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COMPARING DIFFERENT APPROACHES TO ASSESS ENVIRONMENTAL VULNERABILITIES

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Abstract

In this review article, we have compared different approaches to assess vulnerability of environmental systems, and also identified and analysed the major adaptations by the world to measure the environmental vulnerability and their points of convergence of what otherwise might be characterised in the given field of research. The large number of indices and frameworks has been developed to measure the environmental vulnerability. Similarly, there are some assessment methods to assess environmental vulnerability. In this regard, there are many publications that have been published specially in the previous decade, and many from them were considered in this article to find out the best method to deal with environmental vulnerability. We concluded that, by integrating all the components of environmental vulnerability into a common framework within a single context, a reasonable setting for measuring the level of environmental vulnerability could be assessed. Index of simple numeric values for individual component should be developed within each framework of that component. We argued that multiple approaches to measure the environmental vulnerability should be considered to analyse the best to adapt. We have pointed-out the major questions that could be raised in the minds of researchers for the development of risk free (Resilient) societies. We suggested developing the framework of such capability that could be modified by the nations to use it, at their local context.

Keywords: Environmental vulnerabilities, Assessment, Framework, Index, Resilient.

1. Introduction

In the recent decades of modern world, vulnerability assessment has become a vital issue to study for the advancements in human cycles and is considered as a key for the future planning.

Vulnerability is the state of being vulnerable either socially, culturally, emotionally or due to natural events in a specific time frame. Level of vulnerability shows the level (of a society, organisation, etc.) to bear the crisis upto a certain time/duration.

Environmental vulnerability integrates all aspects of vulnerability related to human and natural environment and its study provides a comprehensive output for assessment of indicated problems. The capability to measure vulnerability is progressively more being seen as an input step towards resourceful risk reduction and also to support of a culture of disaster resiliency in the societies. In the light of increasing occurrence of natural disasters and ongoing environmental degradation, measuring vulnerability is very important if science is to help support the transition towards more sustainability in the world (Kasperson, 2005). The study of the vulnerability of human and nature to climate change and unpredictability, and of their ability to adapt to the changes in climate hazards, is a relatively new research field that brings closer all the experts from a broad variety of fields (Brooks, 2003), including, climate studies, developmental studies, disaster risk management, health studies, social sciences, policy making and economics. The flow in the interest of vulnerability study in the 1990s has been determined in a large part by the worldwide environmental change communities, where there were distinct changes in the concepts from the opinions of impacts to an evaluation of all the methods, conditions, and distinctiveness of approaches that intensify sensitivity and reduce adaptive reactions. The changes in the given circumstances can also be

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concluded into three paradigms of vulnerability assessment,

1. Natural disasters,
2. Global environmental change,
3. Human-environmental interactions.

All of these are integrated into the studies of environmental vulnerability, which gives a strong connection among them.

1.1 Environmental Vulnerabilities

This article presents the methods adapted by the world to cope with environmental vulnerability. Generally, environmental vulnerability has been considered as only natural resources related vulnerabilities but environmental vulnerability integrates all of the aspects related to potential issues for human to nature and their interactions, these includes:

1. Social vulnerability
2. Economic vulnerability
3. Socio-economic (Human system) vulnerability
4. Cultural-Spiritual vulnerability
5. Natural disasters based Eco-system vulnerability

There are different adoptions in the world to deal environmental vulnerabilities according to the needs of the area and their potentials to cope. These (above given) vulnerabilities are the core concerns to study the environmental vulnerabilities but unfortunately, the studies (each single) discussed below are not covering all the vulnerabilities provided above. It is not possible to discuss each of the above given vulnerabilities because our focus is to obtain the critical view of vulnerability research and practices done in this regard.

1.2 Vulnerability Research and Practice

When we start to discuss the measurement of environmental vulnerability, formation of framework is the key step, which identifies all aspects of vulnerability individually and sorts them in a manner. Assessment starts from the formation of framework.

