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and adaptation to climate change**

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Assets for health: linking vulnerability, resilience and adaptation to climate change

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Abstract

Human health risks and impacts from climate change constitute significant threats. Reducing vulnerability, increasing resilience and improving adaptation to climate change is vital, but what shapes them is still poorly understood. To examine what shapes human vulnerability, resilience and adaptation, and the connections that exist between these concepts. A literature review focused on assets, human vulnerability, resilience and adaptation drawing on the disciplinary fields of health, sociology, disaster science and environmental science is presented in this paper. Research on these concepts has seen a growing interest in recent decades, but has been limited by the fact that they emerged and evolved from different disciplinary perspectives. As a result, diverse and frequently contended definitions have been conducive to inadequate and poorly defined use. Despite this, interdisciplinary understandings of how human vulnerability, resilience and adaptation to climate change are shaped by are still scarce. Assets (e.g. human, financial, physical, social and place-based) have been found to play an important role in shaping human vulnerability, resilience and adaptation and can thus, be used to make connections between these concepts. An interdisciplinary approach allows the prospect of searching and recognising what contributes to better health. A distinction between general and specified vulnerability and resilience is needed for advancing knowledge on how to improve human adaptation. An integrated perspective on the links between these concepts is also needed for developing tools for assessing human vulnerability, resilience and adaptation, in order to mitigate the impacts of climate change on human health, which this paper contributes to.

Introduction

Recently, human health and well-being impacts of climate change have gathered the attention of the World Health Organization (WHO) as well as the Intergovernmental Panel on Climate Change (IPCC). As an example, both have stated that human health is adversely affected by weather, climate and climate variability (WHO 2012a; IPCC 2014a). Greater impacts on human health and well-being are consequences of higher human vulnerability and exposure (WHO 2012a; IPCC 2014a). Additionally, social and economic inequalities also contribute to negative impacts on health and well-being (Confalonieri et al. 2007). The most vulnerable are older people, chronically ill individuals, children, pregnant women and low income individuals (Balbus and Malina 2009; CCC 2014).

According to the Royal Society (2014), demographic changes such as an ageing population are likely to increase human exposure and impacts of extreme weather on human health. As a result, it calls for policies and actions focusing on safeguarding individuals and their assets from extreme events (Royal Society 2014).

Population and individual characteristics influence the adverse health consequences from extreme events. The most important include, housing quality, health behaviours, social and economic inequalities (Healy 2003; Davie et al. 2007; DoH 2011; Hales et al. 2013). Despite this, some authors assert that further understanding is needed on the different interactions between extreme temperatures and health effects regarding the physical, psychological, social and environmental factors linked to vulnerability (Yardley et al., 2011). Furthermore, others (i.e. Wisner et al., 2004) argue that being able to deal with daily stresses is essential to individual resilience to climate change. As a result, possessing skills to deal with threats influences resilience (Bankoff et al. 2004) and enables adaptation.

However, the Committee on Climate Change (CCC) points out the absence of a conceptual understanding of what human vulnerability entails, which factors shape vulnerability and their relationship (CCC 2014). Furthermore, the IPCC (2004a) considers the need for implementing a diversity of strategies and measures in order to achieve better adaptation. As such, “a first step towards adaptation to future climate change is reducing vulnerability and exposure to present climate variability (high confidence). Strategies include actions with co-benefits for other objectives. Available strategies and actions can increase resilience across a range of possible future climates while helping to improve human health, livelihoods, social and economic well-being, and environmental quality.” (IPCC 2014a: 25-26). As a result, this paper builds on existing knowledge, theories and approaches to better understand the relationship between assets, vulnerability, resilience and adaptation in order to aid in the efforts for reducing vulnerability, enhancing resilience and improving adaptation of individuals.

In this paper, a comprehensive literature review is used as the basis for identifying links and synergies between the conceptualisation and operationalization of vulnerability, resilience and adaptation; these are examined in light of approaches to improve human adaptation to climate change. It is argued here that due to the serious risks climate change and extreme events pose to human health, comprehensive and interdisciplinary investigations are needed to increase our understanding of what shapes vulnerability, resilience and adaptation. As a result of different disciplinary roots, interdisciplinary studies investigating the conceptual and analytical relationships between the concepts of vulnerability, resilience and adaptation are still few (Nelson et al. 2007; Vogel et al. 2007; Miller et al. 2010; Turner 2010). In order to overcome the shortfalls of current approaches

and disciplinary boundaries, here are reviewed the current literature and assessments of human vulnerability, resilience and adaptation to climate change.

This paper reviews the literature to date on vulnerability, resilience and adaptation conceptualisations and assessments, with a special focus on its human dimensions from an array of disciplinary perspectives (i.e. health sciences, environmental science, sociology, economics, disaster science, human development, ecology and psychology). As a result, this paper aims to: (1) review the literature comprehensively to understand and clarify how vulnerability, resilience and adaptation in relation to impacts of climate change on human health have been conceptualised and operationalized, and; (2) based on this literature review, identify drivers that shape these and how they can be more comprehensively conceptualised for future use in human health impact reductions. In the next sections of the paper the diversity of definitions and interpretations, as well as assessments of vulnerability, resilience and adaptation are outlined. It further discusses the interactions between these three concepts, and concludes with suggestions for future research.

Vulnerability

- Definitions and interpretations

The complex meanings of vulnerability have been illustrated by Nunes (2014) and are presented in Table 1. These have in turn repercussions for the way in which we interpret and use such concept, as well as the subsequent outputs or outcomes of vulnerability assessments (see below). The review process identified common elements to all the vulnerability definitions included here (Table 1). The investigation allowed the documentation of common structures and components, different levels of specificity, focus and factor of interest. As a result, some of these definitions were found to be more broad or specific than others. Additionally, disciplinary focus was found to influence the resulting definition (Nunes, 2014).

