APPROACHES TO VULNERABILITY TO CLIMATE CHANGE

by

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Abstract

Vulnerability to the impacts of future climate change remains a critical issue in the interaction of society with global environmental change. While adaptation to evolving climate patterns can and does occur, sections of society already vulnerable to present climate variability could find this vulnerability exacerbated by the changing incidence of extreme climate events such as droughts and floods. Present approaches to vulnerability to climate change focus on the physical aspects of such vulnerability, such as land areas lost or threats to agricultural production. This study, by contrast, focuses on social vulnerability. Theoretical approaches to the causation of famines, and to the impacts of natural hazards on society are reviewed, concluding that the approaches underlying those analyses are useful in identifying quantitative indicators of social vulnerability, akin to the entitlements theory of famine causation. However, the famine literature overemphasises the strategies for coping when hazards are slow in onset, such as with droughts, and can be adapted to, for example by farmers through changing agricultural practices. Potential climate related hazards, from tidal waves to floods, storms and droughts, display a diversity of physical characteristics, classified in the wider literature on the social aspects of natural hazards.

This paper argues that social vulnerability to climate variability is the key dimension in the constitution of vulnerability, and that this parameter shifts emphasis onto the underlying rather than the proximate causes of vulnerability. It is suggested that the aspects of *individual* and *collective* vulnerability are distinct. They encompass relative poverty and deprivation as well as informal social security at the individual level; and infrastructure, the role of the state and policy intervention at the collective level. Vulnerability to climate change encompasses changes in individual and collective vulnerability over time associated with the changing incidence of extreme events. These hypotheses are illustrated by a preview of research results from a case study employing this framework in northern Vietnam. The results show that social and economic change in Vietnam exacerbates some aspects of vulnerability, while offsetting these by other mechanisms. The relevant indicators include levels of poverty, levels of inequality and institutional analysis.

The policy prescriptions stemming from the framework outlined necessarily address underlying causes in order to reduce vulnerability. Policies relevant to the reduction of social vulnerability to climate variability support the capacity of vulnerable groups to maintain resources, and the capacity to invest in maintenance of these resources in the long run. Further, both formal government and informal social security are relevant to this process.

1. Introduction

The purpose of this paper is to examine the concept of vulnerability to climate change, and hence to set parameters for the study of this phenomenon in coastal Vietnam, the subject of subsequent papers. From a social science perspective, it is people who are vulnerable to climate change, and it is institutions, economies and societies which adapt and respond to present day risks from *climate variability* and to *future changes in climate*.

These two factors, present climate variability and uncertainty over future climate, strengthen the need for understanding of the process of vulnerability. Those who are skeptical concerning the significance of future climate change emphasise the uncertainty in climate change scenarios, and particularly in specific projections of extreme events. They also highlight the ability of societies to adapt to changing climates in the past. Hence they argue that global warming is not critical because necessary adaptation can occur if and when it becomes necessary. Beckerman (1995) for example, argues that adaptation to climate change has occurred in the past through human migration. Referring to observed voluntary migration for example, to the southern 'sunbelt' states of the US, he points out that 'global warming could mean that future generations would not have to go to all the trouble [of migrating]' (p91). Beckerman also argues that postponing pre-cautionary action does not jeopardise the ability to cope with future potential rates of warming: delaying action for a decade means that 'we would all have plenty of time to change into lighter shirts' (p100). In this line of reasoning potential rates of future climate change pose no significant problems.

Yet this emphasis is on those sections of the population who would wish to migrate, or have lighter shirts to change into. A large proportion of the world's populations are presently vulnerable to disruption of their livelihoods through their insecure socio-economic situations, exacerbated through extreme climate events. There is growing evidence that such climatic events will become more frequent over time. Further, the economic *impacts* of climate related and other hazards are becoming greater over time, even without change in the incidence of the hazards. The human interaction with the uncertain natural environment is complex, with many paradigms competing to explain observed phenomena. Alternative conceptions of the causes of vulnerability include the reinforcement of marginalisation and vulnerability of poverty stricken groups; institutional and economic factors influencing greater economic activity in hazardous areas; and the coevolution of climate and the natural environment with social phenomena.

This paper first examines current approaches to the issue of vulnerability to climate change highlighting the discrepancies in attempting to incorporate social

aspects of the phenomenon into predominantly physical science approaches. But, as pointed out in the literature on global environmental change in general, the impacts of climate change become significant when they impact on human society and well-being. This is the justification for the explicit examination of social vulnerability to climate change in the present study.

The following sections of the paper examine the research issues and underlying paradigms in the examination of social vulnerability to famine, and social vulnerability to natural hazards. These are relevant issues in this context not only because of the climatic and other physical environment elements sometimes present in these phenomena, but because they illustrate the paradigms which attempt to explain social vulnerability in these contexts. Given the potential wide-ranging impacts of climate change, the natural hazards research offers greater insights as it considers phenomena which are slow and fast onset, long and short duration and other characteristics.

The paper then sets out the basis for developing a theory of social vulnerability to climate change, and illustrates these with a preview of vulnerability indicators for a case study in rural northern Vietnam. The paper concludes that social vulnerability is an important concept in examining the future planned and unanticipated adaptation to climate change, and suggests a number of indicators for further elaboration.

2. Theoretical Approaches

Within the natural sciences, the disciplines concerned with risk and vulnerability to environmental change have generally taken resources such as land or economic assets, as the object of their analysis, and topographical or climatic factors determinants of whether the assets are subject to risk. These approaches are inherent in the IPCC methodologies for examining vulnerability and adaptation to climate change. This section reviews these approaches, and demonstrates that bolting social science analysis onto this model results in a mechanistic approach leading to policy prescriptions which uniformly protect physical areas, rather than policy which incorporates variability in social, economic and cultural constraints and opportunities.

The major subject of this study, is the phenomenon of social vulnerability. Social vulnerability is defined as exposure of groups or individuals to stresses both from exogenous risks, in this case from climate change, and from their social and economic situation. This definition relates to that of Chambers (1989), on vulnerability of social groups to famine. The disciplines of economics, geography and anthropology have attempted to examine various aspects of social vulnerability, often in the context of vulnerability to famine, which is popularly perceived to involve death and destitution on a large scale. While some famines can be triggered by extreme climate events, such as drought or flood, it has recently been recognised that this is a narrow view and that famines are much more often caused by disease, war or other factors (Chambers, 1989; Swift, 1989 and others). The literature on vulnerability to famine and food insecurity is reviewed, focusing on hypotheses based on entitlements, coping strategies, and political economy critiques of these approaches.

As one moves away from the narrow focus of famines related to food production failures into the role of markets and institutions, the explanation of how households cope with crises and adapt to changing circumstances and environments begins to include consideration of reciprocal arrangements between groups and households. These arrangements include the claims that households can make on each other, on the state, and on kin in time of crisis. It is thus postulated that informal insurance against risk forms part of collective security in many societies, but that these arrangements are in decline due to increased intervention by formal government; by increased commercialisation of economic activities; particularly agricultural activities, and by population pressure in particular areas. Evidence for a so-called ‘moral economy’ (after Scott, 1976) is cited as an often ‘hidden’ strategy to reduce vulnerability for many groups where they are particularly vulnerable. Research on these issues, however, has tended to focus on African and Asian ‘pre-capitalist’ societies.

Vulnerability to famine has been explained as a set of linked economic and institutional factors, within an entitlement framework. Entitlements are the actual or potential resources available to individuals based on their own production, assets or reciprocal arrangements. Coping strategies are the sequential actions taken by people when faced by a crisis of food production or exchange failures, and tend to include practices such as selling non-productive assets and use of commons resources (such as collecting non-domesticated foods); selling productive assets such as capital or land; and migration. The major problems identified with both the concepts of entitlements and of coping strategies are the lack of historical perspective in their analysis: each crisis or extreme event is considered in isolation from the previous (see Bohle, 1993 for example). Further, the entitlements approach does not consider scales other than the household: it has been observed that some parts of a community benefit from floods or droughts, and that within households individuals have differential vulnerability and impacts. However, the insight of the entitlement approach is its focus on the risk minimising strategies which individuals or groups appear to adopt in many circumstances. This is discussed further in the following sections.

Box 1: Definition of Terms

Adaptation

Social and physical systems react to climate change through adaptation. These reactions may be involuntary spontaneous changes or can be deliberate adaptive strategies (following Carter et al., 1995). In analysing social impacts of climate change, it is important to consider both 'spontaneous' impacts, through observation of household or individual behavior when faced with present climate variability or future climate change; and those adaptation actions which occur through planned policy intervention by collective action, principally through some level of local or national government from local to national. The observation of adaptation through primary or secondary sources of information is the aim of *positive* socio-economic analysis. The integration of policy recommendations into impact analysis, leads the analysis (such as that of welfare economics) into the *normative* mode. Making recommendations as to what should be done in adaptation to climate change inevitably involves the normative judgment that individuals should bear the cost or enjoy the benefits of such adaptation within the existing distribution of income and wealth.

Physical vulnerability

Physical vulnerability to climate change suggests that biophysical impacts of climate change will occur through various mechanisms, and that this will have significant influence on the future viability or integrity of the physical resource. Thus, agricultural production is vulnerable to climate change if climatic parameters such as temperature or precipitation cause significant negative impacts on yields (it is assumed that vulnerability is applicable where the impacts are negative). For natural ecosystems, vulnerability can occur when individuals or communities of species are stressed, and where thresholds of potentially irreversible changes are breached through climatic changes.

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Social vulnerability to climate change
Social vulnerability is the exposure of groups of people or individuals to stress as a result of the impacts of climate change. Stress in the social sense encompasses disruption to groups' or individuals' livelihoods and forced adaptation to the changing physical environment. Social vulnerability in general encompasses disruption to livelihoods and loss of security. For vulnerable groups it is often pervasive and related to the underlying economic and social situation, both of lack of income and resources, but also to war, civil strife and other factors (see Chambers, 1989). Social vulnerability to climate change and other causes of vulnerability (termed baseline vulnerability by Watts and Bohle (1993)) are not easily separable, and analysis of the interactions is a key research issue.

IPCC Common Methodology
This is a methodological approach suggested to assess vulnerability to the impacts of sea level rise in coastal zones at the national level, attempting to encompass indicators of physical vulnerability, and social vulnerability. The approach uses principally physical indicators to determine normative strategies, stylised as 'retreat', 'accommodate' and 'protect' (see IPCC, 1994).

Mitigation
This is the prevention of the effects of climate change through reduction of greenhouse gas emissions to the atmosphere or increasing net terrestrial or oceanic sinks. Mitigation is not considered as being synonymous with adaptation (see definition) in this paper. Rather the future climate change is assumed to be exogenous to local resource use or emissions, despite this being an important policy issue at other levels of analysis.

In economic terms, vulnerability has many potential costs, not least in foregone potential economic development. In neo-classical economics, risk aversion deviates behaviour of economic agents away from profit or welfare maximisation and hence to less desirable states. Both potential threat of extreme events and coping strategies when such events do occur (Swift, 1993; Corbett, 1988), have been postulated to result in risk minimisation strategies, which have positive and significant costs. Thus the uncertainty of climate variation may have an economic cost in terms of resource sub-optional allocation. The sections below review the evidence for this concluding that the economic model of entitlements and risk aversion does help in explaining economic behaviour, given the cultural and institutional context.

Both the analysis of proximate and underlying causes of famine, and the policy prescriptions resulting from this analysis, focus almost exclusively on drought as the climate variable causing production failure through crop or livestock loss. However, many climate related threats are not slow-onset events, and do not necessarily have impacts across significant geographical areas. Flooding in coastal zones associated

with tropical storms is invariably seasonal and usually short lived, yet can have significant unexpected impacts, and is a threat to which many people are vulnerable.

Many insights on vulnerability to changes in the incidence of extreme events can be gleaned from examining wider perspectives on natural hazards, from which famines as a result of drought is a small subset. Section 4 reviews this literature, starting with the hypotheses of Burton et al. (1993), that hazards are essentially mediated by institutional structures, and that increased economic activity does not necessarily reduce vulnerability to impacts of hazards in general. Vulnerability to natural hazards has been explained by technical and institutional factors, but underlying these explanations are theories explaining the differential vulnerability of different groups, and on the role of economic development in adapting to changing exogenous risk. Thus, differences in class structure and economic dependency have been used to explain the differential impacts of hazards (Hewitt, 1983a; O'Keefe et al., 1976), as a radical critique of the institutional and managerial approaches (Hewitt, 1983b, pp 5-9).

In reviewing this diverse literature on physical approaches to vulnerability to climate change; on economic approaches to social vulnerability to famines, and their critiques; and on diverse approaches to natural hazards widely defined, it appears that the terms vulnerability and adaptation are widely used, but with little consistency. The meaning of the term vulnerability is dependent on the particular hazard or threat being examined. It is necessary therefore, when considering a research agenda for social vulnerability, and adaptation to climate change, to define terms consistently in this study. It is necessary to distinguish between vulnerability to extreme climate events, which involves both coping strategies; and adaptation to long term trends in environmental resources due to climate change. An initial glossary of terms is given in Box 1 to clarify at the outset the working definitions used in this study.

3. Current Approaches to Vulnerability Analysis

3.1 Approaches to physical vulnerability

Analysis of vulnerability to the impacts of climate change is dominated by a view of risk which attaches vulnerability to physical assets. Such vulnerability is measured or quantified by reference to physical indicators, such as return period of storms or floods or length and severity of drought. Where social indicators of future climate change are used, this is usually reduced to estimates of numbers of people potentially impacted, or economic variables such as the capital value of economic assets at risk from impacts such as sea level rise. In many cases, the costs of replacement of assets or of abatement or protection are taken as indicators of vulnerability, where these can only be loose proxies, to the underlying phenomenon, if related at all. This section reviews current assessments of vulnerability to climate change impacts, from the global to local scales (Watson et al., 1966; Bijlsma et al., 1996), focusing as an example on IPCC documents on guidelines for assessment and on coastal zone impacts. It argues that the concentration on physical parameters of vulnerability lead to an inordinate focus on technological or top-down technocratic policy prescriptions in adaptation.

The main IPCC Impacts, Adaptation and Mitigation working group Summary Report, states that:

> 'Vulnerability defines the extent to which climate change may damage or harm a system. It depends not only on a system's sensitivity but also on its ability to adapt to new climatic conditions' (Watson et al., 1996).