A framework is a representation of the relative/virtual vulnerability of a variability of concern to a set of alarming forces (e.g. climate change, ecosystem deterioration, anthropogenic activities) by a position on a three-sided analytical structure, where vulnerability can be defined as a function of sensitivity, exposure, and the state relative to a threshold of damage (Luers, 2005).

Each framework is discussed on the basis of its risks and indicators are identified and arranged in it. Within a given framework, risk that is created by a particular type of hazard to a human system is a meaning of the harshness and probability of incidence of the hazard, especially, the way in which its all circumstances are likely to be submissive by the social vulnerability of the humans and their systems are in question. Therefore, risk can be quantified in terms of outcome, including the terms of human life losses and morbidity and/or economic losses.

Framework indicates the risk levels of the specified vulnerability and the exposed properties of that vulnerability, which are further formulated in index. It also categorises the indicators into their fields for further processing.

On the basis of formed frameworks, different profiles and indices are formulated to apply in the area, having specific kind of vulnerability. These profiles are applicable to the area of interest for future oriented modeling of the adaptations. Here scientist adopts different methods for assessment. Some uses of vulnerability assessment individually and others integrate all aspects in a single platform.

Adaptation is the response from human beings after the implementation of index in the specified area to avoid from future harms. Adaptation includes autonomous and directed actions. It depends upon the ability of the people that how they respond to it.

2. Description

The basic purpose of the article is to represent a certain conceptual analysis for studies of environmental vulnerability and adaptation to all of its components studied by the specialists, like, natural hazards, social, economic, climate inconsistency and changes, generally appropriate to a wide range of perspectives, structures and hazards (Brooks, 2003).

2.1 Reviews

Although a wide range of books, reports and journals have been published on this topic; we are going to discuss most important from them. The studies, discussed below, are to analyse the gap among all of them.

2.1.1 Environmental Vulnerability Frameworks

Warner (2002) described the financial vulnerability in "A framework for identifying, measuring, and comparing economic vulnerability to natural hazards". The given research effort discussed (identified and measured) the ability of a government to compensate for possible stock losses and had taken part in the efforts, that covers the aspects of hazard exposure with the geographical outlines of socio-economic vulnerability (which is a component of financial vulnerability) and which could help researchers better understand the distribution of catastrophic losses of economy and society (Chen, 2001; Dilley, 2001).

There were basically three concerns, which, according to author, were needed to be addressed. These include;

i. The losses from natural disasters have been found to be increased significantly over the last several decades (Munich, 1999, 2001). This increase in the losses has already generated pressure on the international community of donors to supply more resources for disaster reaction and assistance on aneven more recurrent basis and to a large numeral of countries.
ii. Either a country is able or not, to respond to capital stock losses (quickly and efficiently), which could replace a disaster happening, and that a catastrophe can have an effect on long-term economic development (Freeman et al., 2001; Freeman et al., 2001; Freeman, 2000).
iii. The international community of donors could be required the means, which can help to allocate limited resources for catastrophe management in the future and, which takes into consideration the financial vulnerability of the countries to natural catastrophes.

Chen (2001) and Dilley (2001) described that the framework helped to identify the "hotspots" of possible spatial (area based) and temporal (time related) losses. An index of financial vulnerability shows policy makers an integrated, wide-ranging outlook of hazard occurrence, risk components, and vulnerability of these given components to break the catastrophe. The framework also showed the division of losses over time comparative to a government's capability to forfeit for the given losses. The research on financial vulnerability helps the international community of donors to approximate needs of possible hazard finance for the countries, and identify different areas where the needs might be the greatest.

Brooks (2003) developed a conceptual framework of vulnerability, risk and adoptive capacity for climate change. According to him, the evident conflicts could be resolved between different types of vulnerabilities in the climate change literature by distinguishing between biophysical and social vulnerability. Also, we can put the study of social vulnerability within a risk management framework by recognising the broad correspondence between biophysical vulnerability and the natural hazards risk. The third thing, discussed in his framework, was the adaptive capacity of the human systems, which represents the prospective of the system to reduce its social vulnerability and hence to minimise the risk related to a hazard.