Table 1 Selected definitions of vulnerability by discipline

Selected definitions	Disciplines
"The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts including sensitivity or susceptibility to harm and lack of capacity to cope and adapt" (IPCC 2014a: 28).	Interdisciplinary
"Vulnerability is the state of susceptibility to harm from exposure to stresses associated with environmental and social change and from the absence of capacity to adapt." (Adger 2006: 268)	Environmental science
"The conditions determined by physical, social, economic, and environmental factors or processes, which increase the susceptibility of a community to the impact of hazards." (UNISDR 2004: 16)	Disaster science
"Social vulnerability is a measure of both the sensitivity of a population to natural hazards and its ability to respond to and recover from the impacts of hazards. It is a multidimensional construct, one not easily captured with a single variable." (Cutter and Finch 2008: 2301)	Disaster science
"Social vulnerability [...] is shaped by individual people's resources and behaviour as well as by broader societal processes [...]" (Few 2007: 284)	Sociology
"Vulnerability: the susceptibility of a system to disturbances by exposure to perturbations, sensitivity to perturbations, and the capacity to adapt." (Nelson et al. 2007: 396)	Environmental science
"Social vulnerability encompasses all those properties of a system independent of the hazard(s) to which it is exposed, that mediate the outcome of a hazard event." (Brooks 2003: 5)	Climate science
"Vulnerability is a broad concept, encompassing not only income vulnerability but also such risks as those related to health, those resulting from violence, and those resulting from social exclusion - all of which can have dramatic effects on households." (Coudouel and Hentschel 2000: 34, in Alwang et al. 2001)	Economics
"The susceptibility of a population or region to harm" (WHO 2011: 2)	Health
"Results from exclusionary processes related to inequities in power, money and resources, and the opportunities of life" (WHO 2012a: 11).	Health
"The degree to which individuals and systems are susceptible to or unable to cope with the adverse effects of climate change." (WHO 2003: 28).	Health

Source: Nunes (2014)

An important insight on the ambiguous use of the concept of vulnerability is given by Chambers (2006) in the sociology literature. As a result, vulnerability is considered to be a concept that is in many cases used to mean poverty, but vulnerability "is not the same as poverty", being thus linked with the concept of assets (Chambers 2006: 33). On the other hand, the concept of vulnerability has been predominantly used in epidemiology in the health literature, as an outcome assessed through the calculation of mortality and morbidity rates (e.g. Davie et al. 2007, Hajat et al. 2007, Astrom et al. 2011). Epidemiological research in the field of human health conceptualising vulnerability focuses on outcomes rather than inherent characteristics of individuals and the places where they live (e.g. Hajat et al. 2007); which is in contrast with other climate change literature, in which vulnerability is used to better understand what contributes to impacts (e.g. Kelly and Adger 2000).

Moreover, O'Brien and colleagues (2004) assert that this diversity of uses originates from different conceptualisations of vulnerability either as a starting point (e.g. an intrinsic feature impacted by climate change) or an end point (e.g. a consequence of climate change). In response, Adger (2006) states that existing definitions of vulnerability result from two distinct disciplinary stances: the first centred on lack of assets (i.e. resources) that aims to understand the sources of

impacts; the second centred on adverse events that aims to uncover similarities between adverse events. In this respect, the assets approach identifies the role assets play in vulnerability.

In addition, Cutter and colleagues (2008) outlined three ways of understanding vulnerability that help clarify the disciplinary differences noted above and in Table 1: (1) vulnerability as a result of embedded social characteristics - the research taking this position focuses on availability of assets and diverse levels of susceptibility (exposure is considered as given) (2) vulnerability as a result of diverse levels of exposure, and; (3) vulnerability as a complex concept that conveys both biophysical and social components inherent of a specific location or place.

As a result of such dissimilar ways of understanding vulnerability, Wisner and colleagues (2004) have highlighted problems arising from the indiscriminate use of the concept, whereas Adger (2006) and Moser (2011) see benefits in such differences meaning that the concept can be used in a variety of ways, situations and disciplinary arenas. Cutter and colleagues have also considered that developments are needed in order to bring together different conceptual and analytical perspectives on vulnerability (Cutter et al. 2003; Cutter et al. 2008). Clarity is thus needed on how the term vulnerability is used and an agreement urged (O'Brien et al. 2004). Furthermore, as many of the definitions and uses of the concept of vulnerability denote to a general, rather than a specific situation, Brooks (2003) stresses that "it is essential to stress that we can only talk meaningfully about the vulnerability of a specified system to a specified hazard or range of hazards." (Brooks 2003: 3).

Despite the above, the IPCC (2014b) emphasises that population patterns (i.e. growth and age structure, characteristics of individuals (e.g. sex, health status, education, income) and the environment (e.g. geographic location, health and other public infrastructure) impact on human vulnerability. Moreover, the IPCC (2012) includes social (e.g. health and well-being, demography, education, cultural characteristics), environmental (e.g. location, place, urban/rural), and economic characteristics as factors that drive vulnerability and are crucial to understanding how it is shaped (Romero-Lankao et al. 2012). Additionally, it is not just the isolated occurrence of such characteristics but the combination in which they occur that can increase vulnerability (Weber and Messias 2012).

In summary, this section has discussed the vulnerability literature and identified several gaps in knowledge. The importance of identifying and filling these knowledge gaps has been recognised here and assets have been identified as one element related to vulnerability. Here is noted the complex task of making sense of vulnerability given the multiplicity of views and perspectives, which leads to varied ways of operationalizing vulnerability.

- Vulnerability assessments

The diverse definitions of vulnerability have led to the development of a variety of methods used to measure it (Alwang et al. 2001; Adger 2006; Hahn et al. 2009; Gaillard 2010). On this note, a growing interest has been found on the development of quantitative measures of vulnerability in different literatures (Alwang et al., 2001). As mentioned earlier, Kelly and Adger (2000) in the climate change literature, differentiate between three types of vulnerability assessments: end point (i.e. vulnerability as an outcome); focal point (i.e. vulnerability as the central concept of the assessment) and; starting point (i.e. vulnerability as a mean to identify sensitivity) (e.g. Wisner et al. 2004).

