to the complexity and ambiguity of the resilience concept. This, as well, may have serious implications when translated into policy or action. Third, there also seems to be a lack of clear-cut assessment indicators for climate change vulnerability, resilience and adaptive capacity, which makes it difficult to measure progress in this area as well. Fourth, there is also observed inadequacy in research focusing specifically on climate resilience and adaptation strategies employed in the contested urban mining communities even though substantial amount of research has been done elsewhere in similar areas. Fifth, scholars such as Odell, et al. (2018) point to the gap in the literature where the connection between mining, on the one hand, and climate change, on the other, does not seem to have received due consideration. The argument is that the academic literature on mining seems to have been paid more attention to themes such as environmental impacts of extractives; corporate social responsibility; and so on, which bear no relationship to climate change and adaptation.

4.3 Conclusion

This review paper has analyzed the literature on factors and policy options for increasing climate resilience and the capacity of urban mining communities to adapt to impacts of climate change. The review paper has identified several key results relating to climate resilience and adaptive capacity and the factors that influence these variables. First, the review paper has found that although the concepts of resilience and adaptive capacity are extensively explored in a few studies and applied differently in various disciplines, their meanings still remain complex and unclear. Second, the review paper has found that there seems to be little consensus, among scholars and practitioners, on the factors that lead to increased resilience and the parameters that should be used to measure progress in becoming more

resilient. Third, the review paper has also found that very few studies seem to have been conducted to assess progress in becoming more resilient and adaptive in the contested urban mining communities. Fourth, the study has also found that the challenge in the current adaptation research seems to have been in designing climate vulnerability, resilience and adaptive capacity evaluation instruments that are procedurally robust and specific and appropriate for those who make policy decisions related to adaptation. Fifth, the review paper also seems to suggest that although some mining companies have begun addressing climate change impacts on their operations, their initiates do not address the concerns of local mining communities. This implies that mining companies seldom engage local mining communities in their adaptation initiatives by collaborating with them in more beneficial ways.

The author strongly feels that the observed gaps in literature, especially the perceived inadequacy in research focusing specifically on climate resilience and adaptation in contested urban mining communities, need serious attention. This is because, as climate change increases, the implications for a number of economic sectors, such as the agriculture and water sectors, will become more evident. The poor urban community households who live in resource-rich areas where mining companies are using huge amounts of water and energy resources, may render these communities more vulnerable to impacts of climate change. Therefore, responses to these vulnerabilities of the surrounding local mining communities and environments will benefit from more evidence-based research in this critical area. Furthermore, to fully understand and appreciate the contextual and varying levels of resilience and adaptive capacity in urban mining communities, this review paper recommends a need to conduct more comprehensive studies, which clearly explore factors that increase resilience and adaptive capacity and those that suggest clear policy options in the contested urban mining communities in order to supplement the rather limited body of literature in this area and to inform police and practice. This will perhaps shed more light on factors that increase climate resilience and adaptive capacity and will ultimately avoid unequal consequences of adaptation initiatives designed by mining companies alone. Through shared initiatives, local mining communities could also share information about their needs and priorities and come to terms with mining companies on how to sustain their livelihoods and manage their scarce resources. The mining companies also should urgently develop robust measures for climate adaptation in order to promote increased resilience and the adaptive capacity of urban mining communities to manage future environmental risks.

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6.0 Author's competing interests

I, the Author, declare that I have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this review article.

7.0 Author's contributions

The Corresponding Author designed the entire study and wrote all the sections contained in the review article starting from the introduction, the methodology, the results and the discussion and conclusion parts of the paper. The Author also wrote the first and final drafts of the manuscript, managed all the literature searches and read and approved the final manuscript.

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