The emphasis in this definition on systems implies that both socio-economic and natural systems are important subjects of analysis. Within the assessment, the vulnerability of agricultural production, of forests, of other natural habitats, of the global economy and the global food system are all addressed. One particular part of the assessment, on coastal zones and small islands, is focused on here.

Building on a 'technocratic' view of vulnerability in the Common Methodology (IPCC CZMS, 1992), the 1995 second assessment report (Bijlsma et al., 1996) attempts to synthesise the social and physical approaches by adapting an ecological-economic perspective:

> 'Although potential impacts of climate change by itself may not always be the largest threat to *natural coastal systems*, in conjunction with other stresses they can become a serious issue for *coastal societies*, particularly in those

places where the resilience of natural coastal systems has been reduced' (Bijlsma et al., 1996, emphasis in original).

However, this reference to social vulnerability is highlighted as more of a research need, than followed through in actual assessment. To understand vulnerability, and particularly the *causation* of vulnerability it is necessary to start from the 'other end' by taking social vulnerability as a starting point and examining the influence of changes in the physical environment on society.

Hewitt (1983b) picks out features of the dominant technocratic view in natural hazards research which are common to all hazards from geotechnical to climate related. The features of the 'dominant view', from both the social and natural scientists involved, are:

- acceptance of the physical processes as the *cause* of environmental risk; and

- incorporation of a technocratic risk assessment approach to the human dimensions of these phenomena.

The policy interventions stemming from risk assessment inevitably focus on the physical risk, such as greater geophysical monitoring; building flood defence, earthquake proofing or other infrastructure; land use planning in relation to natural agents; and planning for relief and rehabilitation.

So although social scientists have been involved in research on natural hazards and disasters for decades, the 'institutional' focus still leads to an approach to human dimensions of hazards leading to technocratic and bureaucratic prescriptions. The perceived chain of causality between exogenous environmental risk and the human impacts of hazards has also by and large entered the lexicon of recent assessments of the specific risks associated with future climate change.

This evolution of research ideology has been noted by Turner et al. (1991) in the general field of global environmental change, and climatic change in particular. They characterise the risks posed by global environmental change as being principally perceived as external. But Turner and colleagues hypothesise that *over the last two decades* the research of political theorists and anthropologists (as espoused in the collection by Hewitt (1983a)) has been accepted and incorporated. These critiques of the technocratic approach, as discussed in detail below, focus on the distribution of risks in society and visualise these risks as being 'dependent on whether people were able to control the environmental conditions of their existence' (Turner et al., 1991, p402). However, as we now turn to the approaches to climate change impacts inherent in the outputs of the IPCC, the appraisal of Turner and colleagues can be

shown to be over-optimistic in their assessment of the acceptance of social vulnerability by the scientific community. In fact these views have been largely ignored in the many recent vulnerability assessments. Attempts at defining and measuring indicators of vulnerability to the various impacts of climate change and guidelines for the assessment of climate change impacts are now reviewed.

3.2 Food security and climate change and sea level rise indicators

In the light of the discussion above, indicators and assessments of vulnerability to sea level rise follow the convention of adopting an essentially physical approach to the objects of analysis. These assessments of physical vulnerability to sea level rise are shown to bear little correlation to social indicators, such as those of vulnerability to hunger or famine. This is illustrated by comparing indices of vulnerability to these phenomena undertaken independently. This section compares national level food security to national level sea level rise threat for selected countries. At a national level, vulnerability to future climate change has been defined by Downing (1992) using the proxy of a national level food security index (FSI) and assessing the impact on this index of a) climatic changes on threatened economic assets in coastal zones and b) of potential impacts of temperature and precipitation changes on agricultural production. The baseline food security index is an index of components of:

national food shortage (food availability per capita);
household food poverty (GNP per capita);
individual food deprivation (childhood mortality per 1000).

The Food Security Index (FSI) is calculated as:

$$FSI_k = \frac{\sum_{j=1}^{3} \frac{I_{j,k} - \overline{I_j}}{SD_j}}{3}$$

where FSI_k is the FSI for country k
$I_{j,k}$ is the nominal value of indicator j for country k
$\overline{I_j}$ is the mean value of indicator j for all countries
SD_j is the standard deviation of indicator j for all countries.

The food security index is estimated by Downing (1992) from historical data published by UN agencies; the potential impacts of temperature and precipitation change are projections from climate models; and for potential impacts of sea level rise, are subjective assessments of potential threat.

The interactions of national food security and temperature and precipitation changes show significant numbers of people in vulnerable zones. The indicator of agricultural productivity used has two classes of agricultural crop yield change: moderate (with maximum yield decreases of 20 percent) and severe (maximum yield decreases of 30 to 50 percent). The yield estimates are based on crop model results taking CO_2 enrichment, temperature and precipitation changes for a number of crops (see Rosenzweig et al., 1993). The results show that over 2 billion people live in countries that may be subject to high decreases in potential yield. Other analysis of the impacts of temperature and precipitation change (incorporating elevated CO_2 and its impact on plant growth) on world agriculture in the same project (Fischer et al., 1994; Rosenzweig and Parry, 1994) show that, depending on the degree of agricultural adaptation to changes in crop yield and the impacts of CO_2 fertilisation, that the number of people at risk from hunger may increase by over 300 million over the next half century, compared to the base case.

The indicator of hunger used in these studies by Rosenzweig and colleagues is different to that of Downing (1992), being a composite of food availability relative to nutritional requirements, dependent on price of food and income levels. At this global scale, and at the decadal time scale used, the estimates of the number of people at increased risk of food security are also extremely sensitive to the details of the global climate model results. Some commentators (Chen and Kates, 1994) postulate much lower levels of risk from hunger, possibly 100 million people by 2060, only one *tenth* of the levels projected by the modelling exercise. This downgrading of the estimates is based on the observation that institutional and market factors are the key determinants of food insecurity. In some senses these differentials in orders of magnitude estimates of the impact of climate change on food security between 'macro' modellers and expert judgement, reveals a weakness in the scale and resolution of the issues examined. The global food security modelling results have been critically examined and criticised in detail for representativeness, aggregation issues (Homewood, 1995) and the sensitivity of assumptions concerning CO_2 fertilisation (Pittock 1995). But the central issue of such global assessments, as discussed in relation to the vulnerability assessment of sea level rise, is whether top down modelling can incorporate the aggregation of individual decision-making in a realistic way, so that results of the modelling are applicable and policy relevant (see Homewood 1995). In analysing the impacts of future climate change, the incorporation of global scenarios into one sector or into a geographic region is one of the key barriers to progress in climate impact studies (see Warrick 1993 on coastal issues; Raper 1993 on severe storms).

Global assessments of the interactions of the food security index (FSI) with *sea level rise* by Downing (1992), are more arbitrary than the assessment of changes in

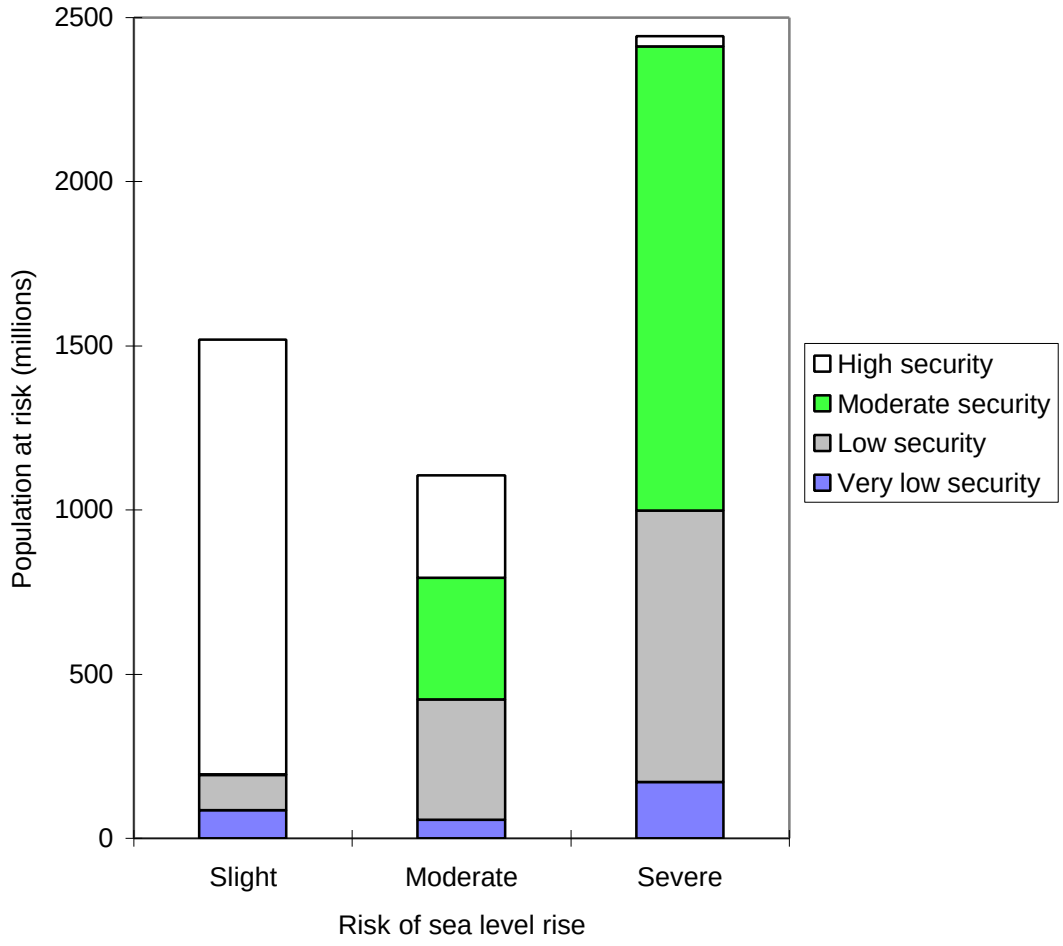
agriculture. The classifications for sea level rise threat are based on economic activity in the coastal zone:

slight (little or no coast or a wealthy economy)
moderate (substantial coastal investment at risk)
severe (sea level rise threatens national economy).

The results of this national level assessment of vulnerability to hunger show that:

(a) 1.6 billion people reside in countries which have low food security (as defined by the FSI);
(b) that 2.4 billion people live in countries vulnerable to sea level rise; and
(c) over 2 billion people live in countries that may be subject to high decreases in potential yield (Downing, 1992).

Figure 1: Assessment of populations in countries at risk from sea level rise, by category of national food security (after Downing, 1992).



For the sea level rise threat for the 172 countries assessed, the results in Figure 1 show that of the 2.4 billion people who live in countries vulnerable to sea level rise, over 1 billion of these live in countries which have low or very low food security. It should be stressed that this does not mean that one billion people would be directly affected by sea level rise, but that this number of people live in those countries. Thus, some large coastal countries have threatened populations, but they also have inland populations. The other threatened areas are small and low lying islands where the whole population may be threatened. Nevertheless, the severe sea level rise threat has been defined as those countries where sea level rise threatens the national economy, and hence the populations are likely to be impacted, even if indirectly so.

3.3 Studies of sea level rise threat

The analysis of Downing (1992) is dependent on the definition of the sea level rise threat. A more robust definition of the threat of sea level rise has been provided by the Global Vulnerability Assessment studies, reviewed by the IPCC (1994) (also Bijlsma et al., 1996). These quantify a number of national level indicators of impacts of 1 metre sea level rise on almost 50 case study countries, results for 22 countries being available in the 1994 report of IPCC Coastal Zone Management Sub Group (IPCC, 1994). These case studies apply the Common Methodology developed by IPCC's Coastal Zone Management Sub Group (first detailed in IPCC CZMS, 1992), which involves a seven step process for case study assessment of sea level rise. The principal objectives of the Common Methodology include:

> 'to identify and assess physical, ecological and socio-economic vulnerabilities to accelerated sea level rise and other impacts of global change on coastal zones;
>
> to understand how development and other socio-economic factors affect vulnerability.' (IPCC, 1994 p.6).

Thus the approach attempts to assess 'vulnerabilities' comprehensively across the physical and social domains. The case studies, however, based on scenarios of 1 metre sea level rise in 100 years, assess these vulnerabilities through simple indicators of risk and exposure to the impacts of sea level rise, without attempting to define vulnerability itself. The diagrammatic representation of the Common Methodology presented in Figure 2 illustrates that socio-economic variables are in fact used in delineation of spatial scale of the case study (Step 2) and as inputs into the scenarios of future state of coastal zones (Step 3).

Yet the vulnerability assessment (Step 4) is defined in relation to the physical parameters and proximate causes of environmental change, rather than social

vulnerability (such as the food security of the case study area, the distribution of wealth and income or other social phenomena). The social costs and benefits of physical changes and responses are brought back into the analysis at Step 5, on formulating response. However, the crux of the Common Methodology is in defining the risk to social and natural systems based on changes in natural parameters.

