

Review Article

Vulnerability Analysis of Impact Assessment in Climate Change: Review

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Abstract

The earth and equilibrium natural dynamics exposed to adverse impacts of considerable anthropological activities and seldom natural effects. Even though impossible to terminate natural hazard process, evokes by human activities in addition to directly contaminating natural equilibrium. Thus, human activities frequently reported as the most dangerous and hasten environmental pollution which can caused directly negative to nature and indirectly impose other impacts such as deterioration of atmospheric components such as ozone layers through chlorofluorocarbon (CFL), diseases and hotness of micro climate. Vulnerability of nature groups in biodiversity make the issues more sensitive and need special attention. Such activities cause disturbances of environmental social life activities. Such activities needs action challenges, reduces and policy to regulate less than threshold level and eco friendly activities. World decided to agree to evaluate any activities, policies, or projects before implementation. For such evaluation, environmental and social impact analysis is a tool uses to assess the design activities. One of the factors dangling for project implementation is vulnerability status of environments and society. Vulnerability is the susceptibility potential of environments or social community. Vulnerability has several types: economical, social, political, environmental etc. Thus, vulnerability analysis help to forecast mitigation methods for evaluated either environment or social than other less vulnerable to risks.

Keywords

Vulnerability, Analysis, Impact Assessment, Hazards

1. Introduction

The purpose of analyzing vulnerability in impact assessment uses in order to propose synergies between research on environmental change and on resilience of social ecological systems. Physiographic and social life interlinks in benefit of living organism is not terminated and continue as long as life present on the earth [1]. This causes minimum to extent impacts on natural equilibrium and found everywhere. The estimated of occurrence period of disaster before a century was

completely different from the current century [21]. This distortion of natural balance and hazards hastened by intensive anthropological impacts up on the nature need assessment to take mitigation and remediation action. Impact assessment is tool uses to assess or evaluate impacts of any project, program, rule and regulation or policies going to implement in environment and societies [17]. Thus, studies that basically focus on environment and social life assessment indicated their

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vulnerability, risk, and forecast hazards may happen during implementation require for alleviate adverse impacts.

Vulnerability defined in different ways based on the objectives of the study. The appropriate definition and subjective is that "a set of conditions and processes resulting from physical, social, economic, and environmental factors [16]. In addition, Dow and Downing [14] defined vulnerability is the differential susceptibility of circumstances contributing to vulnerability that are: biophysical, demographic, economic, social, and technological factors such as population ages, economic dependency, racism and age of infrastructure are some factors which have been examined in association with natural hazard.

Impact assessment's vulnerability analysis has become an essential technique for comprehending and resolving the potential risks and vulnerabilities encountered by people and ecosystems in the face of various stresses [1]. The need for thorough and data-driven ways to identify vulnerabilities grows increasingly more crucial as the world struggles with growing uncertainties caused by climate change, economic swings, and social disturbances. Using the works of Cutter et al. [12] and Turner et al. [30], examines the methodology and consequences of vulnerability analysis in impact assessment. Vulnerability analysis is taken as crucial pillar in encouraging sustainable development in an ever-changing global environment.

In an ever-changing world, the potential for hazards, disruptions, and changes looms large over various systems, communities, and environments. As societies strive for sustainable development and effective risk management, understanding vulnerabilities becomes paramount in the pursuit of resilience [2]. Vulnerability analysis, as an integral component of impact assessment, offers a structured approach to comprehensively evaluate the susceptibilities of entities to adverse outcomes arising from a myriad of stressors ([28, 10]).

It's crucial to define environments and society's status to reduce vulnerability in naturally or anthropological effects. Understanding of disaster, risk and vulnerability are most important to achieve impact assessment. These three (Disaster, vulnerability and risk) guiding philosophy is to take a community's vulnerability into account while thinking about disasters [1]. External elements on a system's stability and well-being cannot be understated, regardless of whether they relate to natural disasters, economic ups and downs, technological changes, or social difficulties [29]. Impact assessments use vulnerability analysis to pinpoint and address the variables that increase the likelihood of unfavorable outcomes, laying the groundwork for strategic risk management and well-informed decision-making.

Vulnerability analysis is a crucial component of impact assessment, especially in the context of risk management, disaster preparedness, and sustainability planning. Through a vulnerability assessment, areas of weakness and potential actions that would exploit those weaknesses are identified, and the effectiveness of additional security measures is as-

essed [13]. It involves the systematic examination of factors that can make a system, community, or environment susceptible to harm or negative consequences in the face of potential hazards, disturbances, or changes. In this review or term paper, I explored the vulnerability analysis in impact assessment in view of application and evoked to resilience ways to help us achieve sustainable development and promote a more resilient and adaptable society.

