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VULNERABILITY – A NEW CONCEPT TOWARDS A SUSTAINABLE ENVIRONMENT

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INTRODUCTION

The vulnerability of any system to on going environmental changes and future environmental impacts depend on the level of anticipated and unexpected risks along with the ability of the system to respond effectively to such risks both in short time and long term period. A Healthy productive and protected environment, social systems and economic viability are the major pillars of "sustainable development" and welfare of the society at large. Our environment provides all the required raw materials and the environment absorbs all the pollution as a result of human activities and industrial development. Man's ever increasing demands makes him devour all the available natural things from his environment and leaves delicate ecosystems in shambles.

At this critical juncture it becomes our duty to save the earth for our future generation. Every human being should know that we have not inherited the earth from our forefathers but instead we have borrowed it from our children. If enough steps are taken then our future generation will be deprived of so many good environments / animal population / and aquatic fauna and exotic plant species with excellent biodiversity1.

Vulnerability is a new way of looking at an old problem. Instead of focusing on what went wrong in the past and its

ABSTRACT

The vulnerability of any developmental system of ongoing environmental variability and future environmental changes depend upon the degree of anticipated and unanticipated risks and the ability of the current system to adapt/ merge/ respond effectively to the risks in both the short and the long term. A healthy, productive and protective environment, social system and economic viability are the major support systems for the sustainable development and maintenance of an amiable atmosphere for the humans. Sustainable development is defined as that development which is the need of the present day generation without compromising the needs and aspiration of future generation. It has to be understood that our earth has enough for our needs but not for our greed. The future depends on our ability to manage and preserve our resources for our generation and the coming generations.

This article discusses in detail the need of a vulnerability concept at this juncture when the world is facing an uphill battle in reviving our environment from increased industrial, developmental and population pressure and the calculation of the vulnerability index

KEYWORDS :*Vulnerability Index, sustainable environment, resource preservation, Pressure-state-response.*

Short Profile

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effects of hazards, vulnerability gives us the opportunity to focus on getting things right for the future. As a future focused approach, vulnerability is a way of using tactics, and strategies for improving our negative developments.

Vulnerability refers to the tendency of developments leading to destruction of environment. The opposite of this is resilience or the ability to resist the destruction and deterioration of the environment. It refers to the resistance of the environmental factors to the damaging destructive forces.

As the saying goes that every action ahs an equal and opposite reaction, similarly reduction has a reaction but it is in our hands to curtail the damage by more scientifically planned developments. Strategies and adopt cleaner technologies i.e. reduce the pollution at the grass root level itself. Here is the common saying "prevention is better than cure fits in very costly at this item. Arguments may arise and say that no development can take place without sacrificing some amount of our comfort. Yes vulnerability and resilient are the two banks of the same river and they run uninterrupted along each other. But it becomes imperative to look for sustainable developments. For a sustainable development we clearly need to understand the limit of vulnerably and then draw strategic line accordingly. The interesting thing about vulnerability is that it can be examined at different levels for different pollution issues. That is it can be used to look at a single issue or to assess a complex entity such as a region.

VULNERABILITY

It is necessary to understand what vulnerability is. Vulnerability is defined as the degree to which a system is susceptible to damage. To address the concept of vulnerability to an exertor in its entirety, it is essential to cover the possible impact of a stress or on humans and natural systems. Such a framework would span three elements. The exertor / stressor which triggers the impacts and triggers response, vulnerability of the entity exposed to the stressor / exertor and the ability of the exposed compartment to cope or respond to the stressor (Noronha 2003)2

There are numerous environmental indicators which clearly demonstrate the stress on the environment, due to pollution, and ecological disruption. The common themes include the lowering of the water table, degradation of fertile land and emergence of new diseases etc. These are immediately felt by the humans and animals equally. Stress on environment indirectly reflects on humans and the country's economy. Man is the main culprit in creating the stress on environment and he is the one who faces the problems. It is the human beings which are the major medium to create the ability of the exposed entity i.e. human and his environment to cope or respond to the stressor, on the entity which is stressed and of which he himself is a part. It is based on these principal that this analysis and assessment is primarily human and specifically the quality of life centric.