In some of the conceptualisations of vulnerability, assets have been found to play a crucial role (Chambers 2006; Adger 2006; Cutter et al. 2008). Additionally, several authors have identified Sen's (1981) entitlement approach as useful for developing vulnerability assessments through the

concept of assets (Ribot 1996; Kelly and Adger 2000) which in turn highlights inequitable access to assets such as education, health, food and services as sources of vulnerability, and incorporates access to assets into vulnerability assessments (see Box 1 for more detail on the concept of assets).

Box 1 The concept of assets

The notion of assets has long been used in the sociology literature as means to understand livelihood strategies in poverty and deprivation contexts in the Global South (Rakodi 1999). Furthermore, the use of assets has also been associated with the concept of capabilities (Sen 1999) in both the sociology and health literatures, which provide arguments supporting the particularly significant role of assets for understanding vulnerability. In the sociology literature, Ellis (2000) defines assets as “stocks of capital that can be utilised directly, or indirectly, to generate the means of survival of the household or to sustain its material well-being at differing levels above survival.” (Ellis 2000: 31). In addition, Ellis (2000) asserts that assets are essential for understanding livelihoods but outlines disagreement on the types of capitals that are part of assets. As such, within the literature, there are many ways in which assets can be defined and interpreted. One of the longest established and most commonly used categorisation of assets are the ones by authors such as Chambers and Conway (1992) and Scoones (1998) who have identified five types of capital-based assets (human, financial, physical, natural and social capital). For Chambers and Conway (1992) assets are resources that offer material and social provisions. According to Bebbington (1999:2022) assets or capitals “are not simply resources that people use in building livelihoods: they are assets that give them the capability to be and to act.” Bebbington’s categorisation of assets human, produced, social, natural, and cultural assets (Bebbington 1999).

These differing definitions lead to variation in the operationalization of assets (Ellis 2000). As an example, a ‘five-capitals’ model has been developed that differentiates financial, human, social, natural and manufactured or physical capitals or assets (Rakodi and Lloyd-Jones 2002; Porritt 2005; Manzi et al. 2010) which can be applied in an array of perspectives, such as social and economic (Manzi et al. 2010). According to Ellis (2000) the different types of assets can supplement and substitute each other, allowing for transformation of one type of asset into another. This is considered to be a common strategy used by individuals and households to compensate for the lack of one type of asset (e.g. financial assets can be transformed into human assets if investment is made in education). Despite its broad use, critics of the five assets model point out operationalization and implementation issues and lack of ability of those applying it to change livelihoods (Morse et al. 2009). Additionally, Morse and colleagues (2009) emphasise that individuals and households are absent from the livelihoods approach as it focuses on different types of assets and not on individuals per se; and that the approach does not clearly outline how to empirically assess and measure assets. Others like Rakodi (1999) argue for the inclusion of political capital; although similar to social capital, it covers access to decision-making networks and institutions. On the contrary, Gutierrez-Montes and colleagues (2009) assert that the assets focus in the sustainable livelihoods approach allows a better understanding of the relationships between individuals and their environment, as well as the interactions between different types of assets in order to increase opportunities to improve the capabilities of individuals, which has been neglected in other research fields (e.g. Rakodi 1999; Rakodi and Lloyd-Jones 2002; Porritt 2005; Manzi 2010).

Source: Nunes (2014)

Categories of assets obtained from different disciplines are grouped in Table 2 where it is shown the commonalities between assets in different disciplines which includes the use of similar terminology as well as meaning but applied to different contexts (Nunes, 2014).

Table 2 Summary of categories of assets, types of assets, relevant sources by discipline

Assets	Examples	Relevant sources	Disciplines
Human	Education level, skills, knowledge, good health, ability to labour, living arrangements, occupation, nutrition status, marital status	IPCC 2012; IPPR North 2011; May et al. 2009; Moser and Dani 2008; Dahlgren and Whitehead 2007; Wisner 2006; OECD 2006; Barton and Grant 2006; Vatsa 2004; Ellis 2000; DFID 1999; Rakodi 1999; Scoones 1998; Carney 1998	Sociology; Health; Environmental science; Economics
Financial	Income, savings, access to credit, pensions, informal economy, expenses	Ford and Berrang-Ford 2011; IPPR North 2011; Moss et al. 2010; May et al. 2009; Moser and Dani 2008; Dahlgren and Whitehead 2007; OECD 2006; Barton and Grant 2006; Vatsa 2004; Ellis 2000; DFID 1999; Rakodi 1999; Scoones 1998; Carney 1998	Sociology; Health; Environmental science; Climate; Economics; Public Policy
Physical	Buildings, type of housing, housing tenure, roads, tools, appliances, machines, terraces, irrigation canals, power lines, affordable energy, water supply, sanitation, telecommunication facilities, transport	IPPR North 2011; May et al. 2009; Moser and Dani 2008; Cutter and Finch 2008; Dahlgren and Whitehead 2007; Barton and Grant 2006; Vatsa 2004; Ellis 2000; DFID 1999; Rakodi 1999; Scoones 1998; Carney 1998	Sociology; Health; Environmental science; Public Policy
Natural, Public or Place-based	Land, atmosphere, water, trees, wild vegetable, wild animals, fisheries stocks, biodiversity, metals, oil and other environmental resources, access to public amenities and services	IPCC 2012; IPPR North 2011; Riva et al. 2010; May et al. 2009; Moser and Dani 2008; Dahlgren and Whitehead 2007; OECD 2006; Barton and Grant 2006; Vatsa 2004; Ellis 2000; Rakodi 1999; DFID 1999; Scoones 1998; Carney 1998	Sociology; Health; Environmental science; Economics; Public Policy
Social	Networks, connectedness, membership of groups and associations, relationships of trust, support, reciprocity and exchanges	IPPR North 2011; May et al. 2009; Moser and Dani 2008; Dahlgren and Whitehead 2007; OECD 2006; Barton and Grant 2006; Vatsa 2004; Ellis 2000; DFID 1999; Rakodi 1999; Scoones 1998; Carney 1998	Sociology; Health; Environmental science; Economics; Public Policy

Source: Nunes (2014)

In order to measure vulnerability both the economics and sociological literatures have for many years used the sustainable livelihoods approach and asset-based approaches aiming at better understand the livelihoods of individuals (Alwang et al. 2001). Despite this, interdisciplinary approaches have been few, but vulnerability assessments have since been measuring access to assets (Birkmann et al. 2010). Even though the existence of diverse vulnerability assessments, they can be subdivided according to key characteristics: actor-centred (Nelson et al. 2007); setting and purpose dependent (Fussel 2007a; Romero-Lankao et al. 2012); and quantitative enabling the findings to be transformed into indices and GIS maps (Kelly and Adger 2000; Cutter et al. 2003). Some vulnerability

assessments combine more than one characteristic, others focus predominantly on one, thus differing in scope and scale.