2. Definition of Vulnerability

"Vulnerability" derives from the Latin word *vulnerable* (to wound) and describes the potential to be harmed physically and/or psychologically. Vulnerability is often understood as the counterpart of resilience, and is increasingly studied in linked social-ecological systems. Vulnerability is defined by several scholars depends on the objectives of the study. Gabor and Griffith [17] defined as Vulnerability is the threat (to hazardous materials) to which people are exposed (including chemical agents and the ecological situation of the communities and their level of emergency preparedness). Vulnerability is the risk context. In addition, Osman [27], Alexander [3] and Cutter [9] explained as it is the Human sensitivity to environmental hazards represents a combination of physical exposure and human vulnerability; the breadth of social and economic tolerance available at the same site. Human vulnerability is function of the costs and benefits of inhabiting areas at risk from natural disaster.

It is also the likelihood that an individual or group will be exposed to and adversely affected by a hazard. It is the interaction of the hazard of place (risk and mitigation) with the social profile of communities. Regarding the impact assessment uses of vulnerability analysis it is defined in terms of exposure, capacity, and recovery potential and bolster damage control (i.e., minimize destructive consequences) via private and public means [36]. Thus, vulnerability means unable of societies to cope up anthropological and natural disaster due to economic problems, unable to stop or less early of forecast and alarming system.

The inability to grasp the context of natural hazards represents one of our greatest barriers to managing the consequences of natural disasters [34]. To view all the factors contributing to a disaster, by cutting across professional and disciplinary boundaries in both time and space, is difficult. General intra-disciplinary approaches are not capable of seizing all characteristics of natural disasters, involving many social, economic, political, technological, organizational, and physical factors [34]. Additionally, single discipline views often ignore the potential for new approaches to disaster reduction that come into view if one broadens the analytic focus to take account of the full range of interacting hazards that occur in modern societies. According to the frequently cited McCarthy et al., [21], definition vulnerability is the degree to which a system is vulnerable to and unable to deal with negative effects (of climate change). The stress to which a system

is exposed, its sensitivity, and its capability for adaptation are the main parameters of vulnerability in all formulations.

2.1. Concepts of Vulnerability

The vulnerability concept has been in use for more than a decade since start from onset of 20th century in different department such as geography [35]. Presently, vulnerability is used in the field of risk, hazard, and disaster management as well as in the areas of global change and environment and development studies. Within the last years, especially urban vulnerability and the vulnerability of megacities became a focal point ([4, 22, 26]). However, there is no common conceptualization of vulnerability [12]. Hence, it is a potential for loss derived from the interaction of society with biophysical conditions which in turn affect the resilience of the environment to respond to the hazard or disaster as well as influencing the adaptation of society to such changing conditions. There are three distinct themes in vulnerability studies: they are vulnerability as risk/hazard exposure; vulnerability as social response; and vulnerability of places [12].

The first research theme vulnerability as pre-existing condition examines the source (or potential exposure or risk) of biophysical or technological hazards [34]. These studies are characterized by a focus on the distribution of some hazardous condition, the human occupancy of this hazardous zone (e.g. floodplains, seismic zones), and the degree of loss associated with the occurrence of a particular event (flood, earthquake).

The second group of vulnerability studies is vulnerability as tempered response focuses on coping responses including societal resistance to hazards. The nature of the hazardous event or condition is usually taken as a given, or at the very minimum viewed as a social construct not a biophysical condition [5]. This perspective highlights the social construction of vulnerability, a condition rooted in historical, cultural social and economic processes that impinge on the individual's or society's ability to cope with disasters and adequately respond to them.

The third direction is vulnerability as hazard of place combines elements of the two, but it is inherently more geographically centered. In this perspective, vulnerability is conceived as both a biophysical risk as well as a social response, but within a specific area or geographic domain. The vulnerability literature is also bifurcated when it comes to an understanding of causes of vulnerability, which is not a surprise considering the different theoretical orientations [9]. Some vulnerability studies take a political-economic perspective and suggest a causal structure that concentrates on the differential social impacts and abilities to cope with the crisis at hand.