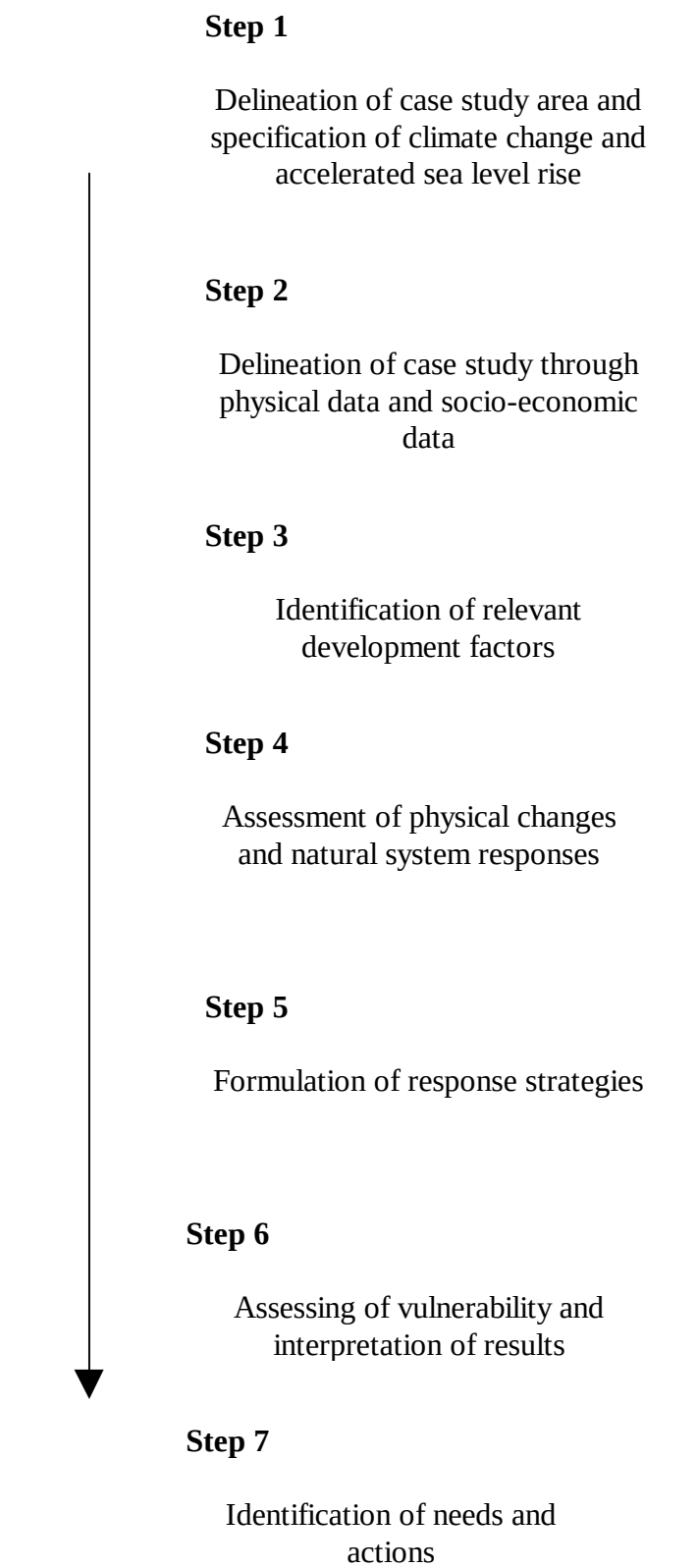
The further objectives of the Common Methodology are:

> 'to clarify how possible responses can mitigate vulnerability;
>
> and to evaluate a country's capacity for implementing a response within an integrated coastal zone management framework' (IPCC, 1994).

These illustrate that it is only in the response stage, on the resource costs of adapting, retreating or protecting the physical assets from sea level rise, that social variables are important to the analysis. The case studies proceed by defining the indicators of risk from impacts of sea level rise, and the results presented in Table 1 show these indicators for the 22 case study national assessments where a range of indicators has been estimated. Other case studies were at the sub-national scale, and only some followed the methodology through to assess policy responses. The main indicators quantified are:

Population affected	number of people area subject to erosion or flooding with a 1 metre sea level rise.
Population at risk	population affected * probability of flooding. A statistical estimate of numbers experiencing flooding, taken on an annual basis.
Capital value at loss	Capital value of dry land and infrastructure permanently lost through erosion or inundation, as percentage of GNP. The case studies use various methods (present value, replacement cost and others.) for estimating capital losses, though these may not strictly be comparable.
Area of land lost	Area of land (as percentage of total area) permanently lost by inundation or erosion by a 1 m sea level rise.
Wetland loss	Natural areas of coastal wetlands lost or dramatically changed by 1 m sea level rise.

Figure 2: IPCC Common Methodology for Assessment of Vulnerability to Sea Level Rise.



Source: IPCC (1994) p. 6.

Table 1: Results of Global Vulnerability Assessment (GVA) case studies on vulnerability to sea level rise with food security index for selected countries

	Popula-tion affected (%)	People at risk	Capital Value at loss (US$)	Capital Value at loss (%GNP)	Land lost (sq km)	Land lost (%)	Wetland loss (sq km)	Sea Level Rise Threat (SLRT)	Food Security Index (FSI)
Antigua	50	1900	0	*2*	5	1	3	-0.04	-0.59
Argentina	**6**	-	5600	6	3400	0	1100	-0.49	0.28
Bangladesh	60	-	0	**15**	25000	18	5800	0.40	-0.32
Belize	35	-	0	**10**	1938	8	0	-0.03	-0.28
Benin	25	-	126	12	230	0	85	-0.29	0.19
China	7	-	0	**10**	35000	0	0	-0.47	-0.40
Egypt	9	30000	59272	204	5800	1	0	-0.17	0.45
Guyana	80	60000	4000	1115	2400	1	500	1.80	-0.40
Japan	15	-	807000	72	8900	2	0	-0.26	0.74
Kiribati	100	-	2	8	4	13	0	0.69	0.15
Malaysia	**10**	-	0	**2**	7000	2	6000	-0.41	-0.40
Marshall Is.	100	20000	175	324	9	80	0	2.45	-0.01
Mauritius	1	-	0	**2**	10	1	0	-0.53	-0.30
Netherlands	67	24000	186000	69	2165	6	642	0.32	0.70
Nigeria	4	-	18000	52	18600	2	16000	-0.41	0.15
Poland	1	196400	24000	24	1700	1	36	-0.50	0.12
Senegal	2	-	700	14	6100	3	6000	-0.46	-0.13
St Kitts-Nevis	**50**	-	0	**20**	1	1	1	0.00	-0.22
Tonga	47	-	0	**10**	7	3	0	-0.02	-0.12
Uruguay	1	-	1800	26	96	0	23	-0.51	-0.28
USA	0	-	0	0	28400	0	17000	-0.55	1.11
Venezuela	1	-	350	1	5700	1	5600	-0.53	-0.36

Sources: IPCC (1994) p19 and own calculations.
Notes: (-) signifies not estimated.
Food Security Index (FSI) is composite index, following Downing (1992). See text.
Sea Level Rise Threat (SLRT) is a composite index of three indicators where data were available for the case study countries: Percentage population affected; Capital loss as percentage of GNP; and Percentage area lost. The index is calculated as shown in text.
Definitions of other variables shown are described in text.
'Missing' data (in bold in table) have been interpolated in order to construct the SLRT, from the median of the ranges of 'vulnerability classes' (low to critical) in IPCC (1994).

There are various levels of uncertainty in these indicators, and some correlation between them. For example, some countries will have no significant wetlands, yet for others, wetland loss will have major impacts on productive agriculture. Senegal, for example has potentially large wetland loss with significant impacts, and loss of wetland and other agricultural land were aggregated in the data presented in Table 1 for that country. Wetlands and other 'natural' physical assets have significant economic value in protecting dryland area from coastal storms, but this is not accounted for in the approach adopted in the case studies.

3.4 Are food security and sea level rise related?

The threat of sea level rise in the IPCC Common Methodology case studies are taken in isolation, without account for the interaction with other proximate causes of vulnerability to climate change, such as the impact of sea level rise on agriculture. The proxy of population displaced assumes that the food security situation and the agricultural production of a country is directly related to the population density. However, countries such as Myanmar, Bangladesh and Vietnam have high agricultural potential rice growing areas in threatened delta areas, and loss of these areas would have disproportionately large impacts on food production, and possibly food security, in these countries, even greater than simply the populations displaced.

In attempting to integrate these aspects, the food security index (FSI) (following the methodology of Downing (1992)) is calculated for the 22 case study countries from UN sources (World Bank, 1993, 1994; FAO 1991), and shown in Table 1, to illustrate the relationship of food security to vulnerability to sea level rise. As the physical impacts of sea level rise and of temperature and precipitation change interact in a complex way to affect the rural and agricultural sectors of low lying countries, there is unlikely to be a simple relationship between the proximate *impacts* of environmental change and *indicators* of vulnerability.

To illustrate this, an aggregate sea level rise threat (SLRT) indicator can be calculated for the national case studies of the IPCC Common Methodology and plotted against a food security index. The SLRT is defined here as a composite index comprising of:

Population affected (percentage of total population);
Capital value at loss (capital loss as percentage of GNP);
Land loss (percentage of total area of country);

and is calculated in a similar manner to the FSI index. The SLRT is:

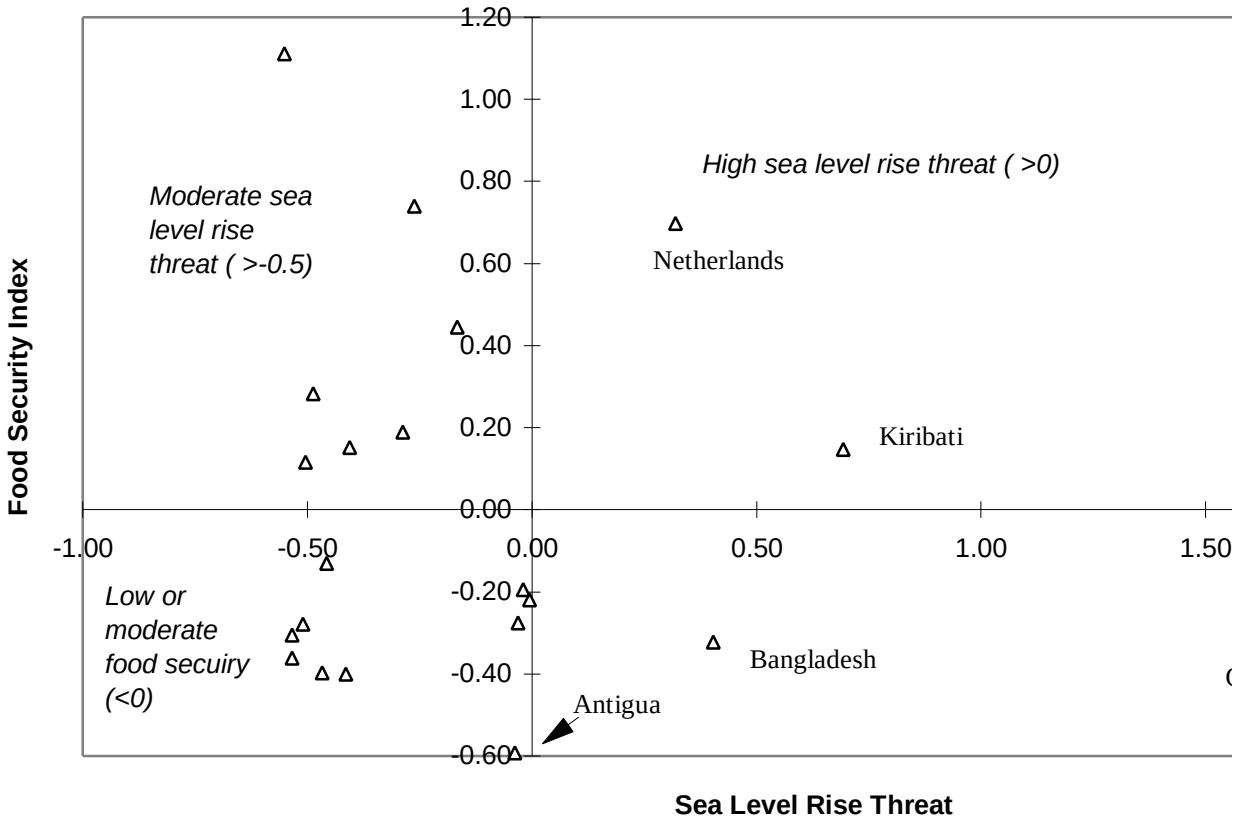
$$SLRT_k = \frac{\sum_{j=1}^{n} \frac{S_{j,k} - m_j}{SD_j}}{n}$$

where $SLRT_k$ is the SLRT for country k
$S_{j,k}$ is the nominal value of indicator j for country k
μ_j is the mean value of indicator j for all countries
SD_j is the standard deviation of indicator j for all countries.
n is the number of threat indicators.

The SLRT and FSI indices are both shown for the case study countries in Table 1, and relationship between these two is shown in Figure 3. This shows that some countries which have currently been assessed as being vulnerable to sea level rise (principally through having high levels of populations under threat in non-urbanised areas) also tend to have low food security. The extreme cases of combined threat of sea level rise and low food security are Guyana, Bangladesh, Marshall Islands and Kiribati. A large group of countries also experience 'moderate' threat of sea level rise coupled with general food insecurity caused by other factors (examples include Antigua). Yet, from the national assessments, the rich countries (which tend to have high food security) are not immune from the sea level rise 'threat' which, as defined, is essentially a topographical phenomenon. The Netherlands has the highest composite threat from sea level rise for the 'food secure' group of countries for which there is data.

The general results are that many of the countries surveyed for the threat of sea level rise, also have low or moderate food security. This result is not surprising given the nature of climate related threats in countries with low food security, and the reliance on agriculture and other primary sector activities in countries with low per capita income. It is important to note that the FSI is an historical index and *does not account for the potential impact of loss of agricultural land through sea level rise or other climatic impacts*. Thus any correlation between the indices is not based on the impact of one on the other. The major conclusion from this analysis is that the threat of sea level rise and climate related impacts on agriculture *tend* to reinforce each other, despite being accounted for separately by global and national assessments of vulnerability to climate change impacts. However, this is not universal for the case study countries, and shows that the complexity of vulnerability issues is not easily captured in indices.

Figure 3: Relationship between Food Security and Threat of Sea Level Rise fo



Source: Sea level rise threat index based on data from IPCC (1994); Food Security I

3.5 A justification for emphasis on social vulnerability

Present attempts to define and to derive indicators for various aspects of vulnerability (social and physical) to climate change show little integration, as has been discussed in this section. Similar conclusions are reached for example by Dow (1992) in reviewing vulnerability to global environmental change in general: although there are recognised links between the physical and social aspects of global change, the detail of these interactions at various scales is often ignored. Indicators of physical vulnerability are often relatively easily available, and are used to define where and when *social* vulnerability to climate change will be prevalent, but also to indicate what adaptation strategies are necessary. Ultimately, global climate change is likely (other things being equal) to increase social vulnerability. The social approach to vulnerability assessment therefore requires a reversal of the stepwise procedure implicit in current assessments. This could be undertaken by initially defining the parameters of social vulnerability, and defining vulnerable social groups (spatially or by socio-economic criteria) and then analysing both changes in social vulnerability over time, and how predominantly exogenous environmental changes interact with the social and economic systems presently under stress.

The approach suggested here follows the progression of defining vulnerability by social criteria and suggesting economic indicators. Development of the concept of social vulnerability to date has largely been undertaken in the analysis of the causes and impacts of famine, an issue with strong links to both environmental change, and even to climatic variability. The following section explains the economic approaches to vulnerability and adaptation within a famine context, but broadens into an exploration of the features of 'natural' hazards in general. This leads to examples of in defining parameters for the study of vulnerability, adaptation and policy in the face of climatic change.

