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Lecture Notes

Part 1

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DEVELOPING VULNERABILITY INDICES - THE ART OF ENCAPSULING THE OBVIOUS

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Introduction

Climate change is accepted as a global reality beyond debate. It is expected to bring drastic changes in the natural cycles in the biosphere and human societies. Though the magnitude of the changes and their impacts in different parts of the globe are still discussed, the direction of changes is more or less understood as irreversible. While there is a high degree of uncertainty in the temporal and spatial manifestations of the impact of climate change, the rate of manifestation is perhaps getting quicker than expected. The inescapable calamities that climate change can bring are identified as major global threat to humanity. The world community has rightly started appreciating measures for remediation of climate change impacts as a mission towards world peace.

Sensing the Reality

While expecting the unavoidable, a rational approach is to take necessary steps to prepare human societies to face the future shocks. Understanding the impacts of climate change and vulnerability of human populations in different regions is a basic prerequisite for planning the future course of action. While the impact on agriculture and food production and consequent threat on food security are important at global level, livelihood will be a major issue in the context of marine fisheries.

Studies on climate change impacts and vulnerability of social and ecological systems perhaps have begun with the seminal work of Timmerman (1981) who provided intellectual underpinning for linking the concepts of vulnerability, resilience, and climate change. Subsequently Intergovernmental Panel on Climate Change (IPCC), particularly the contribution of Working Group II to the Third Scientific Assessment (IPCC 2001b), and the Assessments of Impacts of and Adaptation to Climate Change in Multiple Regions and Sectors (AIACC) implemented by the United Nations Environment Programme (UNEP) had incorporated and elaborated these perspectives. There are a few studies which focused on the coastal ago-climatic zone in India which are prone to the immediate impact of climate change- the increasing frequency of extreme events (Kumar, 2003; Patnaik and Narayanan, 2005). There are some documents outlining threat to fisheries and aquaculture in general (Worldfish, 2006) and some specific regions (Mahon, 2002). Except for the preliminary attempt by Vijayakumaran (2007), vulnerability analysis of marine fisheries is lacking in India.

This article first explains why we need indicators and proceed to dwell upon the concept of vulnerability. Next, the dimensions and variables contributing to vulnerability are examined before discussing the approaches and methods of developing vulnerability indices with suitable examples.

Why Indices?

When we are confronting a complex entity or phenomena such as a market or population or an ecosystem with countless number of variables, we have a complex research problem. We may raise questions and go about searching the important variables that, we believe, at least partially, if not fully, explains (within the frame) the phenomena we are interested in. We measure them over a convenient temporal and spatial frame (sampling design) and generate voluminous data.

Since it is maddening to deal with voluminous data, we use an array of methods for summarizing and interpreting the information. Still we have brains that refuse to strain in understanding these summaries. Without challenging the fundamental right of anybody to stay in their comfort zone, our statisticians have

invented some methods to condense the information into a simple numbers called indices. So we could put voluminous information in a nut shell making our life easy. Thus indices are simple numbers derived out of the complex data pertaining to a population, indicating some state or change of state. So we have consumer price index to tell what percentage increase should be made on our dearness allowances. We also have human development index that tell us how far our country is behind Sri Lanka in human development. For those who would like to have a definition, Barbara Canton gives a comprehensive one:

"*An index relates the value of a variable (or group of variables) to a base level, which is often the value on a particular date. The base level is set so that the index produces numbers that are easy to understand and compare. Indices are used to report on a wide variety of variables, including prices and wages, ultraviolet levels in sunlight, and even the readability of textbooks*."

The terms 'indices' and 'indicators' are often used as synonyms, at least functionally. While indices have direct bearing on variables, indicators may often give indirect clue of certain processes or state of affairs. They may be simply a variable or a sum(mary) of variables or, a derivative of set of variables. Often indices are used as indicators (consumer price index is used as an indicator for inflation). In an extreme case we have an *Index of leading Indicators* (in the USA) which incorporates ten economic indicators to predict recession or expansion of the economy. To simplify, both indicators and indices serve the purpose of giving an indication of the state of affairs of an entity.

Understanding Vulnerability

Vulnerability is a condition of exposure and sensitivity to stress or shocks (Devereux, 2002). Some authors have emphasised the internal ability or lack thereof to cope, recover and adapt to such stress (Kasperson et al., 2000). The concepts, which underpin vulnerability analysis, are often contested and not clearly defined. In the context of climate change, the IPCC has developed working definitions of key terms and outlined the relationship between them. Vulnerability is the extent to which climate change may damage or harm a system; it depends not only on a system's sensitivity, but also its ability to adapt to new climatic conditions (IPCC, 2001). In the social realm vulnerability can be defined as the exposure of groups or individuals to stress as a result of climate variability and change. It complements notions of physical vulnerability to the impacts of natural hazards that concentrate on the physical dimensions of risk. Vulnerability is therefore made up of a number of components including exposure and sensitivity to hazard and the capacity to adapt:

Vulnerability = f (exposure, sensitivity, adaptive capacity)

There are two main approaches to vulnerability analysis. The first one involves specific measurement of key parameters of vulnerability with a view to specified interventions, aiming at food security and disaster reduction. The second approach seeks broader indicators, often using proxy variables, to create profiles of vulnerable situations or syndromes, spatial maps of vulnerability or national comparisons of vulnerability. Both of these approaches to vulnerability rely on underlying concepts of what constitutes vulnerability and both recognize that vulnerability is a state that cannot be directly observed – it is a relative concept underpinned by values of social and physical risks.