The focus is clearly on the dynamic pressures and underlying driving forces that give rise to vulnerability in the first place. The access to resource model is a more refined explanation of the role of political and economic forces as the root cause of the unsafe conditions. Other studies contend that

vulnerability is locational driven. The assumption is that vulnerability is primarily a function of the proximity to the source of the hazard/risk (Figure 1). For example, the Organization of American States [16] developed a series of multi-hazard maps that incorporate vulnerability assessment into their pre-impact planning and mitigation efforts. These assessments include human populations, critical facilities and lifelines, economic production facilities, and differences in vulnerability among economic sectors. In general, the concept of vulnerability analysis is to study the responses of society to hazards and their mitigation potential.



Figure 1. Vulnerability concepts (Source: Internet).

2.2. Components of Vulnerability Analysis

Vulnerability analysis is a fundamental aspect of risk management and plays a crucial role in maintaining the security and integrity of various systems and environments, including information technology, critical infrastructure, and even natural and social systems. It is simply the process of identification of biophysical and people potentially at risk (exposure) physical, economic, environmental, Social/political vulnerability [24]. It's about analysis of self-protection, capabilities by reducing exposure or vulnerability. An emerging consensus holds that vulnerability rests largely within the condition and dynamics of the coupled human-environment system exposed to hazards, and vulnerability analysis must be comprehensive, treating not only the system in question but also its many and varied linkages [32]. Vulnerability is also components of risks (Figure 2).

$$\text{Risk} = \text{Hazard} \times \text{Exposure} \times \text{Vulnerability}.$$



Figure 2. Triangle of Risk sources (source: Internet).

Vulnerability analysis linked to sustainability requires maturation to better serve various environmental initiatives calling for increasing attention to the “so-what” questions. This requirement builds from a rich tradition of past work toward comprehensive approaches that couple human and bio-physical subsystems and detail their condition, function, and linkages to improve understanding of vulnerability and

future projections thereof.

2.3. Types Vulnerability

Several factors or sources contributed into make vulnerability (Table 1) and each source affects mitigation potential of societies and determines types of vulnerability.

Table 1. Factors causes vulnerabilities of societies (Sources: Turner et al, [32].

Categories	Vulnerability factors
Geographical	Physiographic characteristics of area like slope elevation
Climatic	Erratic and absence of rainfall, temperature increase/decrease
Social	Demographic features (population, gender, age, density, literacy and education, insurance, health)
Economic	Livelihood and other economic indicators like property, transport, communication system
Physical	Houses, road bridges, school, hospital, etc
Environmental	Assess to and availability and quality natural resources, and ecosystem services
Development related	Types of developmental activities, location, and process followed.

Based on factors influences the occurrences, major types of vulnerabilities were described below.

2.3.1. Social Vulnerability

Social vulnerability is the initial most common types and reveals everywhere due to several causes. It refers to the incapability of people, organizations, and societies to withstand adverse impacts which they are exposed. These impacts show characteristics of inherent in social interactions, institutions, and systems of cultural values [19]. Thus, the catastrophe need special focus and attention to alarm societies before risk take place. More improve ability of individual to community, systems, and increase ways of against to expected disaster [13]. Hence, it needs construct ability or resilience potential of people, communities, and system of administration to withstand catastrophic events either man made or natural cases.

2.3.2. Economical Vulnerability

Economic vulnerability is very crucial and plays substantial role in independent of individual to society. It is defined as risks caused by external/exogenous shocks to system of production, distribution and consumption [11]. This is the motor of society and correlated with other vulnerability. The same hazard cope up potential of two different countries differentiated due to asset and liquid economy that they have. Thus, the most challenges of food insecurity, absence of basic human needs, good and services out-break diseases; etc relied on economic issues and highly affected resilience potential of human being.

2.3.3. Climate Change and Physiographic Vulnerability

Climate change vulnerability is the agenda of scientists and politicians of 21st century. It is knocking every door of human being; rich, poor, male, female, old, child, etc. Climate risk vulnerability is a concept that describes how strong people or ecosystems are likely to be affected by climate change [23]. It is as the tendency or predisposition to be adversely affected by climate change. It can apply to humans and also to natural systems (or ecosystems). Related concepts include *climate sensitivity* and the ability, or lack thereof, to cope and adapt [20]. In addition, different parts of the world have their own vulnerability in nature. For instance, coastal areas have doubt of over flow, while other marginal areas living in the problem of drought. In addition, climate circulation system guided such as El-nino, Lalina, earth quick, flood, etc need alarm or special early warning technologies and needs economy.