Kaly et al. (2002) developed a framework for managing environmental vulnerability in small island developing states (SIDS, low-lying coastal countries) in which they categorise the hazards into five main groups according to their nature. They also summarise the main environmental challenges to the respondents (land, forests, fresh water, biodiversity, marine/coastal, atmosphere, and cross-cutters).

After discussing the main groups of hazards, they summarise the approaches to manage the vulnerability and making resilience for those five environmental vulnerability challenges, which are being faced by SIDS. It was, in fact, a comprehensive type of framework to manage SIDS.

USA Center for hazards research and policy development, University of Louisville, in 2006, prepared a draft report on "Indicator issues and proposed framework for a disaster preparedness index (DPi)". This draft observed the issues to measure the disaster preparedness, and the procedure of making indices and indicators. All the existing indices were checked, and also

proposed a framework of developing a disaster preparedness index (DPi), and resiliency index (Ri) with a advised list of measurement indicators was forwarded.

According to them, vulnerability is equal to the product of hazard, its probability, its frequency and vulnerability measures of the given hazard. Disaster resiliency index (DRi) is equal to the ratio b/w preparedness index and vulnerability. If DRi > 1, the community is more resilient to hazard, where DRi < 1, the community is less resilient to hazard. Indicator selection is the big issue for any process, and main indicators, selected by them, were hazards, community resources, social assets, planning, infrastructure/system quality, population demographics and social services. Each of the indicators has its parameters to identify its level of vulnerability. They used the indicators defined by South Pacific Applied Geoscience Commission (SOPAC).

Using the above indicators, a comprehensive model was developed that puts the values of measured indicators to find their overall weight which further processed towards three formulas of disaster resiliency index (DRi), preparedness index (Pi) and vulnerability. The result of the described formula can identify the overall index score.

Gooch (2007) described in his paper about three aspects of nature to study vulnerability at watershed level. These include the biodiversity, livelihood and cultural-spiritual diversity. He discussed the weaknesses of the watershed and its livelihood in the manners of tradition, ecological variations and economic influences, which hurdles the companies and public sector organizations to invest there.

Luers (2005) presented "the surface of vulnerability: an analytical framework for examining environmental vulnerability", in which he introduced a logical framework to evaluate the vulnerability of community and places to environmental and social forces. The framework represented the inconsistency of relative vulnerability of concern (e.g., agricultural yield) to a set of alarming forces (such as, market fluctuations and climate change) by a position on a 3 dimensional logical surface and where vulnerability could be defined as a function of sensitivity, exposure, and the state relative to a threshold of damage. He proposed that three-dimensional surface of vulnerability as a tool for analysing/examining vulnerability. He illustrated his approach through an analysis of the agricultural district in the Yaqui Valley, Mexico, as an example.

2.1.2 Environmental Vulnerability Indices

Kaly et al. (1999), (SOPAC) developed an index for the environment to calculate on a scale and making the ranking and giving a single-figure result of relative environmental vulnerabilities of entire states. This work was the response on a call prepared in the Barbados Plan of Action, Alliance of Small Island States (AOSIS), and an increasing consideration that small island developing states (SIDS) look disadvantages to their development with their secluded, dispersed, small size, economic conditions and insufficient natural resources. It was developed basically for three countries, including, Australia, Fiji and Tuvalu. This report presented both the human and environment under the consideration to study all aspects. Environmental vulnerability index (EVI) was assembled, which was based on a theoretical framework that identified three aspects of vulnerability:

1. Risks to the environment (natural and anthropogenic),
2. The innate ability of the environment to cope with the risks (resilience), and
3. Ecosystem integrity (the health or condition of the environment as a result of past impacts).

These three aspects corresponded to three sub-indices, which were the Risk Exposure sub-Index (REI), Intrinsic Resilience sub-Index (IRI) and Environmental Degradation sub-Index (EDI).