In summary, the concept of assets and the five-asset model, despite being defined in a variety of ways and existing disagreement on how they can be employed, they allow linkages between diverse literatures and help the operationalisation of the concept of vulnerability. Furthermore, vulnerability has since been linked with access to assets, where the quantity and diversity of assets determines how vulnerable individuals and households are (Moser, 2011). However, the role assets play in reducing vulnerability is still not fully understood (Alwang et al. 2001). As a result, exploring the relationships with other concepts such as, resilience (Romero-Lankao et al. 2012) and adaptation (Brooks 2003; Romero-Lankao et al. 2012) may help in this process (further discussion in the next sections of this paper).

Resilience

- Definitions and interpretations

The concept of resilience has in the last four decades been frequently used and investigated in a variety of disciplines (i.e. environmental science, economics, public policy, ecology, disaster science, child psychology, engineering, health and sociology) (Gaillard 2010). Despite this, it has an extensive history in both ecology and psychology, having had great developments within the systems and ecosystems arenas (Berkes and Ross 2013; Doring et al. 2013).

Many different resilience definitions have thus been developed due to these diversity of disciplinary roots, which can be characterised based on three key questions: (1) what does resilience refer to? (2) resilience of what? and (3) resilience to what? (see categorisations in Tables 3.1, 3.2 and 3.3, respectively). A review such as the one undertaken here helps to highlight the commonalities and differences among definitions of resilience taking into account different attributes.

Additionally, some authors discuss the resilience of individuals, communities and systems (Rockefeller Foundation, 2014; Edwards, 2009). Notwithstanding, connections between these different angles are possible if individuals are viewed as actors within the systems they are part of (e.g. Brown and Westaway 2011; Simonsen et al. 2014) and constituents of such systems (e.g. Simonsen et al. 2014; Brown and Westaway 2011). Moreover, as seen in this paper many definitions of resilience comprise references to such units (i.e. systems, individuals, families, groups, communities, institutions and nations). As shown in Table 3, such definitions differ according to the focus (system, individual) and scale (temporal and spatial) of resilience being used (Nunes, 2014). As an example, the ecology, climate change and disaster disciplines more frequently consider resilience within a temporal scale (present, future) (e.g. Nelson et al., 2007; Pelling, 2003) and resilience to external events (e.g. Adger, 2000; Adger et al., 2002). Similarly, the climate change literature, resilience is considered to be system-oriented (Nelson et al., 2007) whereas in the psychology and public health fields are mainly interested in the internal or individual responses to either internal or external events (e.g. Masten et al., 1990; Bartley, 2006; Almedom and Tumwine, 2008). The literature review looked at definitions of resilience in a variety of disciplines, aiming specifically at addressing issues related to human resilience (Nunes, 2014).

Table 3.1 Selected definitions of ‘what resilience refers to’ and sources by discipline

Definitions	Sources	Disciplines
“A measure”	Holling 1973	Ecology
“A capacity”	Rockefeller Foundation 2014; Dominelli 2013; WHO 2011; Edwards 2009; Keim 2008; Almedom and Tumwine 2008; Gunderson et al. 2006; Manyena 2006; Walker et al. 2004; UNISDR 2004; Bonanno 2004; Glantz and Sloboda 1999; Cederblad et al. 1994	Sociology; Human development; Health; Disaster science; Environmental science
“An ability”	Resilience Alliance 2014; Marmot 2013; IPCC 2012; Resnick and Inguito 2011; WHO 2011; Lamond et al. 2009; Cutter et al. 2008; IPCC 2007; Jackson et al. 2007; Bartley 2006; Tompkins and Adger 2004; Bonnano 2004; UKCIP 2004; Friborg et al. 2003; Pelling 2003; Adger et al. 2002	Environmental science; Ecology; Disaster science; Health; Psychology
“An internal property”	Davydov et al. 2010; Gallopin 2006	Environmental science; Psychology
“A characteristic”	Wagnild and Young 1993	Psychology
“A process”	Windle 2011; Almedom 2008; Norris et al. 2008; Luthar et al. 2000; Masten et al. 1990	Human development; Psychology; Health
“An outcome”; “Good outcomes”	Netuveli et al. 2008; Masten et al. 1990	Human development; Health
“A product”	Pelling 2003	Disaster science
“Relationships”	Folke 2006; Luthar 2006	Ecology; Human development
“An amount of change”	Nelson et al. 2007	Environmental science

Source: Nunes (2014)

Table 3.2 Selected definitions of ‘what is resilient’ and sources by discipline

Definitions	Sources	Disciplines
“A system”	Rockefeller Foundation 2014; IPCC 2012; Edwards 2009; Almedom and Tumwine 2008; Nelson et al. 2007; Gallopin 2006; Folke 2006; Gunderson et al. 2006; Manyena 2006; Walker et al. 2004; UNISDR 2004; UKCIP 2004; IPCC 2001; Holling 1973	Ecology, Disaster; Climate; Human health
“A social or ecological system”, “social-ecological system”	IPCC 2014b; IPCC 2007; UNISDR 2004	Climate; Disaster
“A social system, society”	Cutter et al. 2008	Disaster
“Human, institutional, and ecological systems”	Dominelli 2013; WHO 2011; Almedom 2008	Human health; Sociology
“Groups”, “communities”, “institutions” and other “social entities”, “families”	Rockefeller Foundation 2014; Marmot 2013; Edwards 2009; Almedom and Tumwine 2008; Almedom and Tumwine 2008; UNISDR 2004; Adger et al. 2002; Adger 2000	Climate; Disaster; Human health
“People”, “individuals”, “actors”	Rockefeller Foundation 2014; Marmot 2013; Windle 2011; Davydov et al. 2010; Edwards 2009; Almedom and Tumwine 2008; Jackson et al. 2007; Bartley 2006; Pelling 2003	Psychology; Human health; Disaster