Vulnerability assessment is a valuable tool for policy makers and practitioners. It also graphically illustrates spatial vulnerability. It shows where there is uneven capacity for preparedness and response and where resources might be used most effectively to reduce the pre-casting vulnerability. It is also a useful in identifying the response to reduce vulnerability and thus contribute to strengthen states capacity to prepare for respond to and recover from vulnerability. For assessing the vulnerability of a system various indicator components can be used based on requirement of derivation. There is hardly any set standard methodology or set of indicators which can be used to measure vulnerability. While deriving the composite of multiple quantitative indicators via some formula delivers a single numerical result is normally termed as 'Vulnerability Index'. The vulnerability index so

calculated for any system whether social, biophysical or environmental, determines the level of susceptibility of the system/ project in particular.

Important criteria, variables, approach and methodology for vulnerability studies are as follows

APPROACH AND METHODOLOGY

Assessing vulnerability with respect to environmental and social parameters has several approaches and various kinds of methodologies have been used for carrying out such studies. But, there is no standard methodology or set of indicators which can be used to measure vulnerability uniformly, neither at macro nor at micro level, globally, regionally or locally there is no set ready reckoner available to derive vulnerability levels. Empirical data analysis of environmental - social variability hardly permits to reach at a particular result at a particular time.3

While carrying out this evaluation an attempt has been made to review different methodologies used in several studies, which demonstrates a wide spectrum of vulnerability assessments with different focal groups and areas. It has been observed that the basic framework of vulnerability assessment is almost similar but the approach made is to suit the scope spread of assessment. For example the Himalayan region, where the geographic, biological diversity is quite heterogeneous in every possible term, it is found to have relevance to derive vulnerability in terms of stress and stressors.

As a normal course of action, though, the human being is one who experiences the stresses and is therefore part of the entity exposed to the stressor, it also happens to be the stressor either directly or indirectly. It is also the human being who is a major medium to create the ability of the exposed entity, i.e. it and its environs, to cope or respond to the stressor, on the entity which is stressed and of which he himself is a part. It is based on these principal that this analysis and assessment is primarily human and specifically the quality of life-centric.

It is not rational to deal at the scale of an entire state in view of the above stated fact. Even at the scale of administrative division, the variations are frequent, to which some of the administrative divisions are substantially, diverse and it is not considered appropriate that the administrative division is taken as a homogenous unit for representing the issues at one scale and level.

It is for these reasons / the smallest administrative unit / administrative sub division has been taken as the lowest denominator of spatial unit. Though even with unit as administrative sub division not sufficient to draw a conclusion at micro level, local level but in view of the limitation of availability of data base etc. it is not easy to scale down to local level. Therefore, the entire approach is based on a rational and objective assessment of the data base available, which, in-turn makes the system inter¬active and subject to up-dating, without any involvement of subjective interpretation. Subjectivity in any process carries a heavy personalized bias, which has to be assiduously avoided, and thus the approach and process has been designed to work within a rational, realistic and objective framework.

Accordingly the approach adopted / the following steps define methodology -. Vulnerability assessment:

a. Identification of variables that define the entity, the natural systems or State.

b. Identification of the variables of the stressor / or the Pressure.

c. Inter-linking the State (natural systems) variables and the Pressure variables (Infrastructural related).

d.Assessment of Vulnerability for the administrative sub division.

e. Identification of the ability / or Response variables to resist and mitigate the stress.

'Pressure' and 'State' variables together when analyzed gives a level of understanding as 'how' and 'where' a particular system is exposed and hence vulnerable at different degrees.

Pressure Variable:

Pressure variables are those which create stress on "State" i.e. natural and manmade systems. These variables are selected based on the importance and impact these variables make on the "State" and for which data /information is available for vulnerability assessment at administrative division / administrative sub division / administrative sub sub division level. Based on these attributes, different pressure variables have been identified namely Utilities & Infrastructure, Irrigation, Agriculture, Forestry, Fisheries, Tourism, Industry, Mining, Roads, Railway, Transportation, Hydel Power and Demography.

State Variables:

State variables are those which define the natural and manmade systems and which are stressed by pressure variables as described above. For the purposes of the vulnerability assessment and based on the availability of data / information at administrative division / administrative sub division administrative sub division / administrative sub sub division level, various state variables have been identified namely Water, Air, Land, Critical Habitat (Natural), Critical Habitat (Manmade, Climate Change, Hazard Susceptibility, Spatial Analysis, Quality of Life (Health) and Quality of Life (Education).