4. The Economics of Vulnerability to Famine

4.1 Introduction

Having established the necessity for a focus on social vulnerability, we turn to examine economic approaches, based on the notion that it is particular driving forces in the allocation and utilisation of resources which determine vulnerability. The foci of economic literature on vulnerability examined in this section are those on the extreme social dislocation and impacts of famine. These foci include an emphasis on low income and subsistence economies (Sen, 1981; Swift, 1989; Devereux, 1993); distinguishing vulnerability from poverty; and explaining the characteristics of social institutions, as well as of physical production of food, which leads people to being vulnerable. Such explorations of other aspects of 'security' of livelihoods have been initially explored by Ruitenbeek (1994) and Lonergan (1993), taking indices such as prevalence of migration as signs of the unsustainable resource use and relative deprivation.

As discussed later in this section, this focus on famines, particularly drought related famines, is integral to the understanding of coping with extreme events, but does not cover the range of characteristics of potential impacts of climate related hazards. For example, an area could be relatively food secure yet experience a production failure through a short term catastrophic event such as a flood, and recover quickly through mechanisms of distribution of social welfare and other social institutions. Such an area would still have people vulnerable to the direct risk, and would obviously be in a 'hazardous zone' as defined by physical characteristics. Despite the caveats on the narrowness of the traditional focus on drought, the economic approaches to vulnerability are taken as the starting point for consideration of climate related hazards in this paper, and are now outlined.

Traditional explanations of famine are bound up with failures of food production leading to lower consumption with ensuing starvation, migration and other impacts. Food production failures have been caused many various 'natural' phenomena, such as drought, animal disease and plant diseases in staple crops for example (Swift, 1989). However, Sen (1981) observed that famine could take place without a food production failure, through mechanisms which he classified as exchange failures. This is a key insight, leading to examination of markets, and exchange and entitlement failures as the underlying causes of famines. Critiques of Sen's approach point to these failures not underlying the causes of famine, but simply being mechanisms which reflect the underlying political economy: famines (and hence vulnerability) are in fact pre-determined by the political and economic structures of resource ownership and control (see Bohle, 1993 for example).

This section proceeds by defining the necessary terms and outlining the theoretical differences underpinning some of these definitions. The approach of Sen (1981) to explaining famine and vulnerability to famine through a diverse set of causal mechanisms is then outlined. The critiques of this approach and the relevance of coping strategies for explaining adaptive behaviour are summarised. The section concludes that there is much to be learned from famine theory in studying vulnerability to climate change: a broad holistic and historic analysis is required to understand the social dynamics of vulnerability; but that household income and wealth and their distribution within communities serve as quantifiable comparative indicators of vulnerability of individuals within a community.

4.2 Definitions and theories

There are many theories and definitions of famine, many of which are bound up with popular perceptions of the *consequences* of famine, namely mass starvation. Thus dictionary definitions of famine tend to emphasise food shortage, hence concentrating on supply of food (Devereux, 1993). Many of the theories of causes of famine have the focus on starvation in common, though the purpose of identifying and classifying famine is often to promote intervention by governments or international agencies to relieve these symptoms. Definitions which point to the consequences of famine, mass starvation or increased levels of mortality, are therefore not useful for the purposes of famine prevention and timely identification. Theories can also be distinguished by their characterisation of famine as a discrete event, or as part of a continuum. Famine is differentiated from starvation in many definitions, such as by Sen (1981), by recourse to indicators such as increases in mortality. Yet increased mortality may occur some time after a sudden collapse in food consumption (or of food production). Revisionist definitions of famine have been termed 'behaviouralist' and anthropological-insider' by Devereux (1993). These definitions question whether starvation or excess mortality are necessary components of famine at all.

Behavioural definitions shift the focus onto famine as social disruption, hence a community syndrome. Famines are essentially discrete disruptions which cause a number of negative impacts on human well-being including the acceleration of migration; increased crime, fatal disease, and the use alternative foods; and the enhancement of the breakdown of traditional social bonds; as well as epidemic levels of malnutrition. Some behavioural definitions also add a class dimension, highlighting the uneven distribution of the impacts of famine within vulnerable communities:

> 'Famine is a socio-economic process which causes the accelerated destitution of the most vulnerable, marginal and least powerful groups in a

> community, to a point where they can no longer, as a group, maintain a sustainable livelihood' (Walker, 1989) (cited in Devereux, 1993, p16).

A further set of definitions of famine springs from observations by anthropologists during droughts that in many cultures or situations, death or starvation do not define famine for those experiencing it (de Waal, 1989). This is reflected in the literature on coping strategies which theorises that many households reduce consumption to secure ownership of capital and hence future livelihoods. By these insider definitions, famine may be indicated by the loss of assets.

Definitions of famine are largely required for intervention, but most definitions from 'outsider' perspective are not suitable and 'arrive too late' (Devereux, 1993). Advance indicators of vulnerability to famine, so-called insider definitions and initial coping strategies are most useful for determining the need for external intervention. The general lessons from Devereux's (1993) review of definitions is that famine is a continuum. It is difficult to define both famine and non-famine states for many individuals and groups. Famines can occur without food shortages, without excess mortality, or where excess mortality when it does occur is not caused by starvation. A further set of definitions of the terms used in this section in analysing famine is given in Box 2, the purpose being to highlight the phenomena in relation to the objectives of this paper, namely the analysis of vulnerability to climate change.

Vulnerability to famine reflects the issues highlighted above in defining famine itself. Vulnerability is however a prior state (hence it can be indicated by actions akin to coping strategies) and leans towards a community and social explanation more than individual. Vulnerability to famine cannot be isolated from other social and economic issues, as doing so puts famine and climatic change into the same category as other natural disasters such as earthquakes, hurricanes or volcanic eruptions. If famine is thought of as a *natural disaster*, then vulnerability is the consequence of living in an area prone to drought or flooding or other triggers of famine, rather than the result of poverty, policies or institutional factors. In the same way that defining vulnerability to climate change in physical terms leads to prescriptions leads to policies concentrating on the physical causes, so the prescriptions stemming from famine being a natural disaster involve moving people to less famine prone areas, or making the areas less physically vulnerable, for example through providing irrigation infrastructure to regulate water availability. The concept of famine as a natural disaster also implies that once the impact of famine has been averted the economic and social system return to normal.

Box 2: Further definitions

Famine
Famine is a socio-economic process of extreme disruption to livelihoods for significant numbers of people, often (but not necessarily) resulting in mass starvation, but also in migration, selling of assets and the breakdown of traditional social bonds. There are numerous definitions of famine, due in part to the fact that there are numerous causes of famine. The proximate causes of famine include natural hazards (see below) such as extreme weather such as drought and floods, earthquakes or biological pests, but more often the proximate causes are wars or other large-scale social disruptions. Underlying the proximate causes are socio-economic relationships such as the distribution and level of income and poverty. One of the difficulties in defining famine, and hence vulnerability to famine, is in delineating famine conditions from normal conditions of poverty. Hence famine is often conceived as a continuum at the extreme of poverty and starvation.

Entitlements
Entitlements are actual resources or calls on resources available to a household or individual based on their own production, their own assets or on reciprocal or non-reciprocal social arrangements. The theory, of entitlements developed by Sen (1981, 1984), is used to explain the behaviour of individuals in the face of starvation and famine. Famine occurs when there is an extreme failure in entitlements, in both exchange and endowments, for a large number of people. The concept of entitlements is wider than that of income, as it attempts to encompass non-monetary calls on assets, consumption or labour inherent in every society.

Coping strategies
Coping strategies are a sequential series of actions taken by individuals or households when faced with potential famine. They typically involve the use of established formal and informal insurance mechanisms; the selling of productive assets when the insurance mechanisms fail; and finally extreme famine measures such as migration. Coping strategies are therefore useful in determining the onset of famine prior to the final stages of destitution. Vulnerability of individuals to famine is enhanced by a lack of alternatives in coping strategies, brought about for example, by a narrow range of income sources, and by a maldistribution of income and wealth within a community.

Hazard
Hazard refers to the nature of extreme events in the environment, defined, for example, by the characteristics of intensity, severity, duration, aerial extent, and speed of onset. Natural hazards are generally those hazards associated with geological, hydrological, atmospheric or biological origins, though they may be classified in many ways. Using the term natural hazards does not infer that the impacts of such events are uninfluenced by social forces, nor that the events themselves do not partially stem from human actions.

The view of famine from economic and from political economy perspectives places famine on a continuum with hunger poverty and social deprivation and

argues that famine is a *consequence of human activity* which can be prevented by modified behaviour and or political interventions. It is the result of processes in which humans actively engage and which they can almost always prevent. This view is gaining greater credence within the social sciences, based on observations in various famine situations.

- There are few famines where rich have starved or where the poor do not suffer disproportionately more. The social differentials in famine impacts illustrate that famine has a social dimension. (This is in effect the same arguments extolled above, justifying the focus on social vulnerability to climate change, and has been observed with respect to natural hazards more generally (see section below)).

- The evidence from large scale famines this century points to breakdown of the distribution of food as being a critical causal factor, as in the major famine in China between 1958 and 1961 during the 'Great Leap Forward'. There are few instances of absolute regional food scarcity nor Malthusian-style famine episodes.

- There are strong links between famine and war and civil strife, related to the *distribution* of food. This is much more frequent than famines caused by simple climate extremes. There are many regions which have experienced severe drought (US) or floods (western Europe, US, China) but are not vulnerable to famine, since they have well functioning markets for essential commodities, sophisticated social security and public provision in the short run.

4.3 The entitlement approach

Having established that famines occur as much for reasons associated with individual or collective or government behaviour as much as by climatic or other natural effects, and that famines do not necessarily lead to mass starvation, the theory of entitlements as an explanation for famine causes is now discussed. The theory was principally expounded by Sen in the early 1980s (Sen, 1981, 1984) and essentially displaces food production failure as the cause of famine (and risk of food production failure as the cause of vulnerability to famine), by focusing on the effective demand for food, and the social and economic means of obtaining it.

Entitlements are real and potential sources of welfare or income. They are 'the set of alternative commodity bundles that a person can command in a society using the totality of rights and opportunities that he or she faces' (Sen 1984, p 497). Entitlements are production-based, trade-based or transfer based. Hence they are endowments entitlements and exchange entitlements. Individuals and

households have endowments which include privately owned wealth, but also may be calls on national social security or their neighbours and kin. They also have exchange entitlements from their labour or the output from labour (income). Essentially, vulnerability occurs when people have insufficient real income and wealth, and when there is a breakdown in other endowments which they have previously had.

The advantage of the entitlements approach to famine is that it can be used to explain why people have been vulnerable to famine where there are no absolute shortages or no external factors apparently present. Although controversial, this theory focuses analysis on the demand side of food rather than simply on supply side. Famines and other crises occur when entitlements fail. Diverse mechanisms cause these failures, from wars and social disruptions, to large increases in the price of food resulting in large sections of the population not being able to afford food (which can be a result of government policy). The merits of the theory are that the approach is robust to all these potential causes of famine, explaining famines which happen in times of apparent boom as well as during times of climatic catastrophe.

Sen's (1981) analysis which applies this theory identifies the Great Bengal Famine of 1943, as a period when social differentiation, speculation and hoarding drove up food prices faster than real wages, and caused a rural famine. The effective demand (their exchange entitlements) of rural people had effectively collapsed and no social security system (transfer entitlements) was in place (see also Sen 1993, Nolan, 1993).

Without doubt, the famine in China in 1958-1961 had also little to do with climatic factors but rather was a result of government policies in both the agricultural and other sectors. Recalling her childhood, Jung Chang, in her autobiography refers to so-called unprecedented natural calamities which the Chinese government said were responsible for food shortages:

> 'China is a vast country, and bad weather causes food shortages somewhere every year. No one but the highest leaders had access to nationwide information about the weather. In fact, given the immobility of the population, few knew what happened in the next region, or even the next mountain. Many thought then, and still think today, that the famine was caused by natural disasters. I have no full picture, but of all the people I have talked to from different parts of China, few knew of natural calamities in their regions. The only have stories to tell about deaths from starvation' (Jung Chang, 1993, p.311).

Similarly, with the Irish Famine of 1845-1850, the trigger was undoubtedly a biological pest, potato bight, but the famine relief policies and regulated markets exacerbated the food shortages and determined the nature of the coping strategies, through for example migration from Ireland to England and to North America. Although the British Government repealed the existing Corn Laws in 1846 to provide cheap grain in Ireland, this reform is argued to have come about too late to avoid famine conditions. Further, current historians appraise the repeal of the Corn Laws in the context of overall response, concluding that this action was undertaken principally because of the free trade agenda of the time, rather than famine relief.

Kinealy (1994) acknowledges that the potato blight was 'an unforeseen ecological disaster', but questions whether famine was an inevitable outcome of the failure of the potato crop. She leads the current reappraisal of the importance and causes of the Irish Famine in her analysis, essentially refocussing on the lack of political will on the part of the British Government to avoid the worst excesses of famine impact. The ineffective policy interventions when faced with a biological pest were:

> 'distorted by an even greater desire to seize the opportunity presented by the Famine to bring about social and economic changes in Ireland that were considered to be desirable by a ruling class, who, for the most part, did not even reside there' (Kinealy, 1994, p xvi).

Thus many major famines in the last two centuries can be interpreted as failures of entitlements to resources brought about through government policies or policy failures, sometimes, but not always, in the presence of a natural hazard. However, the underlying reasons for government interventions, or lack of them, are not detailed within an entitlements framework, as discussed below.

The concept of entitlements is wider than simply the economic well-being of individuals. Rather it encompasses some risk sharing 'potential income' or other types of support. A narrow economic approach simply focuses on income, but this loses the essential link between income and real purchasing power. If the real price of food or other commodities rise through external forces, then vulnerability to famine increases and this is apparent in both real income and exchange entitlement explanations of this phenomenon (Devereux, 1993). In many circumstances it is lack of direct or endowment entitlements which is the real cause of hardship in such circumstances. For example, the differential access between urban and rural dwellers to government social security, in many countries in crisis situations, determines the higher impacts of food price rises in rural areas. This phenomenon of differential impacts can be better explained by

higher direct entitlements in urban areas, rather than by differential income (see also Drèze and Sen, 1991). Entitlements therefore encompass access to food and other resources provided not only by incomes (exchange), but also by labour supply and transfers from government or more informal social security (endowment).