Source: Nunes (2014)

Table 3.3 Selected definitions of ‘resilience to what’ and sources by discipline

Definitions	Sources	Research fields
“Change”, “external change”, “future uncertain change”, “disturbance”, “perturbation”, “adverse and/or turbulent changes”	IPCC 2014b; WHO 2011; Resilience Alliance 2014; Almedom 2008; Norris et al. 2008; Nelson et al. 2007; Gallopin 2006; Gunderson et al. 2006; IPCC 2007; Tompkins and Adger 2004; Walker et al. 2004; Adger et al. 2002; Holling 1973	Ecology; Climate; Human health
“Hardship”, “adversity”	Marmot 2013; Davydov et al. 2010; Lamond et al. 2009; Netuveli et al. 2008; Jackson et al. 2007; Masten and Obradovic 2006; Luthar et al. 2000; Glantz and Sloboda 1999	Psychology; Human development; Human health; Climate
“Stress”, “external stresses”, “significant sources of stress or trauma”	Rockefeller Foundation 2014; Windle 2011; WHO 2011; Manyena 2006; Adger et al. 2002; Adger 2000	Climate; Disaster; Human health
“Disaster”, “hazard”, “potential hazard”, “hazard stress”, “hazardous event”	IPCC 2014b; IPCC 2012; Cutter et al. 2008; Keim 2008; UNISDR 2004; Pelling 2003	Disaster; Climate; Human health
“Extreme load”	UKCIP 2004	Climate
“Threats”, “shock”, “challenging or threatening circumstances”	Rockefeller Foundation 2014; Marmot 2013; Dominelli 2013; Manyena 2006; Masten et al. 1990	Disaster; Human health; Human development; Sociology
“Catastrophic events and/or experiences”	Almedom and Tumwine 2008	Human health
“Illness or loss”	Resnick and Inguito 2011	Human health
“Crisis”	Marmot 2013	Human health
“Risk”	Netuveli et al. 2008	Human health

Source: Nunes (2014)

The definitions presented in this paper are not contradictory but comprise important differences, such as within human health, human development and psychology fields. Among these resilience is mainly considered as an “ability, capacity, characteristic or process a system uses to positively respond or adapt to threats, stresses or events” (Nunes, 2014). As a result, resilience is present in any given system and can be assessed in certain conditions (e.g. disaster, shock). This raises the question of “resilience to what?” which according to Folke et al. (2010) in the ecology literature means that we should differentiate between general resilience (e.g. to a wide range of disturbances, shocks or threats) and specified resilience (e.g. to individual disturbances, shocks or threats). Consequently, Folke and colleagues (2010) have defined general resilience as: “The resilience of any and all parts of a system to all kinds of shocks, including novel ones.” (Folke et al. 2010: 3), and specified resilience as “The resilience “of what, to what”; resilience of some particular part of a system, related to a particular control variable, to one or more identified kinds of shocks.” (Folke et al. 2010: 3). Miller and colleagues (2010) have also distinguished between general resilience and specified resilience and have urged the need for a better understanding of both types of resilience. As a result, both Folke et al. (2010) and Miller et al. (2010) have argued that efforts for increasing resilience need to account for both general resilience and specified resilience, as concentrating on certain types of shocks (i.e. specified resilience) could threaten general resilience. More recently, the Royal Society (2014) has similarly adopted the distinction between general resilience and specific resilience in its latest report on resilience to extreme events, which is also advocated in this paper.

The array of conceptualisations of resilience presented above raise concerns about the difficulties in finding “the appropriate analytical unit for the measurement of resilience” (Leichenko 2011: 164). Notwithstanding, the concept of resilience has gained interest for better understanding what entails adaptation. For example, Nelson and colleagues (2007) argue that resilience comprises the ability to adapt and as a result, ask for a resilience approach that focuses on improving the roots of resilience in order to be able to assess adaptation and ultimately reduce vulnerability (see Discussion).

- Resilience assessments

It has been suggested that the diverse disciplinary definitions and conceptualisations have enabled the concept of resilience to become “overused but, ironically, somewhat underutilized.” (Werner 2012: 20).

The panarchy approach to resilience developed by Gunderson and Holling (2001) is widely used to assess resilience in ecology as it focuses on social-ecological systems and looks at resilience through different scales (Cutter et al., 2008). Within the hazards literature, a model to assess the resilience of communities to threats has also been developed (Cutter et al., 2008). The DROP (Disaster Resilience Of Place) comprises six resilience indicators (ecological, social, economic, institutional, infrastructure and community competence), but no indication is given to the type of data to be used (i.e. primary, secondary) and possible ways of operationalising each indicator which is somewhat disappointing as no way forward is outlined on how to measure resilience using the indicators presented (e.g. ecological, social, economic) (Cutter et al. 2008). Later on, such conceptual framework of resilience set the foundations for Cutter and colleagues (2010) to develop an analytical tool to measure community resilience using secondary data from the Census and other statistical data, which in some cases were 10 years old. Here is highlighted the need to understand the concept of resilience for developing an analytical approach to assess resilience using either updated secondary data or primary data collected especially for a specific purpose. Other examples of frameworks and tools to assess resilience are still scarce.

In their model of community resilience Berkes and Ross (2013) use a variety of resilience features (e.g. social networks, knowledge, values and beliefs, people-place-relationships). Additionally, according to these authors, the health literature is thought to convey the concept of agency to the forefront of the resilience debate which in their view has been ignored in other sciences, such as natural sciences (Berkes and Ross 2013). Interestingly, Walker and colleagues (2004) highlight the significance of having access to assets, good institutions and good governance as some of the influential factors in the resilience of social-ecological systems, with impact on individual empowerment and agency. This perspective results from considering resilience, as well as adaptability and transformability, as attributes of social-ecological systems which has implications for resilience analysis, adaptive management and governance, which has gathered interest from different disciplinary circles (Walker et al. 2004). Despite this, this paper argues that opportunities for interdisciplinary research into novel theoretical and analytical approaches to human resilience are crucial to understand how it is shaped, but are still under developed.