The EVI was calculated as a weighted average of keep counts, allocated in the array of 0-7, derived from a total of 57 indicators. This report presented that a single figured vulnerability can be obtained and it can also be enhanced for more perfection. The beautiful theme of the study is that it shows its strengths and weaknesses for further consideration.

Kaly and Pratt (2000), (SOPAC) revised the index, developed in 1999, and implement on the countries, includes, Fiji, Samoa, Tuvalu and Vanuatu. This was the phase II report for the development of EVI. There were a lot of changes

occurred in the Phase II report from Phase I report including;

1. Change in scale from 0-7 to 1-7.
2. Indicators decreased from 57 to 47.
3. Refinement of EVI model.
4. To develop a mechanism for the collection of data.
5. To develop criteria and a work plan for testing and refining the index to a point, where it could be internationally acceptable (atlas.ambiente.gov.ar).
6. Data from 4 pacific countries.

They developed a Think-Tank of experts to study and analyse thoroughly, which caused the countable changes in the report. Report strongly encourages developing the EVI phase III report on Global basis instead of Pacific.

Gowrie (2003) developed an environmental vulnerability index for the island of Tobago, West Indies, based on the basis of EVI Phase II study developed by the (SOPAC) 2000. This vulnerability index was constructed to determine the meteorological, anthropogenic, geological and biological events and for general distinctiveness of a particular country. He categorised the areas according to its level determined by Phase II EVI report, which gave the value of 3.05 showing normal values.

Fuzzy analysis method was adopted in Mid-Atlantic region for integrated environmental vulnerability assessment by Tran et al., in 2002. Ecological indicators were used to develop a ranking method, which identifies the level of environmental degradation. The method was able to rank the ecosystem in the words of existing environmental conditions and recommending collective impacts on a great region. Using data on population, land cover, streams, roads, air pollution, and topography of the Mid-Atlantic region. Using it, they could point out areas that were comparatively in bad condition and/or more exposed to future corrosion. There were 26 environmental indicators, used to interpret the areas at watershed level.

South Pacific Applied Geoscience Commission (SOPAC), the United Nations Environment Programme (UNEP) and their partners developed vulnerability index in 2004 (Pratt et al., 2004), after the consultation and association with countries, institutions and professionals from around the world for the natural environment and for human welfare. The EVI had 50 indicators for the estimation. These indicators were developed to estimate the vulnerability of the environment of a country from future threats. These indicators were combined within a single index by simple averaged and reported values. Each index had policy-related sub-indices and also a profile showing the results for each indicator. There were main elements/categories, like;

1. Weather and climate (six main indicators),
2. Geology (four indicators),
3. Geography (six indicators),
4. Ecosystem, its resources and services (twenty eight indicators) and
5. Human populations (six indicators)

These categories were selected to ensure a relatively better interaction of the ecological processes, including, human interactions happening in a country. There were basically 32 indicators of hazards, similarly 8 indicators of resistance and 10 indicators that measure damages shown on a 1-7 scale. The hazard indicators were related to the hazardous event frequency and intensity estimation. The indicators of resistance were referred to the intrinsic characteristics of the countries that would tend to make them more or less able to manage with natural and human induced hazards. These indicators were included to measure absolute size (small countries have fewer options for refuges) and a large amount of sharing of borders (such as, greater risks of trans-boundary conflicts). Indicators of damage were developed to show the vulnerability as a result of acquired loss of ecological integrity or increase in the level of degradation of ecosystems. The classification/ categories, shown below, indicate the level of an overall vulnerable country.

1. Extremely vulnerable 365+
2. Highly vulnerable 315+
3. Vulnerable 265+
4. At risk 215+
5. Resilient <215 (vulnerabilityindex.net)

The design of EVI reflected the level of harm or degradation up to the certain extent. EVI was not addressing the economic, cultural, social or human induced environment because all of these

were counted as social and economic vulnerability indices, which need to be identified separately. Therefore, biophysical systems were included in the natural environment that could be sustained without continuous and/or direct human efforts/support.