4.4 Limitations of the approach

The entitlements approach set the agenda for research on famines and on social vulnerability to famines and extreme events throughout the 1980s and many theoretical deficiencies, as well as empirical arguments on Sen's examples, were discussed. Swift (1989) outlines a critique of Sen's theory which focuses on the limitations of the approach:

- Entitlements do not give an explanation of when exchange failures occur, particularly as they can occur when the food production or distribution situation is improving. The approach as such does not incorporate an historical perspective, treating each event as unrelated to the previous one.

- Entitlements theory does not explain the differential prior vulnerability between communities apparently facing similar failures.

- The unit of account of the analysis is that of the household and cannot readily be applied at the community level.

- The role of war and civil strife is external to Sen's model. Such occurrences may affect expectations of government assistance, and strategies of migration and of maintenance of assets even through reduced consumption.

Sen's entitlements approach apparently therefore, has limitations in explaining phenomena such as intra-household dynamics (so called dependency entitlements); in explaining strategies which become illegal due to war or civil strife (and hence not 'entitlements'); in explaining famine crises where food consumption is not critical but disease epidemics are the crucial factor; and in the delineation of famine state as separate from non-famine poverty which causes of vulnerability to famine (see also Bohle, 1993; Watts and Bohle, 1993; Rangasami, 1985 among others).

But the greatest limitation of the approach is that entitlements to food assume that households have a single objective of maintaining and even maximising their food intake, and hence will trade their entitlements to do so. This may be correct

for people involved in severe crises, but empirical research on activities of many households faced with a escalating insecurity in their livelihoods reveals a more complex dynamic set of adjustments, often termed coping strategies (see Corbett, 1988). Thus the entitlements approach misses the dynamic complexity of *vulnerability* to famine by focusing on the end state, where the extreme crisis is already upon the populations involved.

4.5 Coping strategies and adaptation

Coping strategies are actions taken by households when faced with a famine situation, which as noted above, may arise from for a plethora of reasons, from climatic extremes to wars, or actions which may take place in advance of famine situations. They are in effect short term adjustments and adaptations to extreme events; are usually involuntary; and almost invariably lead to a different subsequent state of vulnerability to future famine situations. Such coping strategies are postulated by Corbett (1988), in the context of African evidence, to be strategies primarily concerned with maintaining the future income generating capacity of the household (as the decision-making unit) intact, rather than maintaining current consumption. Evidence from Rajasthan in India presented by Jodha (1975) confirms that the objectives of farmer's adjustment mechanisms are to protect the assets and the sources of future income, rather than current consumption, thereby providing further evidence of the stages of coping. The policies which stem from these observations are that drought or famine relief policies which are instigated once second stage strategies (of selling land or capital) have been undertaken may not be effective. Interventions based on increasing consumption may 'prove self defeating and contribute to the process of pauperisation initiated and accentuated by recurrent droughts' (Jodha, 1975, p1619).

There are therefore obvious trade-offs involved between current consumption and coping with famine, the strategies being essentially of risk minimisation (see Ellis, 1988 for example). Coping strategies generally fall into three categories:

Initial use of established insurance mechanisms which include the collection of wild foods, changes in cropping patterns (where the threat is slow onset drought); inter-household transfers and loans; and selling non-productive assets such as jewelry.

Disposal of key productive assets including livestock; agricultural tools; and sale of land. This stage is where trade-offs between current consumption levels and the productive assets occur.

Destitution and distress migration. It is often only when this stage occurs that famines are externally recognised, hence the debate noted above on what should constitute a definition of famine.

In summary, the explanation of household adaptive behaviour as risk minimising through a set of coping strategies adds a time dimension to the static entitlements theory. The strategies referred to in the African context discussed by Corbett (1988) and in the Indian context by Jodha (1975), are specific to rural households coping with drought, which may have an onset time of years which does not account for the range of experience of vulnerable groups. Sen (1981) for example, discusses the vulnerability of people involved in informal service sectors or landless labourers, in the Asian context. Such groups do not have the opportunity to undertake second stage coping strategies of selling productive agricultural assets, nor have they opportunities to make short term adjustments to livelihoods such as changing cropping patterns, referred to by Corbett (1988). Further, it has been postulated that Asian famines may have faster onsets than those in Africa, as there is a greater prevalence of events such as widespread flooding (as a proximate cause of the subset of famines related to external climatic events).

The distinction between coping strategies and adaptation to long term trends is inevitably somewhat blurred, and constitutes a limitation to this approach in assessing vulnerability to climate change. As discussed below, people are vulnerable to extreme events today, and make adjustments to their livelihood strategies to compensate. However, observing adaptation to climatic changes over the time scale of decades is more difficult. Davies (1993) has drawn a distinction between coping and adaptation, coping may be defined as acting to survive within the prevailing rules system whereas adaptation involves changing the institutional arrangements and the livelihood strategies themselves. Adaptation may involve alternative income sources, migration or other significant changes, as well as interventions by the state.

A further element in adapting to external threats to livelihood security is that of the so-called 'moral economy' (after Scott, 1976). It is a set of claims to non-reciprocal social security assisting households through periods of relative deprivation, and is redistributive in nature. Scott (1976) attempted to use economic analysis to explain tenure arrangements, peasant unrest, and the challenge of peasant movements to the legitimacy of central authorities using evidence from Burma and Vietnam (see Adams, 1986 for review). The moral economy is not static. The implicit risk minimisation and survival strategy underpins systems of livelihoods and will change over time depending on risks to livelihoods. Indeed Swift (1993) hypothesises that African pastoralists are

becoming more vulnerable to the impacts of drought in this century, as the moral economy aspects of their livelihoods, such as the right to call upon traditional leaders for support, have been breaking down. Strategies for maintaining a diversity of incomes and reciprocal arrangements include 'horizontal distribution' through migration and marriage. Climatic risks are often localised in geographical area, hence this strategy for 'off-farm' income and reciprocity can be effective. 'Vertical redistribution' occurs through agreements between landowners, patrons and the local state with households. The decline of customary collective coping has occurred, according to Watts (1983) and Swift (1993) due to the extension of the market for essential commodities and the loss of communally owned resources; the extension of state power and replacement of traditional by formal social security; and the growth of population.

Increased vulnerability through reduction of the moral economy, as hypothesised by Watts and Swift, may not however be universal. Contrary evidence is available of the continuation of reciprocal social security ensuring the survival of all members of a community, for particular areas. Paulson (1993) for example, studies the impact in Western Samoa of both integration of agriculture to the world economy through cash crops; and of the presence or absence of reciprocal social security in the aftermath of widespread hurricane damage in 1990.

She observes that the cultivation by Western Samoan farmers of some hurricane resistant crops and 'famine food crops' have declined in recent decades and cash crops were being grown and usually sold for export. However, this did not increase vulnerability when comparing regions which did not grown these cash crops. This is partly explained in this case by a low reliance on coconuts, which are particularly open to loss of the whole crop from high winds. The hazard characteristics of the crops grown, rather than the extent they were integrated into the market system explained the impact of the climate hazard in this case (Paulson, 1993). Further, although poorer villages did seem to experience greater impacts and take longer to recover from this hurricane, attributable in part to weakening of the moral economy.

Nevertheless, non-monetary informal arrangements for sharing of food persisted in general, and the moral economy seems to be resilient to increased state and market involvement in Western Samoa (Paulson, 1993). Some of the roles of traditional or customary coping have been taken up by the state in most societies. Scott's (1976) findings it should be remembered, were that collective informal social security were often at odds with state intervention, for example from colonial governments, and formed part of strategies to resist such intervention. The case of Vietnam, where centrally planned collective agriculture, and

provision of services was initiated in the 1970s and subsequently revised, is therefore an engaging case for the role of the state in alleviating vulnerability.

4.6 How do theories of the causes of famine help?

Theories of famine, of vulnerability to famine and coping strategies have evolved in recent decades in their focus on food production decline into the examination of complex social dynamics of livelihood strategies and the distribution of power and assets within a community. Over the last two decades the issue of indicators of vulnerability to famine has also sharpened the focus on those indicators which are timely and precipitate intervention to alleviate the impacts of famine. Climate extremes are more readily seen as a single causal factor of famine, rather than the paradigm example of famine cause. Famine is therefore regarded as part of a continuum of poverty and insecurity, where many parts of the social system break down and the livelihoods of many people are disrupted.

The debates on famine parallel those in analysing vulnerability to climate change:

- Vulnerability to climate change as with vulnerability to famine, is a prior condition, bound up with the social and economic situation of households and communities; vulnerability and poverty are inextricably interlinked.

- As with famine, external physical factors play a role in raising vulnerability, but they are not preconditions, neither are they sole causes.

- Focusing on the social and institutional causes of vulnerability to climate change leads to a radically different policy agenda then that which uses physical indicators. Interventions to reduce vulnerability to climate change should therefore address the causes of poverty and access to resources.

These parallels between vulnerability to climate change and vulnerability to famine, do not however controvert the direct relationship between physical factors and social impacts. Climatic extremes associated with climate change can and will trigger famines, but the insights from theory about the causes of famine show that they will not necessarily do so.

There is a distinction in the literature on famines between coping with a crisis situation and adaptation to longer term impacts. Again parallels can be drawn to analysing vulnerability to climate change, in that the same indicators of vulnerability to present climate variability by not be appropriate for analysing adaptation to climatic changes. The strategy for analysing vulnerability to climate change is therefore to define social indicators which show vulnerability to present

climate vulnerability (sustainability of livelihoods, distribution, capital assets, institutions), are measurable over time; and relate to physical vulnerability indicators which will change with changing climate (increased probability return period of floods, for example). The appropriate social indicators are wider than simply food consumption, and may be most easily based on measures of household capital and income. This is not to deny the importance of informal social security and other household strategies (Platteau, 1991), and is particularly apposite in subsequent empirical research in Vietnam where the role of the state in reducing vulnerability is critical (Adger, 1996).

The major limitation of theoretical developments in analysing famines is, *despite* the contrasting theories of social dimensions to famine, the undue attention on famines occurring in drought prone areas of sub Saharan Africa and south Asia. This is also despite the impacts of many other so-called natural disasters in creating the pre-conditions for famine. These include, plant diseases and other epidemics, earthquakes, volcanic eruptions and wars.

It has been hypothesised that the impacts of future climatic change will be principally the increased incidence of extreme events, such as hurricanes, floods, heavy rainfall, tidal waves as well as droughts (see Pittock, 1995). Many of these other climatic events do not share the characteristics of droughts which are slow in onset, and are difficult to isolate from 'normal' conditions such as extended 'hungry seasons' (Chambers, 1983). Floods and hurricanes by contrast, although seasonal, occur with independent probabilities of occurrence from one year to the next, rather than having accumulating impacts, and may not necessarily occur at the most critical time in terms of food production.

Theories of vulnerability to famine have shown that use of income, assets, and informal social security form the mechanisms of adaptation to famine conditions. We now turn to empirical evidence of the social dimensions of all natural hazards, to find common characteristics applicable to examining vulnerability to climate change.

5. Widening the Debate: Approaches to Natural Hazards Research

5.1 Natural hazards research agenda

As discussed above, the analysis of hunger and famine, their causes and remedies, has led to an undue focus on drought hazard. Droughts are generally long term, pervasive and take place over a wide area. Other extreme climate events can have short lived, localised consequences. To generalise, natural 'hazards' are only hazardous in their impacts on human populations. As some natural hazards are random, such as lightning strikes, all places and most populations are at risk from some purely natural hazard or other. Many aspects of natural hazards also convey advantages to economic activity. Riverine flooding for example is an integral part of many farming systems in providing nutrients in fertile floodplain areas: it is abnormal flooding which causes damage and is the hazardous part of this partially natural phenomenon. In these cases a natural hazard is 'an occasionally disadvantageous aspect of a phenomenon which is beneficial to human activity over a different timescale' (Middleton, 1995, p265).

Indeed, famines may be thought of as the 'bottom line' of natural hazards, as it is famines which are identified with greatest human suffering and also characterised as being associated with both natural hazards and the 'interpersonal forces of sociobiology, most notably population' (Hewitt, 1995, p116). As with the causes of vulnerability to famine however, vulnerability to natural hazards (apart from the most random) are socially determined, and hazard events have differential impacts on groups in society dependent on institutional and socio-economic parameters. Paradigms competing to explain the incidence of the impacts of vulnerability to natural hazards, and prescriptions to prevent them, focus on these institutional and economic factors. For example, the approach adopted by Winchester (1986) utilises the following definition of vulnerability in relation to cyclone impact in southern India:

> 'a household is in a vulnerable state if there is a high probability of suffering loss or damage (to life or property) from which there is a high probability of it not recovering quickly or fully because the effects are either irreversible or the opportunities of recouping losses are negligible' (Winchester, 1986, p 122).

Vulnerability, as used here, is therefore defined as a set of processes which impact on households, and which incorporate a dynamic element of recovery, to a status quo.

Theories of economic development are integral to the understanding of vulnerability in general. Theories of economic dependency, brought about through globalisation of the world economy, postulate that vulnerability to hazards is dependent on class and

the structure of economic relationships. Alternatively, neo-classical economics postulates that risks from all natural hazards are incorporated into individual decision-making, and that rational use is made of hazardous environments: hazards are deleterious in that they prevent *optimal* use of resources, when economic agents are forced into risk averse behaviour. Other explorations of vulnerability to hazards, essentially from the perspective of human ecology, focus on institutional arrangements precipitating failures in collective action in reducing hazard risks, which are seen as largely exogenous.

The literature on natural hazards is large, spanning many aspects of hazards and paradigms of explanation of their impacts. The approaches and issues are summarised in Blaikie et al. (1994), Burton et al. (1993), Alexander (1993), Middleton (1995), Varley (1994) and Hewitt (1983a, 1995) among others. This section reviews aspects of research on the nature of natural hazards and social vulnerability to their impacts. The range of climate related phenomena reinforcing social vulnerability is wide - so a theory of vulnerability to climate variability and to climate change, to be robust, must encompass this range of physical precursors to vulnerability.