Dimensions and Variables

We go ahead reiterating the premise that vulnerability is an anthropocentric concept. Even if the impact of climate change is severe on the ecosystem, we speak about vulnerability with reference to the human component. Thus in the context of marine fisheries, coastal fishermen obviously occupy the focal point in our study. Now let us examine what makes them vulnerable.

Of the major impacts of climate change projected in marine fisheries, sea-level raise and consequent changes in habitat, frequency of extreme events, variability in the catch and revenue are the most important (Vivekanandan, 2006). We can identify a number of broad areas or dimensions such as physical, demographic,

resource and exploitation, technology and market, health and welfare etc., where the fishermen are particularly vulnerable. Then we delineate all variables that contribute to the vulnerability of fishermen, under each dimension. Now we may examine the variables to identify the measurable and non-measurable. We look for some proxy variables which can be substituted for the variable we cannot measure. Then we search for suitable models to transform the information to some simple index of the right property to suit our requirement. Then apply the model to the data. The matter seems quite simple isn't it?

But it is not as simple as it seems, especially in the marine fisheries context. Fish catch being the prime input in the study of economics of fisheries, the economic impact of climate change could be assessed only with the accurate information on quantitative and qualitative changes in the catch that different climate scenarios could cause. The currently available information is not amenable for translation into quantities or values and so it is not useful for any empirical treatment. Further the physical features of the coastal zone and characteristics of the fishermen population and their socio-political and natural resource endowments are so diverse that assessing those factors to build a comprehensive vulnerability profile is a gigantic task. As direct assessment of a multitude of variables contributing to the vulnerability is not possible most of the studies on vulnerability indices have considered proxy variable for analysis. We shall examine two examples below to understand the method of building vulnerability indices.

Coastal Vulnerability Index

Kumar (2003) constructed a coastal vulnerability index by hypothesizing vulnerability as a function of impact on the district and the resistance and resilience of the district in responding to the impact it experiences. He used district specific data on the following broad areas:

Demographic (population density, annual population growth rate, population at risk due to sea-level raise), *Physical* (Coast length, insularity, frequency of cyclones, probable maximum surge height, area at risk or inundation due to sea level raise, vulnerable houses etc.), *Economic* (Agricultural dependency, income and/or infrastructure index etc.) and *Social* (Literacy, spread of Institutional set up etc.)

Composite indices were calculated by taking average of all the standardized observations of each district over all the components. The averaging procedure implies that equal weights are assigned to each component. The procedure is similar to that followed in the construction of human development index by the United Nations Development Programme (UNDP). He constructed eight different indices using different components as listed below:

V1 = Insularity, Population density, Population growth, Population in agriculture, Literate Population, Vulnerable houses (Total), Probable Max surge height and Cyclone frequency

V2 = Insularity, Population density, Population growth, Population in agriculture, Literate Population, Vulnerable houses (Destroyed), Probable Max surge height and Cyclone frequency

V3 = Insularity, Population density, Population growth, Population in agriculture, Literate Population, Vulnerable houses (Damaged), Probable Max surge height and Cyclone frequency

V4 = **V1** + Income as Vulnerability Indicator

V5 = **V1** + Income as Resilience Indicator

V6 = **V1** - Insularity + Area Affected

V7 = **V6** + Income as Vulnerability Indicator

V8 = **V6** + Income as Resilience Indicator

These indices were used for comparison of coastal districts and for preparing maps.

Vulnerability of Fishing Communities

In another study by Vijayakumaran (2007), approximate direct scores were made for 39 factors under seven dimensions based on the information obtained from the villages. Vulnerability was assessed under the different dimensions of habitat, infrastructure, demographic, livelihood, health institutional and social structure etc. A seven-point scale was used for scoring the relative vulnerability on various parameters as well as adaptive capacity of fishing villages. A factor contributing least to the vulnerability is assigned score 1 and a factor which contributes most to vulnerability is given a score of 7. The sores were subjected further analysis for constructing the relative vulnerability profiles of different villages adopting a slightly modifying the model used by Patnaik and Narayanan (2005) as given below:

At the first stage, a relative factor index for each of the factors and each village was calculated using the formula:

Relative Index of j^{th} factor for i^{th} village

I_{ji} = (Actual X_{ji}-Min X_j)/ (Max X_j –Min X_j)

Further a dimension index for each village was calculated by taking the average of the relative factor indices for factors under each of the *k* dimension for each village.

Dimension Index, D_{ki} = Average I_{ji}

Finally the vulnerability index for each village V_i is calculated by the formula:

$V_i = [(\eth (D_{ki})^{á}_{k}]^{1/Ó á}_{k}$

Where á = the number of factors in a given dimension of vulnerability.

Concluding Remarks

It should be noted that no single method is capable of generating an ideal index for vulnerability. We often make the best possible attempt with the available resources. So an imaginative researcher can always come up with a better model and better index which would capture more features of the population and reflect the situation better. There is tremendous scope for researchers to work on the area of indices and indicators. The objective is to help the planners to allocate scarce resources for adaptive measures on a priority basis. The priority has to be decided based on the relative condition of vulnerability of a community or place.

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