2.1.3 Social-Environmental vulnerability:

Eakin and Luers (2006) "Assessing the vulnerability of Social Environmental system", in which the authors showed their views to measure the vulnerability of social-environmental systems and identify the union of significant points of what might be differentiated as different fields of research. A consensus on the critical importance to vulnerability reduction was developed, which includes the concerns of social equity and integrity. This article integrated three paradigms of natural disasters, global environmental change, and human-environmental interaction for near future vulnerability assessment.

Yeletasi et al. (2009) "A framework to integrated social vulnerability into catastrophic natural disaster preparedness planning" it is usually necessary to consider the contribution of various individual social vulnerability factors in preparedness planning projects for large scale natural disasters as some of those may better transmit to the selection among available preparedness actions. In this research-in-progress paper, they discussed social vulnerability and its use by disaster planners. They provided a conceptual framework to show how social factors alongwith vulnerability principals and vulnerability criteria may influence the selection of preparedness actions.

"Quantifying social vulnerability: A methodology for identifying those at risk to natural hazards" by (Dwyer et al., 2004) developed to assess the vulnerability of individuals within households to risk from natural hazards. The methodology introduced a technique for measuring certain attributes of individuals living within a household that can add to their vulnerability to a natural hazard impact. The methodology had four main steps, including, Indicator Selection, Risk Perception Questionnaire, Decision Tree Analysis, and Synthetic Estimation.

Tapsell et al. (2010), in their report, "Social vulnerability to natural hazards" provided a strong conceptual framework for social vulnerability to natural hazards, their relationship and risk governance through social capacity building. After identification and measurement of related parameters and formation of framework, they explained their linkages through empirical examples of natural disasters and their impacts on the societies.

They explained all types of known natural hazards and their impacts on societies. They related the impacts through diagrams and cycles. After complete study, they provided the different themes of their CapHaz-Net Project (Kuhlicke et al., 2012) with different work packages. These include;

1. Social capacity building
2. Risk governance
3. Risk perception
4. Risk communication
5. Risk education (caphaz-net.org)

They concluded that a large number of point of views and methodological approaches have been used as inputs to social vulnerability assessment. The authors were agreed that the CapHaz-Net project should be mapped on the different perspectives instead of agreeing on an overarching clarity of social vulnerability.

2.1.4 Economic-environmental vulnerability:

The impacts of Natural hazards including floods and droughts are often neglected in the long-tem sectoral strategies development and national development planning in the world. Both of the above discussed natural hazards have considerable negative impacts on the economies of the world every year (such as direct asset losses, poverty increase, and reduction of GDP).

The World Bank, RMSI, IFPRI and GFDRR, in 2011, worked on "Economic Vulnerability and Disaster Risk Assessment in Malawi and Mozambique, Measuring Economic Risks of Droughts and Floods". The basic concept was about applied probabilistic risk analysis to evaluate the impacts of the natural hazards. The essential building blocks in the probabilistic risk analysis modules were hazard, exposure, vulnerability, and loss. Hazard represented the occurrence and severity of adverse events. The exposure represented the asset(s) which were at risk. A statistical analysis in the form of methodological framework was adopted to

measure the level of hazard and its impacts, using the given meteorological and other data. The given methodology had subdivision of six modules to implement: Stochastic Weather Module, Drought and Flood Hazard Module, Exposure Module, Vulnerability Module, Direct Loss Computation Module and Macroeconomic Module.

3. Analysis of the Reviews

Frameworks generally based on the single component of environmental vulnerability specially include economic, social, natural environment and/or cultural vulnerability, with the classification of each component according to its condition for analysis. Framework may also be based on the indices for the classification of hazardness of that discussed components.