5.2 The characteristics of hazards

The characteristics of natural hazards and their consequences include:

- magnitude (for example, maximum height reached by a flood);
- frequency (recurrence interval for the flood);
- duration (length of time over which the impacts persist);
- aerial extent (tornado compared to a continental drought);
- speed of onset (length of time between onset and peak - soil erosion and drought are slow onset hazards while floods can occur very rapidly);
- spatial dispersion (are there specific boundaries to the impacted area?);
- temporal spacing (seasonal, as with hurricanes, or random such as earthquakes).

The impacts of climate change is therefore a small subset of potential 'natural' phenomena which impact on society and to which individuals and groups become vulnerable. In attempting to define a general theory of natural hazards, human geographers have emphasised the social and institutional reasons for increased vulnerability: people make decisions individually which increase societal risk overall. Reliance on single technologies increases the levels of societal risk; and increases in the scale of economic activity, other things remaining equal, increases risk. Burton et al. (1993) present evidence on a number of these issues, hypothesising that at the macro level, social vulnerability to natural hazards does not necessarily decrease with increasing wealth or income, and that individual decision-making can also be

characterised across diverse hazard types. As one of the received wisdoms of the climate change debate is that the world will become more susceptible to hazardous events (Pittock, 1995 for example), the controversy over whether the world is becoming riskier *to all hazards, even without changes in the exogenous environment*, is a key issue debated within this research field. The crux of this general theory is now discussed.

Disasters associated with natural hazards have been estimated to burden the lives of one fifth of the world's population at least once in each generation, according to data cited in Mitchell and Ericksen (1992). When absolute risk is defined strictly in economic terms, then the world is also becoming riskier to all hazards over time, as evidenced from the economic value of the losses from recorded storms and earthquakes.

Figure 4: Frequency and Real Insured Damage (Constant Prices) of Global Natural Catastrophes.

Source: After Middleton (1995) based on data from the Swiss Reinsurance Company.

Figure 5: Change in Deaths from Natural Hazards per Million of Population and Income, 1973-1986 for Selected Countries.

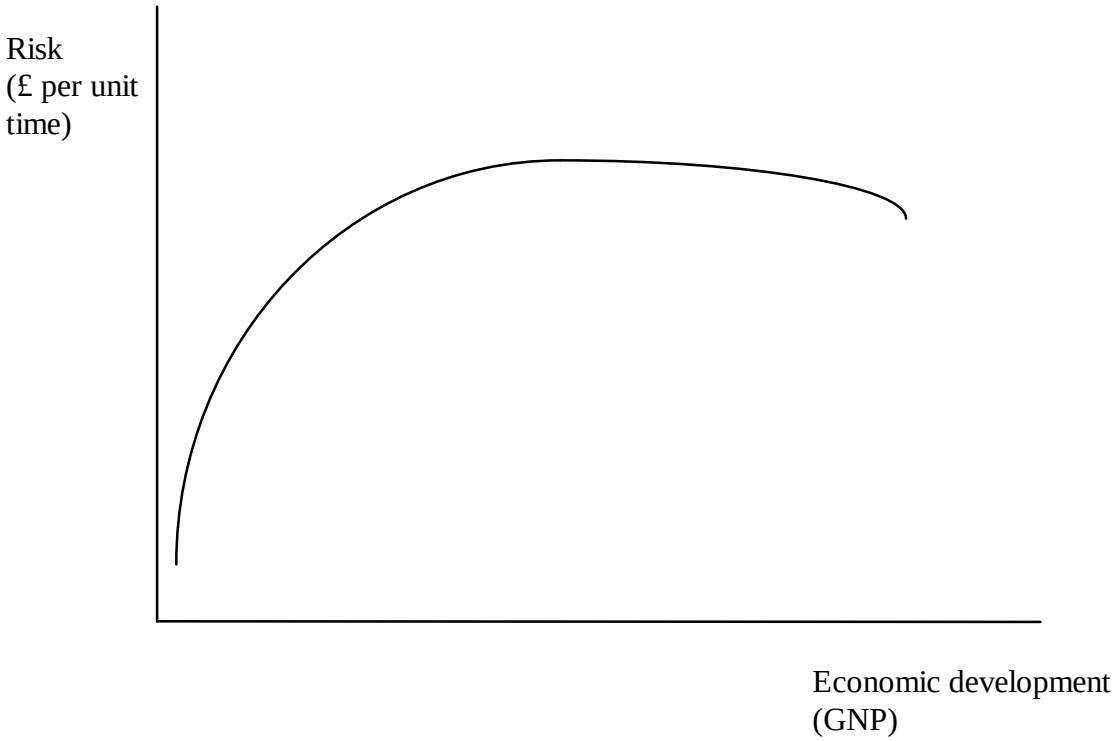
Source: Burton et al. (1993) p. 14.

Evidence on the economic losses associated with insured damage, and catastrophic events as defined by the insurance industry are show in Figure 4 (From Middleton, 1995). Globally the trend would appear to be upwards for both number of disasters, and certainly for insured losses. How increased frequency and economic loss are correlated to increasing or decreasing economic activity or other indicators of economic development is unclear. Figure 5, for example, shows changes in deaths per capita changing with income between 1973 and 1986 for selected countries. Some high income countries such as Denmark, the Netherlands and West Germany made major income gains over the period without changing the proportional risk of death from natural hazards, while the USA, Greece, Indonesia, Australia and Rumania all became richer but incurred proportionally more deaths from natural disasters. Pakistan, Bangladesh and Kenya made steps in the right direction. Although most countries made gains in income, the proportional rate of deaths from natural hazards moved in both directions. Needless to say, the figures are dependent on the accurate reporting of deaths from natural events, (particularly unreliable if they do not attract international assistance, see Mitchell and Ericksen, 1992); on the definition of what these events are; and on the influence of one event with a high death toll over the decade.

As stated above, there are many instances of direct causation between hazardous areas and high levels of economic activity, such as volcanic and floodplain fertile soils. The physical characteristics in this case can be seen as both the trigger for intensive use and the proximate cause of the hazard. There are also areas which are hazardous and wealthy, but with no causal link. Examples are the earthquake-prone areas in Japan or California. Based on evidence across countries, Burton et al. (1993) hypothesise that economic development within a hazardous zone, defined in terms of the different types of hazard, increases the risk of deleterious impacts, and also increases the risk of catastrophe despite the probability of the hazard remaining constant over time:

> ‘People make a wide range of adaptations and coping adjustments that may retard or reverse destruction and enhance productivity. In dealing with extreme events in nature, more intense development at first restricts the wide range of these individual adaptations in favour of collective adjustments. To that extent it helps breed catastrophes while moderating the effects of less threatening events. But there is also evidence that critical points may be reached beyond which the trend may be reversed’ (Burton et al., 1993, p124).

Figure 6: Relationship between Economic Value of Environmental Risk and Level of Economic Activity



Thus, according to such analysis, the world is becoming a riskier place due to the scale of economic development, particularly in areas such as the world's coastal zones. However, this increasing risk reaches a threshold so that risk reduces with higher levels of economic activity and income: hence there is an implied relationship between absolute risk (as defined in monetary terms by value of financial loss per unit time, assuming no change in the probability of hazard event) and income levels in a particular locality depicted in Figure 6. The mechanism for this to happen suggested by Burton and colleagues is through both increased perception and knowledge of the particular hazard; and through access to capital leading to preventative measures. This is a critical hypothesis in the analysis of potential impacts, in that the level of economic activity will increase economic losses holding other factors constant, such as the increased frequency of occurrence or severity of the hazard.

Yet there is some evidence that future climatic change will bring about greater extremes in climate. Studies of El Niño phenomena associated with the Southern Oscillation illustrate that changes in sea-surface temperatures in the Pacific Ocean are followed by shifts in the world wide occurrence of extreme weather and related

impacts (Cane et al., 1994 Salafsky, 1994 for example). Increases in precipitation intensity are believed to be a potential result of global temperature rises (Whetton et al., 1993) and the increasingly vigorous hydrological cycle. Increases in precipitation intensity potentially lead to increased flood frequency and magnitudes with impacts on soil erosion and other physical assets, other things being equal.

Wigley (1985) has demonstrated that probability functions of events are extremely sensitive to changes in the mean value, such as the mean incidence of flooding. A change in the mean by only one standard deviation would cause an extreme event with a return period of 100 years, to have its return period reduced to 11 years, thus becoming nine times more frequent. Such changes would have severe implications for recovery periods for those individual communities who already have a high base-line vulnerability. Similarly Katz and Brown (1992) show that the frequency of extreme events is relatively more dependent on changes in overall climate *variability* than in mean changes. Hence assessments of frequency of extreme events based on inference from changes in means do not adequately quantify the potential incidence of the particular extreme events. Mitchell and Ericksen (1992) summarise the climate related research on the increased incidence of weather extremes thus: 'there is cautious general agreement that worsening weather extremes are possible and portentous; but few are willing to predict the magnitude and timing of future extremes, much less the regional pattern of events' (Mitchell and Ericksen, 1992, p144).

The combination of the two effects discussed above: (1) increased economic loss over time due to technological dependency on hazard avoidance, and the societal acceptance of hazardous environments; coupled with, (2) increase in the future frequency (at least of climate related) extreme events, together result in a more hazardous world, if the relationship follows the simple pattern of:

Impact of hazards = population at risk * probability of occurrence.

In the paradigm of human ecology, people will individually undertake a wide range of adaptations and coping adjustments, though restricted by the 'bounded rationality' of their knowledge, and by the role of collective actions, which often increase risks further (Burton et al., 1993, p 124). The impacts of hazards will only *potentially* be reduced when institutions evolve effective collective strategies and recognise the catastrophic risks which often are created while moderating the effects of less threatening events.

However, this mode of analysis which dissects the institutions involved in hazards, inevitably leads to prescriptions for alleviating vulnerability which assume that these institutions are the attendants of comprehension of the hazard

phenomenon. Thus policies will emphasise the collective management of risk and centralisation of information and early warning systems. The determinist logic applied in this human ecology perspective to natural hazards has been criticised by Zimmerer (1994) as simplifying both the objects and the mechanisms of adaptation:

> 'Explanations of human behaviour based primarily or entirely on ecological concepts of adjustment and adaptation invited theoretical and historical critique. Application of simple adjustment concepts frequently overlooked the roles of ethnicity and power in shaping human behaviour. Similarly, the initial concept of adaptation favoured the continuity of homeostasis over the dynamics of change. In this fashion, adaptation became essentially teleological, change could not be explained, and the whole concept was bereft of historical meaning' (Zimmerer, 1994, p112).

Zimmerer's (1994) critique of human ecological approaches to all resource interactions is more wide ranging than its application to natural hazards. It shows the weaknesses of analysis of all human-natural environment interactions which rely on notions of systems ecology such as pervasive equilibrium and niche competition, where many social and biophysical situations are in fact exemplified by disequilibria and instability. The implications of this 'new ecology' in human ecology are to 'call for flexible environmental management responses that accommodate at once change, risk, complexity and development based on local participation' (p109). Thus, their are direct parallels and lessons for vulnerability to climate change from this critique of institutional approaches to natural hazards. These include a necessary emphasis on diverse knowledge bases and perceptions of risk, as well as political economy and historical foci for analysing present baseline vulnerability.

In summary, the essential point from the technocratic institutionalist approach are that institutions adapt to environmental risk. Given resources and favourable circumstances, this adaptation will ultimately minimise the impact of exogenous disasters. This is antithetical to the view that there is a close interdependence between risk and development (Hewitt, 1995).

5.3 Individual decision-making in hazardous situations

In the face of uncertainty concerning the frequency and severity of natural hazards, there are innumerable apparently contradictory types of behaviour, some of which hold to economic explanations of risk aversion, risk neutrality or risk loving, and to the axiom that individuals maximise their utility. Some other types of behaviour do not hold to these theoretical models. In the face of a natural hazard, the synthesis of

studies by Burton et al. (1993, p123) shows four patterns of behaviour of those living in a hazard zone. These are:

- to deny the hazard exists and to ignore it;
- to tolerate the prospective loss without taking countermeasures;
- to take action to prevent impacts in their location; and
- to take significant action including abandoning the hazard zone.

These behaviour patterns are not necessarily inconsistent with a neo-classical economic explanation of expected utility underlying individual decision-making when faced by natural hazards. However, Burton and colleagues suggest that from their review of evidence, the gradation from inaction to major action is not easily correlated with wealth or income, but rather is correlated with such issues as whether the threat is pervasive (such as increased long term salinity of water) or intensive (such as sudden devastating bursts of salt water); and whether experience of such events is recent or remote in past time. Again, these do not necessarily deviate from the economic model, but show the complexity of information which is incorporated into decision-making by individuals in weighing their costs and benefits.

The economic analysis of decision-making in the face of natural hazards relies on the notion that the *objective risk* of an event occurring (the probability given the best available knowledge) is not usually relevant to individuals, but rather their *subjective risk* (based on personal degree of belief about the occurrence of events) determines the actions of households or individuals. This concurs with the observations of Burton et al. (1993) above. The existence of pervasive subjective risks or uncertain events such as from natural hazards has been hypothesised to lead to risk averse behaviour such as slowness in adopting innovations, and to lead to reduced production in agriculture and detrimental impacts on poorer households (see Ellis, 1988), and a deviation from 'rationality' in economic behaviour.

Rationality in the neo-classical economic sense is the efficient allocation of the factors of production, (land labour and other inputs) in response to prevailing prices, and innovation in response to price signals as new technological options emerge. comes from not only natural hazards, but also from wars, state actions on controlled prices of staple foods or other goods, and by uncertainty in the control and ownership of property. In policy terms, actions which reduce other forms of uncertainty offset uncertainty from natural hazards. Increased security of tenure over land shifts the perceived value of the asset base, creates incentives for preventative action, and could reduce the impact of future hazards. Direct ways to reduce the output risk of variations in yields and agricultural output caused by variations in

weather, are to invest in irrigation, in crop insurance and in varieties which are resistant to the prevailing threat, such as drought or salinisation.

A review of research into whether small farmers are in fact risk averse by Ellis (1988) reveals that risk aversion can be found in many instances, with peasants deviating from neo-classical economic rationality with diversity of personal behaviour and cultural factors. Risk averse behaviour is also found to generally decline as income rise. Some of this research is based on observation, with the limitation that any deviation from optimal allocation of resources is taken as evidence of risk aversion. Other approaches are based on direct survey of farmers, determining their certainty equivalences of particular outcomes and experiments with real money payoffs. Binswanger (1978, 1980) for example, found that high levels of production risks, coupled with risk aversion leads to underinvestment in capital, relative to profit maximising levels by a large proportion of farmers in the sample in India. Almost 80 percent of farmers in his sample could be classified as risk averse. These latter experimental techniques have been criticised for not representing the reality of decisions concerning survival, rather than simply different economic states.