Despite the perceived preference of policy makers for quantitative outputs for informing policy-making (Engle et al., 2013), a qualitative approach to human resilience (i.e. at the individual, family and community levels) is also considered to have added value in overcoming some of the challenges for compiling resilience indicators and can even have advantages in measuring resilience

(Engle et al. 2013). Examples of such an approach in the health literature are studies by Antonovsky (1979, 1978, 1993, 1996), Glandon and colleagues (2008), Kimhi (2014) and Nunes (2014) who assessed human resilience at the individual level after the Holocaust, Hurricane Katrina, Second Lebanon War and extreme temperatures, respectively, through the 'Sense of Coherence' (SOC) scale. These authors used an approach to human resilience that has a health and salutogenic viewpoint linking the characteristics of individuals to their ability to respond to threats (Almedom 2008). These allow links between the concepts of resilience and Sense of Coherence (i.e. central construct of salutogenesis). In this respect, Lorenz (2013) also links resilience and health through salutogenesis and the 'Sense of Coherence' construct, which focuses on the assets (e.g. general resistance resources, resources) that contribute to individual resilience (Wilkinson 2005). In addition, the links between health and resilience are only possible if the concept of health is used in a holistic form (Berkes et al., 2012; Doring et al. 2013). Moreover, using the SOC scale to assess human resilience has gained further interest from scholars and is currently recognised as an accepted measure of individual resilience (e.g. Kimhi 2014; Nunes, 2014). For more detail on the Sense of Coherence approach see Box 2.

Box 2 Using the 'Sense of Coherence approach' to assess resilience

The 'Sense of Coherence' approach to resilience is grounded in the theory of salutogenesis (Antonovsky 1978, 1987, 1993). Its developer, Antonovsky defined the SOC as: "a global orientation that expresses the extent to which one has a pervasive, enduring though dynamic feeling of confidence that (1) the stimuli deriving from one's internal and external environments in the course of living are structured, predictable, and explicable; (2) the resources are available to one to meet the demands posed by these stimuli; and (3) these demands are challenges, worthy of investment and engagement." (Antonovsky 1978: 19).

The three components presented above are called comprehensibility (1), manageability (2) and meaningfulness (3), respectively (Antonovsky 1993). First, the comprehensibility component refers to the cognitive dimension defined as the skill to make sense, assess order, structure and understand the stressor. Second, the manageability component represents the instrumental or behavioural dimension and is defined as the perception of availability of assets to face the threat and the power to do so. Third, the meaningfulness component refers to the motivational dimension and expresses the degree of incentive and aspiration to deal with the stressor. Hence, the components reflect cognitions, capacities and motivations, respectively (Almedom 2005; Lindstrom and Eriksson 2005; Lindstrom and Eriksson 2006; Lezwijn et al. 2011a). Within the Sense of Coherence approach individuals mobilize generalized resistance resources (GRRs) (i.e. assets) to cope with stresses and threats (Almedom 2005), which indicates a relationship between individuals and their environment (Eriksson and Lindstrom 2008). These assets can be psychosocial (e.g. social support, tradition, knowledge, experience), economic (e.g. money) and biological elements (Billings and Hashem 2009). According to Antonovsky (1996) an individual with a strong SOC facing an adversity or threat will "wish to, be motivated to, cope (meaningfulness); believe that the challenge is understood (comprehensibility); believe that resources to cope are available (manageability)" (Antonovsky 1996: 15).

However, some critics of the Sense of Coherence argue that it disregards the relationship between the individual and the environment they live in (e.g. society) (Lazarus and Folkman 1984). Others like Geyer (1997) stated that rational thinking as well as emotions play a role in the way individuals deal with threats but Antonovsky's explanations on the role of emotions are lacking, which can be seen as a weakness (Lazarus and Folkman 1984). In addition, criticisms to the wording of questions of the SOC scale have also been put forward (Flensburg-Madsen et al. 2005). Despite this, the SOC scale has been very popular and widely used to measure the Sense of Coherence concept. As a result, concerns arose that Antonovsky's formulation may have been in some way compromised by the range of translations and versions of the SOC scale (Flensburg-Madsen et al. 2005). Despite this, the Sense of Coherence continue to be widely used in the health literature (e.g. Lindstrom & Eriksson 2005; Lindstrom & Eriksson 2006) and used to measure human resilience (Almedom et al. 2007; Glandon et al. 2008; Kimhi 2014). According to some of the latest literature, the SOC scale continues to be a common measure of individual resilience and the empirical findings of such research continue to show benefits in its implementation, such as its validity (e.g. Kimhi 2014).

Source: Nunes (2014)

In summary, the Sense of Coherence approach to human resilience can be used to understand human adaptation and the role of assets (Almedom et al. 2007). By using the assets available, individuals and communities can increase their chances of coping effectively when facing threats. Furthermore, according to Almedom (2009) “individuals, families, and communities that can generate and access social capital and the material resources needed to maintain health and social stability are likely to build resilience” (Almedom 2009: 3). In other words, as with general resilience, the SOC represents an ability to respond to threats (Eriksson and Lindstrom, 2005), through the way individuals make sense of the threats they face and how they used their assets when responding to such threats (Lezwijn et al. 2011a).

Adaptation

- Definitions and understandings

The need for human adaptation is not new and has been happening since individuals had to deal with the environments they inhabit (Smithers and Smit 1997; Beall et al. 2012). Moreover, it is expected that humans will have to continuously adapt to changes in their environment, for example due to climate change (Parry et al. 2007).