2.3.4. Political Vulnerability

Political vulnerability means unable or absence of strong and regular policy system. It is a kind of policy or governing system susceptible with any situation. Political vulnerability can be understood as "the weakness of the democratic system, with its negative effects on the efficiency of public policies, the legitimacy of the government action, limited participation of citizens and the private sector in national efforts, linkage with local governments and civil organizations, the handling and management of emergencies, processing of citizen's de-

mands and needs, and the capacity to meet them [7]. Democratic backsliding is a direct result of political vulnerability, and has been documented across the globe throughout history. Such vulnerability syndromes shows mostly absence of sustainable peace, corruption, internal war and conflict, absence of democratic election at different level and municipality of government, shift from one way or the other on a national scale indicated political vulnerability.

2.3.5. Emotional Vulnerability

The *Brene Brown* theory of defines vulnerability as "uncertainty, risk, and emotional exposure [18]. Brown goes on to suggest that vulnerability is our most accurate measure of courage; we allow ourselves to be seen when we are vulnerable. Brené Brown [33] defines vulnerability emotion as it is the center of emotions, such as grief, shame, fear, and disappointment, but it is also the center and birthplace of love, belonging, authenticity, creativity, courage, and accountability [37]. Emotional vulnerability is also impacted by respondents that express feelings of sadness about the uncertainty of change. Increasing awareness and impact leads to heightened emotional responses [8]. Along with this, emotional vulnerability can affect the physical well-being of all ages when they suppress their emotions in highly distressing situations. For instance, less job opportunity demoralizes generation habit to learn modern education in different African countries. When these vulnerabilities are supported through conversation with an emotionally safe "other," this vulnerability can lead to resilience and the capacity to support others.

2.3.6. Cognitive Vulnerability

This is about to create erroneous physiology, bias, believed in wrong ways in mind without practical or nor justification [6]. Cognitive vulnerability is in place before the symptoms of psychological disorders start to appear, such as high neuroticism [25]. In psychopathology, cognitive vulnerability is constructed from schema models, hopelessness models, and attachment theory [19]. The attachment theory states that humans need to develop a close bond with their caregivers. When there is a disruption in the child-parent bonding relationship it may be associated with cognitive vulnerability and depression. Attention bias is a form of cognitive bias that can lead to cognitive vulnerability.

2.4. Vulnerability Analysis in Impact Assessment

Vulnerability assessment is a process to identify, evaluate, and assess susceptibility to expected hazards. Vulnerability analysis is a critical aspect of impact assessment tools, especially in fields like environmental impact assessment, cyber-security, and social impact assessment. It involves identifying potential weaknesses or vulnerabilities within a

system, process, or project that could be exploited to cause harm, disrupt operations, or lead to negative consequences. Integrating vulnerability analysis into impact assessment tools helps in identifying and addressing potential risks before they escalate into significant issues. Here's how vulnerability analysis can be applied in impact assessment tools:

Identification of Vulnerabilities: In the context of impact assessment tools, vulnerability analysis involves identifying vulnerabilities that could impact the system being assessed. This could include technical vulnerabilities (in software or hardware), environmental vulnerabilities (such as weak points in ecosystems), or social vulnerabilities (like marginalized communities at risk from a project) [15].

Risk Assessment: Once vulnerabilities are identified, a risk assessment is conducted to determine the potential impact and likelihood of exploitation. This step helps prioritize vulnerabilities based on their potential consequences and the likelihood of them being exploited.

Mitigation Strategies: Impact assessment tools can recommend mitigation strategies to address identified vulnerabilities. These strategies could include technical fixes, process improvements, policy changes, or even suggesting alternatives that avoid the vulnerabilities altogether.

Scenario Analysis: Vulnerability analysis often involves scenario analysis, where different potential threat scenarios are considered. This allows impact assessment tools to evaluate how vulnerabilities might be exploited in various situations and what the consequences could be.

Integration with Decision-Making: Impact assessment tools that incorporate vulnerability analysis can provide decision-makers with a clearer understanding of potential risks and their implications. This information is crucial for making informed decisions about whether to proceed with a project, what changes might be necessary, or whether additional safeguards are required.

Continuous Monitoring: Vulnerability analysis isn't a one-time process; it should be integrated into ongoing monitoring efforts. Impact assessment tools can continuously monitor for new vulnerabilities and changes in the threat landscape, ensuring that the system remains resilient over time.