Vulnerability Index

As stated above Vulnerability index is a measure of the exposure of a population to the vulnerability on account of pressure on natural environment which determines the quality of life. The vulnerability Index is a composite of multiple quantitative indicators that via some formula, delivers a single numerical result.

The 'index' is designed to be used with economic and social vulnerability indices to provide insights into the processes that can negatively influence 'sustainable development'.

The reason for using indices for this purpose is to provide a rapid and standardized method for characterizing vulnerability in an overall sense, and identifying issues that may need to be addressed within each of the three pillars of sustainability, namely environmental, economic and social aspects of a region's development.

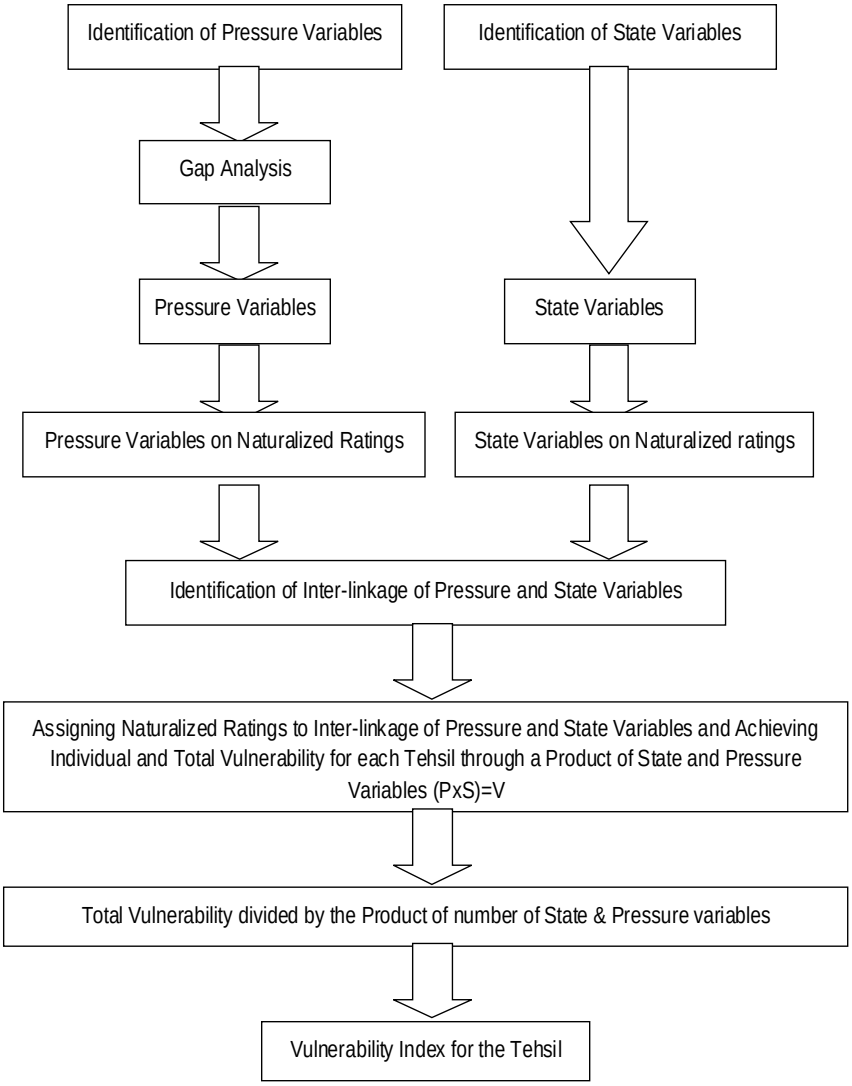
Through this study the vulnerability index has been derived for each administrative sub division is an objective number with reference to similar numbers for other administrative sub division / administrative sub sub division, it helps in prioritization on a rational basis. The brief regarding the criteria, variables, approach and methodology are as follows.

Range of Vulnerability Index

The Vulnerability Index has been categorized in various categories as under

Vulnerability Index Range	Vulnerability Index Category
Up-to 1.5	Very low vulnerability
1.51-2.5	Low vulnerability
2.51- 3.5	Moderate low vulnerability
3.51-4.5	Moderate high vulnerability
4.51-5.5	High vulnerability
>5.51	Very High Vulnerability

Flow Diagram of Steps followed for Vulnerability Assessment



METHODOLOGY

Step 1 Data base for all the variables (Pressure & State) are tabulated for all the Tehsils. These data, for each of the variables carry a value expressed in the designated units (i.e., %, lcpd, ha etc). The values are expressed as V_1, V_2 etc.