Warner (2002) discussed the financial vulnerability within a framework. He linked the financial vulnerability with the natural hazards for measuring the environmental vulnerability within the given framework. He emphasised on the role of government to compensate for potential capital losses. He also encouraged the researchers to study, which should be based on his framework to analyse the socio-economic vulnerability to compare with financial vulnerability. In the context of framework he raised three basic issues, needed to be addressed on urgent basis. These issues can be concluded in terms of his own recommendations. He emphasised on the international donor community to increase supply of resources to minimise the catastrophe causing intense stress on the natural resources, which are causing economic degradation. Long-term loss of capital can cause disastrous impacts on the economic growth of a country for future trade-offs. International community of donors may require means to help distribute limited resources for catastrophe/disaster management. This framework was based on identification, measurement and comparison economic vulnerability to natural hazards that leads to the following:

- Firstly, identification of “hotspots” with special linkages.
- Secondally, formation of an index for measuring the economic vulnerability with the presentation of policy making, integrated hazard outlook, risk components, and the vulnerability of above components to catastrophe break.

He raised two important circumstances for comparing vulnerability, Firstly the ability of the government to forfeit hazard and importance of international donor community for research on economic vulnerability. Although the report covers most of the issues, related to economic vulnerability, but there are some enhancement and modifications in the given framework needed to be a worldwide recognised framework.

- Identification of causes of natural hazards due to anthropogenic as well as natural modifications.
- Transformation in the measuring capability of the index to minimum and maximum range to make a clear view through development of metric divisions.
- Identifications and comparisons of the worldwide recognised methods for the improvements, efficiency and effectiveness of governmental as well as international donor community to forfeit the economic vulnerability natural hazards, etc.

Although, his research was a mile stone in the relevant field, but it majorly concise on the financial resources and their benefits to overcome the hazards, but it does not provide the details of the kinds of vulnerabilities with such hazards categorically.

Brooks (2003 describes all the concepts of environmental vulnerability with adoptive capacity for climate change. He clarified most of the possible linkages of the components of environmental vulnerability with climate change within his conceptual framework. Bio physical, social and natural hazards vulnerability can be broadly corresponded with their risk. He clarified the concepts of vulnerability risk and adaptation with connection of each other. He discussed the adoptive capacity of the society to reduce the social vulnerability, which leads to the triggering component of all hazards after natural disaster.

An excellent approach was taken by Kaly et al. (2002), in the form of the framework, describing the management of environmental vulnerability in small Island development states (SIDS). They categorised the hazards into five main groups and to measure the hazard of each

category they develop the small parameters. Similarly, with reference to the management of environmental vulnerability, they categorised five managing approaches to build the resilience. This report also leads towards the development of environmental vulnerability index (EVI) and forced the researchers and think tanks to produce a comprehensive EVI mechanism for the movement of SIDS towards resilience.

Disaster preparedness index (Dpi) is another effort done in the favour of using the framework for environmental vulnerability. Center for hazards research and policy development university of Louisville prepared this draft report in 2006, providing itself a comprehensive theoretical as well as practical thought towards management of environmental vulnerability to disasters. Through formation of disaster preparation index, disaster resiliency index, they clarify their vision towards sustainable development through management of disasters. The use of SOPAC indicators is a good thought for development of framework by them.

It is a complete thought that environmental vulnerability works have been done at national, regional or global levels, but Gooch (2007) presented a paper on the aspect of vulnerability at watershed level. He compared most of the components of environmental vulnerability at this level to discuss the weaknesses of the watershed.

An analytical framework was developed by Luers (2005), to identify the surface of vulnerability. He evaluated the vulnerability of the people, places to environmental and social forces. He proposed a three dimensional framework for analysis and supported his idea through analysing an area as an example. Although, it is an incomplete thought, but is a valid effort about another possibility to manage the natural environment.

History of environmental vulnerability index starts from 1999, when Kaly et al. (1999) developed first EVI (Environmental vulnerability index) based on theoretical framework (identified three characteristics of vulnerability).

EVI developed by SOPAC on the demand of Barbados plan of action for the development of SIDS, including, Australia, Fiji and Tuvalu. That index included 57 indicators and measure 0-7 scale to get single figured vulnerability value. In 2000, Kaly and his colleagues revised the index developed in 1999 and implemented it in small islands, including, Fiji, Samoa, Tuvalu and Vanuatu. There were changes, including, scale from 0-7 to 1-7, indicators from 57 to 47, formation of mechanisms of collection for data and developing criteria for tasting and refining index to be internationally acceptable.