In summary, uncertainty is pervasive in household individual decision-making in all contexts, from industrial societies to subsistence farmers. Historically a large research focus on peasant farmers has arisen due to the belief that balanced economic development in developing countries required growth in the agricultural sector and that this growth in the agricultural sector could come about through reduction of risk, and hence reduction of non-rational behaviour in the small farm sector. In economics, uncertainty is used to explain deviations from the neo-classical rational model of economic behaviour. Other researchers from anthropology and other disciplines explain non-rational behaviour through cultural norms, or risk minimisation, whilst acknowledging the role of uncertainty in these factors. Peasant rationality, as reviewed by Adams (1986) shows that neither the moral economy hypothesis nor the peasant rationality hypothesis can be more than partially validated in South East Asia. In any case, uncertainty from hazards, and particularly from natural hazards is likely to increase in the future due to climate change. The framework in which to examine individual decision-making when faced with extreme events, requires a recognition of both bounded rationality and other aspects, particularly since hazards potentially accentuate customary behaviour patterns.

5.4 Social interpretations of natural hazards

The focus on technological dependency and on the changing physical environment inherent in the work on *Environment as Hazard* and the research following this paradigm, is questioned in a broader interpretation of the role of social forces and the ‘normality’ of natural hazards in the lives of vulnerable

groups by O'Keefe, Wisner and others (O'Keefe et al. 1976; Wisner, 1978; Torry, 1986; Blaikie et al., 1994). This group of researchers also agree that the world is becoming a more hazardous place, but the reasons why this is so, are antithetical. Leaving aside the climatic extreme events, Susman et al (1983) point to increased impact of disasters in the last 50 years with no increase in the probability of their physical occurrence. Thus, increasing disasters are explained by the marginalisation of increasing numbers of people and by the process of underdevelopment.

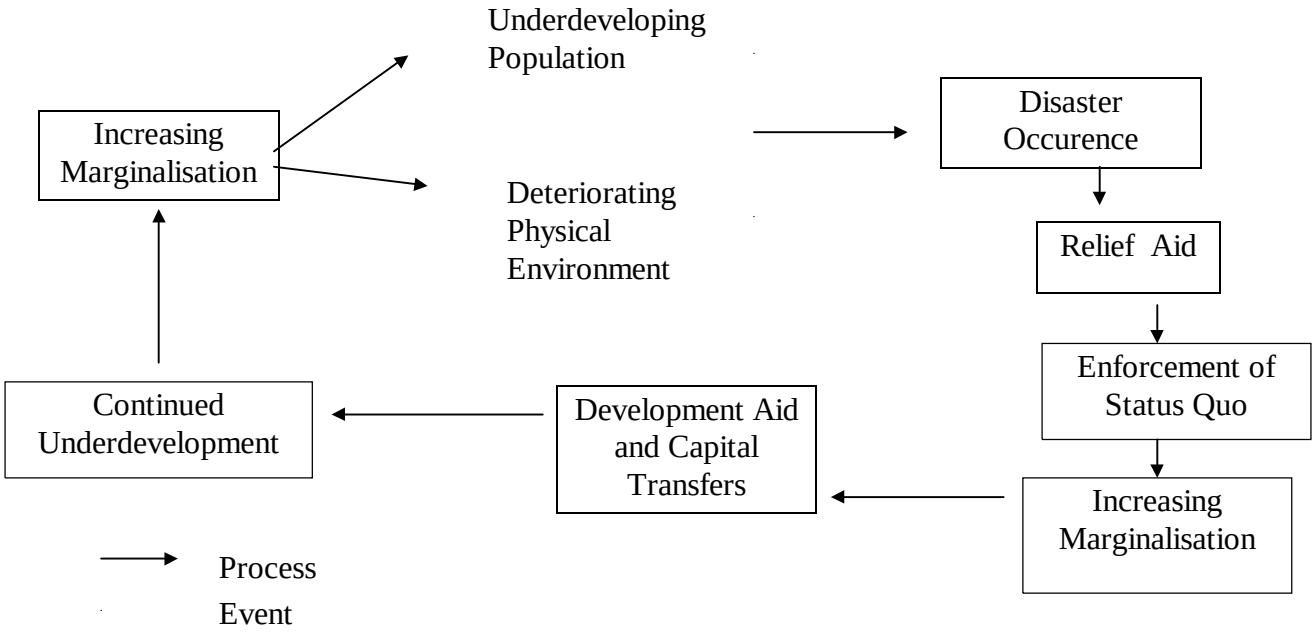
Within a theory of dependency and of marginalisation of classes and groups, analysis of changes in the riskiness of countries within changes in income per capita, as presented in Figure 6, can never explain the social vulnerability within societies. The theory of marginalisation and dependency theory of disaster occurrence is a, firmly rooting the focus of vulnerability on human populations:

> 'Vulnerability is the degree to which different classes in society are differentially at risk, both in terms of the probability of occurrence of an extreme physical event and the degree to which the community absorbs the effect of extreme physical events and helps different classes to recover' (Susman, O'Keefe and Wisner, 1983, p264).

The emphasis in this definition of vulnerability is on differential impacts of events on different socio-economic classes, evidenced by the time taken to recover from such events. These explanations concur with both observations of coping strategies in the face of potential famine, and with the theories of entitlement failures, which postulate differential impacts based on the level and diversity of exchange and endowment entitlements. The interpretation of natural hazard impacts as portrayed for example by Susman et al. (1983) and illustrated in Figure 7, explains the vulnerability of marginal groups as a process reinforced by a deteriorating physical environment, and by the interventions by state and international agencies. O'Keefe and colleagues (1976) explain the causes of vulnerability thus:

> 'the increased vulnerability of people to extreme physical events can be seen as intimately connected with the continuing process of underdevelopment recorded throughout the world' (O'Keefe et al., 1976, p 560).

Figure 7: The process of Marginalisation in Disasters



Source: Adapted from Susman et al. (1983) p 279.

The key features of the process and mechanisms which exacerbate vulnerability over time in this alternative neo-Marxist paradigm shown in Figure 7 are:

- External factors related to globalisation and capital ownership. This process enhances vulnerability through imported technology and inward investment promoting the funneling of economic resources out of dependent countries.

- Internal economic factors. Land ownership and tenure arrangements, and the focus of export oriented cash crops from agriculture increase food insecurity. Reduced *diversity* of income sources through involvement with global markets, such as the reliance on cash crops, opens smallholder farmers to direct risk of extreme weather, disease or pests. Increased marketed activity has also been hypothesised as a cause of breakdown of reciprocal informal social security (Watts 1983, Swift, 1993 for example).

Both these phenomena are exacerbated through recent phenomena such as the debt crisis and related structural adjustment policies designed to relieve the impacts of the debt crisis (see George, 1992). Central government expenditure on health, education and agriculture in Africa, for example declined by up to 50

percent during the 1980's for those countries most heavily indebted. In the same period interest payments on debt rose dramatically (Stewart, 1992). These factors are used in the framework in Figure 7 to explain why larger numbers of people are poor, and hence marginalised within the economy and vulnerable to natural hazards. Susman et al. (1983) also cite evidence of the links between development assistance, such as under structural adjustment, and continued marginalisation of poorer sections of society.

5.5 Lessons from Natural Hazards research

In summary, research on natural hazards contributes to our understanding of vulnerability to climate change by presenting a wider perspective on all types of hazard and theoretic frameworks for analysing vulnerability to these. The major research issues and hypotheses which arise from these perspectives are:

Economic development either alleviates or amplifies risk to impacts from hazards. As has been illustrated, the theory of dependency and the risk management approach both attempt to explain the globally observed increase in the economic losses from natural hazards, and the purported increased numbers of marginalised and vulnerable people. The economic approach, which incorporates the impact of expectations, offers a dynamic perspective on risk at the household or individual level. It is therefore of some use in addressing vulnerability to and expectations of changes in the frequency of extreme climate events.

The institutional context determines both attitudes to hazards and ultimately the severity of their impacts. The institutional dimension is apparent, in the context of most hazards, by the differential impacts of the same physical severity of hazards in different regions. The focus on institutions inevitably leads to prescriptions for alleviating vulnerability such as collective management of risk and centralisation of information and early warning systems. This may disavow dealing with underlying causes of vulnerability such as unequal access to resources.

The critiques of technocratic approaches reaffirm the importance of political economy perspectives in further research on climate impacts. These perspectives are useful in ensuring an historical perspective on the causes of vulnerability, and on the notion that vulnerability can increase over time. An example is the Pressure-and-Release model of Blaikie et al (1994) which postulates increasing pressure on vulnerable groups through both the impact and severity of hazard and from underlying social conditions. Theories of marginalisation and the links between local economic activity and globalisation however, have more explanatory power at the national or international level, than at the level of individual

decision-makers, who are constrained by their assets, their income and their other entitlements.

In each of these areas there are parallels with the earlier section on famines. Essentially notions of how social vulnerability to famine, or to all natural hazards, occurs are dependent on how economic development is conceptualised. The natural hazards research offers greater insights of relationships between the range of extreme events associated with climate to which social groups are presently vulnerable and to which they may become more vulnerable in the future.

6. Lessons for the Analysis of Vulnerability to Climate Change

6.1 Essential features of a model

The preceding discussions on approaches to conceptualising and measuring social vulnerability to famine and to all natural hazards has illustrated the great diversity of theories and the wide use of the same terms to describe different phenomena. Nevertheless these are useful starting points when we come to define and measure vulnerability to climate change.

The essential features of a model of vulnerability is firstly that it focuses on social vulnerability. Ultimately understanding of present climate variability on society will reduce the ultimate impacts of climate change on individuals and society. Thus a social science approach is based on human centred preferences and welfare, specifically on individual well-being. Hence environmental changes associated with climate change become important when they impact on the relative and absolute well being of individuals and groups. As O'Keefe and colleagues put it: 'without people, there is no disaster'. Further, the impetus for present *mitigation* and reduction in the causes of human induced climate change will be informed through demonstration of social vulnerability. For example, in the negotiations on international action under the Framework Convention on Climate Change (FCCC), perceptions of vulnerability directly influence countries' bargaining position, as well as feeding into the overall objectives of prevention of 'dangerous anthropogenic interference with the climate system' as stated in the FCCC.

Secondly, analysis of vulnerability should ideally encompass all types of climate related hazard. These include hurricanes and related wind damage, tsunamis (tidal waves), floods, droughts, and secondary impacts such as increased occurrence of disease epidemics and other health issues related to climate change. This requires detail from many sectors.

Coping strategies to famine can be observed over a long time frame, when the proximate cause of social disruption is drought. However, such initial behavioural indicators of impacts are not relevant for many climate hazards, such as floods and tsunamis, which often arrive without warning. Thirdly, therefore, the focus on agricultural strategies in coping with drought also needs to be widened to encompass the vulnerability of non-agricultural or even urban dwellers to climate-related threats, and to investigate their adaptation to these. Rural farming communities and landless labourers are often the most vulnerable groups, but not always.

A concept of vulnerability should also be easily measurable as a fourth criterion, though this requirement is not synonymous with the necessity to project the

indicators over time. Rather it means that indicators should have a temporal dimension. The theory of vulnerability needs to be robust to different socio-economic conditions, hence applicable across all regions of the world. As shown in Table 1, individuals in countries with high per capita GDP can still be vulnerable to climate change: social vulnerability and failure of institutions are often the dominant factors.

A theory of vulnerability to climate change also must encompass the collective vulnerability of a group or community to the impacts of climate change. This collective security is a complex set of factors, essentially including the institutional arrangements for preparedness for hazards. In this economic approach, if household vulnerability can be indicated by distribution of and relative income and wealth levels, then the social element of vulnerability can be indicated by some notion of the state of the moral economy (or informal social security arrangements) as well as by levels of absolute income.

With greater numbers of social factors involved in collective vulnerability (gender, ethnic and other differentials of vulnerability (see Blaikie et al., 1994)), as well as the nature of different climate-related hazards, the exclusive focus on relative and absolute poverty has been argued to be misplaced. For example, while Cannon (1994) agrees that assets tend to be redistributed after a flood or drought in accordance with the pre-existing patterns of ownership (hence income and assets are a suitable indicator of vulnerability), some impacts of events such as floods are not correlated with wealth (Cannon, 1994, p28), and economic criteria do not exactly reflect vulnerability. This observation however, does not invalidate the economic approach to quantifying vulnerability, it simply urges the identification of impacts on particular productive assets with a finer resolution. An extreme flood in a coastal area for example, will affect both the privately owned agricultural assets, and communally owned and managed fisheries and other resources. In such case the differential impacts on groups depends on the use of the communal resources, and dependency on agriculture and privately owned resources. Do the poorer, more vulnerable groups, depend to a greater extent on the communally managed fisheries resources? Will floods have greater impact on agriculture or fisheries?

As noted above, it is important to specify vulnerability both to climate variability and to future climate changes. The focus in this paper on hazards and disasters naturally leads us to focus on extreme events, which are important proximate cause of vulnerability both now and in the future. In Section 4 large uncertainty surrounding predictions of intensity and frequency of extreme events with changing climate was noted (see Emanuel, 1987; Mitchell and Ericksen, 1992; Katz and Brown, 1992; Kelly, 1996). However, vulnerability to climate change indicators suggested here necessarily focus on extreme events, as it is the cases of droughts, floods and other events to which vulnerable groups cannot simply adapt to by ‘wearing a lighter

shirt'. The approach to social vulnerability suggested here is therefore not a theory of absolute food availability, and is not readily informed by indicators of food production, national food sufficiency or composites proposed, for example, by Fischer et al. (1994).

6.2 Some hypotheses

Social vulnerability to climate change is the exposure of groups or individuals to stress as a result of the impacts of climate change. Stress encompasses disruption to groups or individuals' livelihoods and forced adaptation to the changing physical environment. Social vulnerability to climate change does not equate to poverty, as there are many other factors involved, not least the climatic and topographical factors which define environmental risk. Vulnerability can therefore be explained by a combination of social factors and environmental risk:

Vulnerability to climate variability = f (social vulnerability, environmental risk)

where environmental risk can be indicated by the return period of a threshold physical hazard: Environmental risk = Impact * Pr

where Pr = 1/R (Pr = probability and R = recurrence interval (years)).