Since each value is in separate units, they have to be naturalized on the same scale and in same manner of expression

Step 2 These values are now rationalized in the following manner-

(i)For any given variable, across all the administrative sub division of the administrative division, the highest value and the lowest value is selected and designated as V_H and V_L. The highest value is assigned a rating of 10 while the lowest value is assigned a rating of 1

(ii) The intermediate values are interpolated based on the formula $V_H - V_L/9$ - Naturalization Factor = N_F

($N_{F\,state}$ or $N_{F\,Pressure}$ as the case may be)

$V_{Naturalized} = 1 + (V_{1,2,3}... - V_L) \times N_F$

(iii)Thus all the interim naturalized values for all

the Pressure and State variables for all the administrative sub division in the administrative division are tabulated. In this manner, the difference in units is eliminated

Step 3 A matrix with the State variable sectors (e.g. water, land, air, etc) on the x-axis and the Pressure variable sectors (e.g. Utilities and Infrastructure, roads, Industry etc) on the y-axis is plotted with the relationship of each sub-sector variable ascertained. Wherever a relationship exists, e.g. source of perennial water has a relationship with gap in potable water supply as the effort to bridge the gap is going to influence the perennial source of water. Or for that matter, the gap in sewerage is bound to impact the perennial source of water through pollution and thus has a relationship. Such relationship grids are assigned a value of 1 while those grids which do not display a relationship are assigned a value of 0.

Step 4 Now for each administrative sub division, the Naturalization Factor for each variable is applied in the inter-relationship matrix which has been prepared in Step 3. In the grids where an inter-relationship exists, the assigned value of 1 gets multiplied both by N_F state and NF pressure, giving a grid value of G_{vuln} for each grid. Thus, we have G_{vuln}= 1 X N_F state X N_F Pressure. The grids, which do not represent an inter-relationship, gets both the values of N_F state and N_F pressure multiplied by 0 and thus result in the Grid value of 0.

Step 5 The grid value totaled up in the row format gives the vulnerability of the sub sector. So in the Utilities & Infrastructure Sector, the grids in the row of Gaps in potable water supply give a total vulnerability of the gaps in potable water, $V_{U\&I(Pot.wat)}$. Similarly, the total vulnerability scores for other variables such as gaps in sewerage $V_{U\&I(Sewerage,)}$, and gaps in solid waste collection $V_{U\&I(Solid\ waste)}$, are determined. The sum total of all the vulnerability scores in the Utilities & Infrastructure sector gives the sum total score of vulnerability in the sector as $V_{U\&I}$. Similar exercise is carried out for all the sub-sector variables in all the Pressure Sectors. This Results in $\Sigma V_{pressure\ sectors}$, a sum total of all the vulnerability scores in the Pressure Sector.

Step 6 Similar exercises are carried out for the State Sectors also, the difference being that in place of rows, the sum total is arrived at in columns. This results in various sub sector vulnerability scores and the sectoral vulnerability score a sum total of which is $\Sigma V_{state\ sectors}$, a sum total of all the vulnerability scores in the State Sector.

Step 7 To arrive at the Vulnerability Index the formula that is used is $\Sigma V_{pressure\ sectors}$ X $V_{state\ Sectors}$ / Total no. of State variables X total no. of variables

Step 8 In this manner Vulnerability Index for each administrative sub division is determined' and tabulated administrative division wise

Step 9 In order to calculate the Vulnerability Index of each sector, the Sum total of the Sector, such as $V_{U\&I}$ or V_{water} is divided by the no. of variables in the State or Pressure themes.

With this methodology the Vulnerability Index at the administrative sub division Level and at the Sector Level is determined.

CONCLUSIONS:

From the studies it can be inferred that vulnerability assessment using vulnerability indices is a valuable tool for policy makers and practitioners. Spatial vulnerability can also be graphically evaluated, which in turn indicates where there is uneven capacity for preparedness and the response, where the resources can be effectively utilized to reduce the pre-casting vulnerability, etc.

This study also helps in curtailing the wasteful use of resources and predicting vulnerability of the states' capacity thus contributing to the environmental safety. Vulnerability assessment using vulnerability indices should thus be utilized for almost all environment impact studies

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