Through time, the concept of adaptation has been defined in many ways (Table 4.1), who adapts can also vary (adaptation of what) (Table 4.2) and adaptation can also be defined as a response to changes (adaptation to what) (Table 4.3). As with resilience, adaptation definitions also tend to have a similar structure but different specificity levels. These differences are a result of disciplinary idiosyncrasies (Nunes, 2014).

Table 4.1 Selected definitions of ‘what adaptation refers to’ and sources by discipline

Definitions	Sources	Disciplines
“A process”	IPCC 2014a; Moser and Ekstrom 2010; Smit and Wandel 2006; Burton 1992	Interdisciplinary; Environmental science
“A process of deliberate change”	Nelson et al. 2007	Environmental science
“A dynamic social process”	Adger 2003	Environmental science
“A decision-making process”	Nelson et al. 2007	Environmental science
“An adjustment”	IPCC 2007; Janssen and Ostrom 2006; Adger et al. 2005; Pielke 1998; Smit et al. 1996; Watson et al. 1996; Smit 1993; Stakhiv 1993	Interdisciplinary; Environmental science; Sociology
“A continuous stream of activities, actions, decisions and attitudes”	Nelson et al. 2007; Adger et al. 2005	Environmental science
“Responses or actions”	Scheraga and Grambsch 1998	Environmental science
“Actions”	Nelson et al. 2007; Smit and Wandel 2006; Adger et al. 2005	Environmental science
“An outcome”	Smit and Wandel 2006	Environmental science
“Changes”	Moser and Ekstrom 2010	Sociology

Source: Nunes (2014)

Table 4.2 Selected definitions of ‘what adapts’ and sources by discipline

Definitions	Sources	Disciplines
“A system (household, community, group, sector, region, country)”	Smit and Wandel 2006	Environmental science
“Vulnerable systems”	Scheraga and Grambsch 1998; Watson et al. 1996	Environmental science
“Human and natural systems”	IPCC 2014a; IPCC 2007; Scheraga and Grambsch 1998	Environmental science
“Ecological, social or economic systems”	Adger et al. 2005	Environmental science
“Social–ecological systems”	Moser and Ekstrom 2010; Janssen and Ostrom 2006	Sociology; Environmental science
“Society”	Adger et al. 2005; Adger 2003	Environmental science
“A behaviour or economic structure”	Smit et al. 1996	Environmental science
“An individual, group and institution”	Pielke 1998	Sociology
“Individuals, groups and governments”	Adger et al. 2005	Environmental science
“People”	Burton 1992	Environmental science
“Organism”	Engle 2011	Environmental science

Source: Nunes (2014)

Table 4 (cont.) Selected definitions of ‘adaptation to what’ and sources by discipline

Definitions	Sources	Disciplines
“Climate change”	Scheraga and Grambsch 1998; Smit et al. 1996; Stakhiv 1993; Burton 1992	Climate
“Climate”	Pielke 1998; Smit 1993	Climate; Sociology
“Changes of climate”	Watson et al. 1996	Climate
“Climate variability”	Scheraga and Grambsch 1998	Climate
“Observed or expected changes in climatic stimuli”	IPCC 2007; Adger et al. 2005	Climate
“Changing condition, stress, hazard, risk or opportunity”	Smit and Wandel 2006	Climate
“Environmental changes and their impacts”	Janssen and Ostrom 2006	Climate
“External stimuli and stress”	Nelson et al. 2007	Climate
“Current or future predicted change”	Nelson et al. 2007	Climate
“Actual and expected impacts of climate change”	Moser and Ekstrom 2010	Sociology
“The surrounding environment”	Engle 2011	Climate

Source: Nunes (2014)

As mentioned earlier in this paper, the concept of adaptation has also been linked to other concepts, namely vulnerability and resilience (Davoudi et al. 2012). Similarly to what was found regarding the resilience definitions, there are commonalities and differences among these. The literature review undertaken here looked at definitions of adaptation in a variety of disciplines, aiming specifically at addressing issues related to human adaptation. Climate change adaptation can thus represent the adjustments individuals, communities and other systems implement (Gallopín 2006; Nelson et al. 2007) to increase their agency and reduce vulnerability (Nelson et al. 2007). For example,

within the health literature, Kjellstrom and McMichael (2013) consider adaptation and prevention as being synonyms as both consider the actions individuals, communities and other systems implement to deal with threats.

In addition, Oven and colleagues (2011) have found similarities between climate change adaptation and health promotion which include for example, allocation of time to evaluate the implementation of interventions. Furthermore, in the health literature, John Last (1998) has outlined a series of conditions needed for prevention or adaptation, these include: awareness that the problem exists; understanding of the causes; a sense that the problem matters; the capacity to intervene or influence; the political will to deal with the problem (Last 1998).

On another note, according to Adger (2003) access to and availability of assets is crucial for adaptation. Additionally, for adaptation to be successful three main factors need to be taken into account: “timely recognition of the need to adapt, an incentive to adapt, and ability to adapt” (Fankhauser et al 1999: 68-69). The first factor is considered to be reliant on access to information, its credibility and detail; the second factor considers the role of the environment in facilitating changes; and the last factor considers the use of the information available when responding to threats (Fankhauser et al. 1999). Here it is thus argued that understanding what human adaptation currently entails is crucial for better adaptation to future climate change.

- Assessment of adaptation

According to the IPCC an adaptation assessment corresponds to “the practice of identifying options to adapt to climate change and evaluating them in terms of criteria such as availability, benefits, costs, effectiveness, efficiency, and feasibility.” (IPCC 2014a: 2). Adaptation assessments have seen great developments (Fussler 2007b; IPCC, 2014d) being mostly top-down or bottom-up approaches, but also a combination of both (Dessai and Hulme 2004; Brown et al. 2011; IPCC 2014d).

For example, Adger and colleagues (2005) consider that adaptation assessments ought to have a human centred analysis focusing on the capacity to respond to threats. Additionally, such assessments should also take into account changes in the local climate, as well as social, demographic, economic and political changes due to the role they play in the capacity to respond to threats (Pelling and Wisner 2009). Moreover, “to date, few adaptation assessments have considered the uneven distribution of climate impacts and vulnerability across groups and individuals within society” (Benzie 2014: 1), which brings us back to the beginning of this paper and the lack of research on the links between adaptation and other related concepts such as vulnerability and resilience. Evaluating adaptation is not an easy task (Adger et al., 2005), as it is difficult to understand which factors shape adaptation and the relationship between adaptation, resilience and vulnerability.