Multi-disciplinary Approach: Vulnerability analysis often requires input from multiple disciplines. In the case of social impact assessment, for instance, expertise from social sciences, economics, and community engagement might be necessary to identify vulnerabilities related to social factors.

Stakeholder Engagement: Including stakeholders in the vulnerability analysis process enhances the identification of vulnerabilities that might not be apparent to experts alone. This approach fosters a broader understanding of the potential risks and impacts.

Documentation and Reporting: Impact assessment tools should provide clear documentation of identified vulnerabilities, associated risks, and mitigation strategies. This documentation is essential for transparency, accountability, and

future reference.

Incorporating vulnerability analysis into impact assessment tools ensures a more comprehensive understanding of potential risks and helps guide decision-making to create more resilient and sustainable systems, projects, or processes.

2.5. Vulnerability Analyzing Tools (VAT)

Vulnerability analysis need a tools use to dig out an exact sources of most exposed bodies [31]. This needs participation of stakeholder's inclusiveness of skill person and generate information map. To do this, several tools listed and described for VAT.

Group discussion: Involves group discussions and application of participatory tools to design or map the vulnerability issues, either environmental or others. During this, to map the factors of vulnerability, it is possible to use local materials such as sticks, stones; seeds, etc. are needed for vulnerability mapping on the ground. Besides, community workers critically look at various elements i.e. human, assets, infrastructure, and physical features that are more vulnerable to prevalent hazards.

Risk mapping: Risk mapping is the most important task that facilitates the whole process. Once the map is drawn, the next step is to look at what makes people vulnerable to specific hazards thereby identify vulnerable people and elements through a participatory session. A vulnerability triangle can be drawn for each of the hazards that the participants have identified. This information can be shown graphically on the ground and then, a circle is drawn and the extent of vulnerability element is represented in an angular manner (degrees). This tool is called the Vulnerability Proportion Circle. N.B: The disaster in this example is *drought*.

Transect walks: involves walking through the community with key informants, observing, listening, and asking to get adequate information about whom and what are most vulnerable. Try walking in a fairly straight line through the area, making a careful note of whatever is relevant, e.g. the soils, agriculture, water sources, and activities. Then, analysis and report the results. A timeline is used to show major local events, ecological change, disease, and population trends. Agree how many years to timeline should cover. Ask community member to discuss key events and to write them in. The example below is a timeline of well-being, which is used to reflect on the well-being of the community in recent years. Events that influenced well-being are included.

Targeting elements at risk: It helps us in several ways. It enables us underscore the importance of community level targeting for effective risk reduction. It assists the participants to target various categories and individuals within the vulnerability bracket with respect to a specific hazard. It enables participants use community knowledge and resources for improved targeting. Remember that the process of targeting should be useful in assisting the community to know the particular individuals/households or elements at risk to a partic-

ular hazard. This is necessary not only for devising appropriate intervention strategy, but also for directing and apportioning in accordance with the actual needs of the people. In fact, the actual work of targeting elements at risk depends on various factors including the type of hazard being addressed, the phase of the disaster at the time of targeting and available resources to carry out the process. However, to be meaningful the process should fulfill the following:

- (1) It should be easy to undertake i.e. not cumbersome and time consuming to the extent that it negates plans for swift action.
- (2) It should be undertaken through a participatory approach that ensures community involvement.
- (3) Ideally, it should be community-led.
- (4) It should be possible to operate within a framework where sustainability is inbuilt.

3. Conclusion

Vulnerability is the important components in risks. The major objectives of impact analysis is reduce risk or adverse effects, while improve mitigation and advantage expect from innovation things going to implement. Thus, vulnerability is concept which describes factors or constraints of an economic, social, physical, or geographic nature, which reduce the ability to prepare for and cope with the impact of hazards. This shows that the other side of vulnerability is looking for cope up or adaptation searching. Vulnerability analysis used to identify the most exposes sides with help of vulnerability analysis tools. It is also use to develop mitigation methods through alarming, awareness creation, and used technologies to overcome the problems. Finally, vulnerability analysis in impact assessment is the most important issues and guarantee for successive of new ideas, projects, program and others due to provides the way touch the most expose community.

Abbreviations

CFC Chloroflorocarbon

Author Contributions

Daba Etana Rago: Conceptualization, Investigation, Methodology, Writing – original draft, Writing – review & editing

Efrem Asfawu Gutema: Validation, Writing – review & editing

Conflicts of Interest

The authors declare no conflicts of interest.

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