EVI for the island of Tobago, West-indies, was developed in 2003 by Gowrie. It was based on SOPAC reports of EVI phase II. The results for island were 3.05, showing normal for environmental vulnerability.

2004-05 are the years for the consideration of EVI finalisation by SOPAC and UNEP. This EVI is showing 5 main components and 50 indicators on the same scale of 1-7. This final EVI index covering nearly all of the components related to the natural environmental vulnerability but “is natural environment stands equal with all the components of overall environment?” Because it is Environmental vulnerability index (EVI) and not the natural environmental vulnerability index.

Mid-Atlantic region adopted integrated environmental vulnerability assessment method named fuzzy analysis. Using 26 ecological indicators, Tran et al. (2002) ranked echo system in words of environmental conditions at watershed level. So this method is based on small scale management of environmental vulnerability. This assessment method could be an applicable adaptation in the world, if it also includes the human influenced conditions (economic, social, cultural-spiritual indicators).

Social environmental vulnerability is the major component of environmental vulnerability as reviewed in 2.1.3, but there is not a significant work done on it, according to its need. From review in 2.1.3, it can be concluded that (Dwyer et al., 2004) methodology is an exceptional effort done in this regard and through modification and enhancement in it this methodology can play a major role in making a social environmental vulnerability framework. Similar kind of effort by (Tapsell et al., 2010) reported in the relation between social vulnerability top natural hazards which can also provide significance while making social vulnerability framework.

According to the importance of economic vulnerability, there is a big gap of studies towards

the development of economic vulnerability framework. Economic vulnerability framework also includes the socio economic conditions and impacts of natural disasters on economy but unfortunately there is a lack of studies providing sufficient knowledge to cope with economic-environmental vulnerability. World Bank with the collaboration of some organisations developed an assessment of economic vulnerability of economic and disaster risk assessment (2.1.4). This report only presents the economic risk of droughts and floods on Malawi and Mozambique.

4. Conclusions

Although, we are at a stage, where the world has exposed most of the possible levels of environmental vulnerability and researchers have introduced the important methods to assess environmental vulnerabilities, but there are most of the simple questions, raising in every one's mind including;

- What is the best method to measure the environmental vulnerabilities?
- What are adoptive methods/techniques for disaster/hazard resilient society development?
- What should be the level of environmental vulnerability measurement (either watershed, national, regional or global), etc.

Through, careful studies from the previous research, it can be concluded that individual framework for each component of environmental vulnerability sets a bench mark and is a pathway towards the finalisations of an environmental vulnerability index (EVI) within each component, which leads to the management of environmental vulnerability. Formation of an index for one or more components of environmental vulnerability is like an incomplete thought, which could be completed by its use in the formation of environmental vulnerability framework. It is a powerful consideration while making a framework, in which the index can develop the best way towards the transformation of concept within the framework. Environmental vulnerability index (EVI) means to develop the indices for measuring all of the components environmental vulnerability not only related to the natural environment.

Economic conditions reflects natural environmental management conditions, level of society (with reference to social behaviours, motivations and cultural-spiritual levels) and adaptation capacity should also be included, when we are making a worldwide recognised environmental vulnerability framework.

Environmental vulnerability framework should present proper questions, which identifies the root problems which are needed to be addressed (legislative, theoretical, conceptual, etc). Similarly, Environmental vulnerability frameworks should be designed in such a way that each component of environmental vulnerability integrates its problems in metric of index to quantify.

The framework of the given component of environmental vulnerability should be able to explain all the prospects of management (by providing answer to all the above considered questions).

Environmental vulnerability framework should propose the future pathways and dynamic mechanisms towards making a resilient society. Environmental assessment methods, especially, fuzzy analysis and others, this type of analysis could be used when we start from small scale to the larger level.

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