In summary, in order to address the gaps identified from the literature discussed so far, it is crucial that advances are made to better understand both the theoretical and empirical interactions between adaptation and related concepts (i.e. vulnerability and resilience).

Discussion: Interactions between vulnerability, resilience and adaptation

Some of the theoretical connections between these three concepts have been explored by a growing number of studies (Berkes 2007; Vogel et al. 2007; Nelson et al. 2007; Miller et al. 2010;

Turner 2010) but the development of assessments for the operationalisation of the links between such concepts are still few.

According to Brown and Westaway (2011) in the environmental change literature, adaptation has links with assets, and access to assets is what influences adaptation (Grothmann and Patt 2005). In addition, in the climate change arena researching adaptation usually considers an assets approach on the concept of vulnerability as it focuses on the responses used by individuals and households that depend on the use of assets (Birkmann et al. 2010).

Furthermore, the public health and the climate change arenas could join forces through interdisciplinary research in dealing with current and foreseen risks and impacts of climate change (CSDH 2008). In this respect, Michael Marmot (2010) argues for a holistic approach combining climate change and the determinants of health, in order to achieve reductions in health inequalities and thus impacts of climate change (Marmot 2010). Furthermore, Curtis and Oven assert that “a more ‘differentiated’ perspective on the links between climate change and health is needed to capture the variable factors influencing health vulnerabilities and resilience to climate change of individuals and groups in different societies and different geographical settings” (Curtis and Oven 2012: 660). Understanding which factors shape knowledge, perceptions and behaviours for “building resilience to extreme weather now will mean individuals, communities and sectors will be better prepared to deal with climate change in the long-term.” (Oven et al. 2011: 5).

As a result, this paper argues that understanding the relationships between literatures focussing on vulnerability, resilience and adaptation, between concepts and between resulting frameworks is critical. An important view on the relationship between these concepts is summarised in this quote: “resilience and vulnerability represent two related yet different approaches to understanding the response of systems and actors to change; to shocks and surprises, as well as slow creeping changes” (Miller et al. 2010: 1). Within the Health 2020 Policy Framework and Strategy, the WHO gives emphasis to “resilience and assets that protect against harm, and on reducing or altering exclusionary processes’ (i.e. vulnerability)” (WHO 2012a: 12). Additionally, it has been asserted that there is “no one-size-fits-all approach to climate vulnerability, adaptation and resilience” (Bulkeley and Tuts 2013: 648).

Despite this, a shared agenda for vulnerability, resilience and adaptation is emerging, thus the need for understanding how these concepts are developed and operationalised in relation to each other (Nunes, 2014). In this context, a resilience thinking is useful in providing tools for analysis and improvement of adaptation (Nelson et al., 2007; Leichencko 2011; Bulkeley and Tuts 2013). Furthermore, improving adaptation should also include vulnerability reduction efforts as well as efforts to increase resilience (Nelson et al., 2007). However, not enough is known about how resilience is shaped thus more research is needed to better understand the factors that influence adaptation (Leickenko and Silva 2014).

According to Brooks (2003) vulnerability is influenced by previous adaptation as well as current potential for adaptation, both relying on assets. Moreover, an asset-focused framework for understanding climate change has been developed by Moser (2010) which is based in research on asset vulnerability and asset adaptation which provides “the link between climate change adaptation and the erosion of assets” (Moser 2011: 226). This framework has strong links with the arguments developed in this paper about the relevance of assets and asset-based approaches to operationalize vulnerability, resilience and adaptation. Despite all these developments, as highlighted earlier,

resilience tends to be left aside when exploring empirical interactions between vulnerability, adaptation and assets due to complexities regarding definitions and assessments, but linking vulnerability, resilience and adaptation to assets represents a step forward for the conceptual linkage of such concepts.

From another perspective, an individual may present high resilience and at the same time be considered vulnerable (Miller et al. 2010). Reason why some authors assert that it is crucial to translate theory into practice and policy in order for research to target individuals that are most impacted by shocks (Vogel et al. 2007; Miller et al. 2010).

This paper therefore, based on the diverse literatures reviewed, suggests that an assets, vulnerability, resilience and adaptation framework is possible and desirable to understand the root causes of climate change health impacts .

Conclusion

As seen throughout this paper, the different disciplinary perspectives, diverse conceptualizations and operationalisations of vulnerability, resilience and adaptation stand as major obstacles for integrating and developing shared definitions and concrete measures and tools for their assessment.

This paper revealed five main gaps in the literature and research concerning the need to mitigate the impacts of climate change on human health, which include: (I) understand the role assets play in human vulnerability, resilience and adaptation; (II) understand and operationalise human vulnerability; (III) understand and operationalise human resilience; (IV) understand and address what influences adaptation, and; (V) understand the links between vulnerability, resilience and adaptation.

In addition, this paper's contribution rests is advancing knowledge through a novel perspective on the concepts of vulnerability, resilience and adaptation taking into account the broader literature it draws upon and combine (i.e. health, climate science, disaster science and sociology). Another contribution relates to using the concept of assets to make connections between the concepts of vulnerability, resilience and adaptation, and to better understand how vulnerability, resilience and adaptation are shaped.

This paper suggests that there is a need for better understanding of how human vulnerability, resilience and adaptation are shaped. It is thus argued here that an opportunity exists for empirical research exploring the role of assets in shaping vulnerability, resilience and adaptation, as well as the interactions between these concepts. Future research could arise from the development of a theoretical and analytical framework aimed at developing novel methodological approaches for assessing general and specified human vulnerability, resilience and adaptation. Furthermore, exploring human vulnerability, resilience and adaptation is key in shaping individual responses to reduce or mitigate health risks or impacts, and may help develop and implement policies and actions to reduce vulnerability, increase resilience and improve adaptation.

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