Vulnerability to climate change involves changes in these parameters over time:

Vulnerability to climate change = f (Δ social vulnerability, Δ environmental risk)

Change in social (baseline) vulnerability incorporates notions of economic development (Pareto-type improvements in economic welfare reducing vulnerability), as well as adjustments to livelihoods based on adaptation to climatic conditions, and changes in institutional and political structures. As discussed below, there are both elements of individual and collective vulnerability in this concept. Thus as a population becomes richer and has a smaller proportion of income dependent on resources vulnerable to extreme climate impacts, social vulnerability decreases. If institutions fail to plan for changing climatic conditions and risks, social vulnerability increases. The environmental risk component is determined by the probability of an event occurring, and by its intensity, duration and speed of onset (and hence its impact). As noted above, small changes in the mean of rainfall, windspeed and other variables can lead to large changes in the probability of extreme events at the upper or lower end of normally distributed phenomena.

It is helpful to disaggregate the social vulnerability aspect into the two distinct aspects of individual and collective vulnerability in order to clarify the scale issue and the unit of analysis. **Individual, or household, vulnerability** is determined by access to resources and the diversity of income sources, as well as by social status of individuals or households within a community (essentially similar to their entitlements). **Collective vulnerability** of a nation, region or community is determined by institutional and market structures, such as the prevalence of informal and formal social security and insurance, and by infrastructure and income. Collective vulnerability is exacerbated by the 'exogenous' environmental changes which will occur through climate change. The two aspects of vulnerability are obviously interlinked: a whole region with low income levels, even if this were evenly distributed and had a strong system of informal social security, would be expected to have a lower number of vulnerable people than another region with similar exogenous environmental risk, but with a chronic maldistribution of resources.

The distinction between the causes of collective and individual vulnerability are illustrated in Table 2 which also highlights potential quantitative and qualitative indicators, of vulnerability both to present climate variability and to future climate change. Both absolute and relative measures of economic well being are required at the individual level, as vulnerability to impacts such as starvation are related to the failure to obtain basic needs. Relative income is often correlated with education and other factors which determine whether individuals can access formal social security when an extreme event occurs (see Drèze and Sen, 1991).

6.3 Indicators

The approach suggested by the preceding discussion leads to a focus on income as a measurable indicator of that part of the social vulnerability aspect to vulnerability to climate change. This is a starting point for the analysis of social vulnerability. Recognising the criticisms of Cannon (1994) and others, income is not the sole indicator of social vulnerability, but is a quantifiable important element in this set of factors. The issues of absolute and relative poverty are incorporated in the measures, which can be divided into measures of individuals' absolute deprivation and some indicators of collective vulnerability.

These alternative indicators in Table 2 can be used to determine the aggregate poverty of a particular community, to rank individuals within a community and hence to act an indicator of individual vulnerability to climate variability. The information can be combined with other indicators of the proportion of income dependent on resources physically vulnerable to climate variability, such as agricultural production, forestry or other primary sector activities. The adoption of simple income based measures of relative and absolute deprivation suggested here have advantages in

terms of data collection and collation, but are recognised to be partial in attempting to quantify and understand individual social vulnerability. In the context of the present study, these indicators have been utilised in designing a household survey for the assessment of both the individual and collective aspects of vulnerability to extreme climate events in northern Vietnam (Adger, 1996).

At the regional or community level social vulnerability is affected by relative distribution of income, access to and diversity of economic assets; and by the operation of informal social security arrangements. Further, vulnerability to climate extremes is determined by the institutional arrangements which organise warning, planning and other services.

The probability of an extreme event is important as noted above is one of the determinants of environmental risk, but the specific timing of the events is also important, in terms of preparedness, and in terms of time elapsed since the previous extreme event. Thus two 100 year floods occurring in consecutive years have greater impact than two floods of equal magnitude 10 years apart. This is because the relative deprivation of vulnerable groups means a longer recovery period, to return to the previous state (if the previous baseline vulnerability is reached at all (Watts and Bohle, 1993)).

Table 2: Collective and individual vulnerability to climate change: determinants and indicators

Type of vulnerability	Causes in relation to climate variability	Indicators of vulnerability	Causes and indicators of vulnerability to climate change
Individual vulnerability	Relative and absolute poverty; entitlement failure in the face of extreme events.	Poverty indices; distribution and proportion of income dependent on risky resources; expected potential resource losses.	*Causes*: change in occurrence of extreme events; involuntary adaptations including migration. *Indicators*: changes in probability of extreme events; thresholds in physical (topographical, climatic) parameters.
Collective vulnerability	Absolute levels of infrastructure, market development; institutional and political factors -insurance and formal and informal social security.	GDP per capita; relative inequality; qualitative indicators of institutional arrangements.	*Causes:* change in hazardous zone area leading to real economic costs of public interventions. *Indicators*: change in proportion of population vulnerable.

The relationship also notes that the *vulnerable* population is the subject of analysis and that changes in total population over time does not necessarily mean and increase in vulnerability. Thus neo-Malthusian approaches are specifically rejected. Neo-Malthusian arguments of increasing populations vulnerable to famine are based on the unidirectional causality of increasing population leading to extensification of agricultural area or intensification, both of which have decreasing returns to labour input, hence food production falls behind population growth. The neo-Malthusian approach would recommend per capita land availability as an indicator which, if decreasing, would suggest greater vulnerability. However, consideration of income and the diversity of sources of income per person ratio, (such as through income both on and off-farm income) is a judicious basis for an indicator of absolute vulnerability at the community level.

Devereux (1993) argues that modern insights to demography do have some explanatory powers as pre-determinants of famine. The issues of population density and population growth must be looked at separately, however. High population density frequently provides the opportunity for social investments in infrastructure and markets (essentially economies of scale) and hence possibly reduced vulnerability. This is true at least up to the point where intensification of land use poses threats to natural resource base itself, such as increasing use of hazardous environments and over reliance on preventative technologies. Conversely, high rates of population growth may increase vulnerability by perpetuating high dependency ratios within a population, and according to Griffin (1981), has a negative impact on income distribution in an economy through in those economies with underemployment.

Evidence from Asia shows that 'high population density has facilitated the development of rural infrastructure, market integration and diversification of the rural economy' (Devereux, 1993 p62). Population density therefore matters far less than its geographic and economic distribution, though population growth rates have increased vulnerability.

The level of infrastructure, institutional preparedness and other factors important in the implicit collective vulnerability of a nation, region or community may not be accurately reflected in measures of economic activity. Measures of economic activity as noted earlier, do not readily correlate with economic well-being for many reasons, including non-incorporation of environmental degradation, and the role of subsistence and non-marketed activities in economies. However, if it is assumed that there is high correlation between the hazard and economic activity in hazardous regions (such as occurs in fertile floodplains for example), then it may be hypothesised that increasing levels of absolute wealth, in a Pareto-fashion, will reduce vulnerability to climate change. Nevertheless, national or regional level

indicators of absolute income, and distribution of that income, are a relevant starting point for quantitative indices of collective vulnerability.

In summary, social vulnerability to climate change is made up of the elements of individual and collective vulnerability as shown in Table 2. Social vulnerability in general encompasses disruption to livelihoods and loss of security, and for vulnerable groups is often pervasive and related to the underlying economic and social situation, both of lack of income and resources, but also to war, civil strife and other factors (see Chambers, 1989). The two elements of individual and collective vulnerability incorporate adaptations to long term climate changes, which are assumed to happen over a time frame to allow planned adaptation and are not significant in terms of social vulnerability, compared to extreme events. In effect, planned adaptation is ignored. Vulnerability to extreme events is the principal climatic element in vulnerability which is defined in socio-economic terms (and narrowly in economic terms). It affects both individual and collective vulnerability and increases over time, all other factors held constant, if the probability of recurrence of extreme events increases, vulnerability to climate change increases. Analysis of social vulnerability leads to prescriptions on poverty alleviation and underlying causes as well as disaster prevention, rather than exclusively on infrastructure or disaster preparedness.

7. A Preview of Vulnerability Research in Vietnam

The preceding discussion defines the concept of social vulnerability to climate change. This framework will subsequently be applied to a case study in Nam Ha Province the northern deltaic region of the Red River in Vietnam. This section briefly previews some of the empirical results by way of illustration of the approach and highlights critical research issues in the implementation of the framework.

Vietnam is a natural resource based economy with a large agricultural sector. Its economy is presently decentralising from a system of state planning in existence countrywide since reunification in the mid 1970s. The liberalisation from the mid 1980s onwards first concentrated on decollectivising agricultural land and production, with profound impacts on agricultural production, resource use and the rural as well as the urban economies (see for example Luong, 1992; Fforde, 1987; Irvin, 1995; Ljunggren, 1993). The history of resource use and the political economy of Vietnam also provide unique insights into the relationship between colonial influences, war and state planning and vulnerability, poverty and development.

The issues highlighted above, of individual and collective vulnerability are impacted both the by the physical environment, and by the observed institutional and economic transition. This research, in contrast to the global and national scale assessments reviewed in Section 2, necessarily focuses on a smaller geographical scale. In the case of Xuan Thuy District in coastal Nam Ha Province, research based on secondary sources and on a household survey on income levels and reliance on risky resources (Adger, 1996) shows that there is a high level of heterogeneity in the indicators of baseline vulnerability, even between Communes (the smallest administrative unit) within a single District.

Table 3 shows preliminary results on indicators of vulnerability for Xuan Thuy District. These show that in the most recent five years, accelerated deregulation of agricultural markets has led to increases in intensity of resource use and increases in income sources overall for the population of Xuan Thuy. However, the implied trend is that incomes are becoming more skewed, primarily evidenced through the emergence of new income sources, particularly through intensive aquaculture, and the concentration of these income sources at the top end of the income distribution.

The land allocation system, which traditionally contributes to an unusually high levels of equality of income in rural centrally planned economies such as China and Vietnam (see Griffin and Zhao, 1993; Hussain et al., 1994 for example), is presently being replaced with rental markets and the privatisation of land holdings. This has undoubtedly led to increasing output in the agricultural sector for Vietnam as a

whole, and the privatisation has led to relatively even distribution in the intensively used lowlands compared to the upland Provinces of Vietnam (Rambo, 1995).

Table 3: Preview of Trends in Vulnerability Indicators in Xuan Thuy District, Nam Ha Province, Vietnam.

Trends in:	**Trends**	**Hypothesised impacts on vulnerability**
Incomes (Y)	Increasing Y with deregulation during Doi Moi; greater integration with national economy; Y more skewed.	Increasing Y ↓ Skewed Y ↑
Land	Longer leases (*Xa* dependent); increased specialisation; emerging land rental market; land allocation system less enforced.	Investment in conservation ↓ Skewed ownership ↑
Aquaculture and open access resources	Enclosure of commons coastal aquaculture; leaseholds on intensive aquaculture; increasing absolute impact from storms in terms of economic losses.	Skewed ownership ↑ Paradox of increased economic and physical vulnerability
Collective action	Reduction in labour allocation coastal defenses (eligibility, duration and land taxes); reduction in the influence of *Xa* in resource allocation.	Collective vulnerability ↑

Source: Adger (1996).
Notes: *Xa* (or Communes) are the smallest administrative unit in Vietnam. Commune does not signify communal ownership of resources.

Nevertheless, this increasing inequality is the 'wrong' direction as an indicator of vulnerability, principally because of the role of land resources as communal security, and the potential for marginalisation in resource allocation decisions within the Commune political structure, as presently evolving. Other institutional changes associated with decentralisation of planning, may be offsetting such trends. Luong (1992) for example, cites evidence of the re-emergence of traditional collective institutions at village level, from before the collective period. Such institutions may, he suggests contribute to collective social security, partially offsetting the formal social security for the poor during present withdrawal of state support.

The reduction of importance of the local government structures may also be contributing to increasing vulnerability through reduced labour allocation to communal activities associated with reducing risk from climate extremes: labour and tax allocation to dike repair which protects the infrastructure from the impact of tropical storms for example has been reduced in the last five years. Such institutional changes exacerbate collective vulnerability in a period when the future frequency of cyclones could well increase in the region (Kelly, 1996).

A further important focus for privatisation has been communally owned coastal resources, principally for use in intensive aquaculture. As indicated in Table 3, the skewed distribution of the benefits of aquaculture within Xuan Thuy (as quantified by its contribution to overall inequality using Hussain and colleagues' (1994) pseudo-Gini method) is complicated in its contribution to vulnerability by its apparent high relative *physical* vulnerability to coastal storms.

These observations illustrate the local level issues in assessing vulnerability to climate extremes in coastal northern Vietnam. The economic and institutional context are central to understanding present vulnerability, and indeed greater historical analysis of why technologies and land use practices have coevolved is required. Secondly, the summary of results illustrate the complexity and the opposing directions of particular indicators. The research also shows, though not discussed here, a dichotomy between coastal and inland Communes in the sample, even within a single District of 380,000 people. The political economy of resource use in Vietnam has changed dramatically in the intervening decades, and present economic vulnerability indicators as outlined above need to be considered in analysing present and future vulnerability, and importantly in policy responses.

8. Conclusions

This paper has reviewed present approaches to defining and analysing social vulnerability to famine, natural hazards and climate related hazards. The objectives have been to distil the useful parts of this diverse set of research for the purpose of defining and analysing social vulnerability to climate variability and to climate change. The predominant implicit approaches in the climate change literature to date have involved assessing physical impacts, though some passing reference is made to the importance of social and economic factors. This paper has argued that understanding social vulnerability should be the central objective of interdisciplinary analysis and that this will shift the focus of policy prescriptions towards the underlying causes of social vulnerability, rather than on the symptoms.

The two research areas most relevant as starting points for the analysis of social vulnerability to climate change are the study of social vulnerability to famine and the study of social vulnerability to natural hazards in general. Each of these areas demonstrate how social vulnerability can be defined as a set of economic, social and cultural processes feeding into proximate and underlying causes of vulnerability and prescriptions for alleviation and mitigation of vulnerability. Most of the concepts necessary for the definition of social vulnerability to climate change have therefore been debated in these contexts, and have been discussed in the sections above. The central issues are the role of distribution and access to resources and the incidence of poverty within populations; disruption of livelihoods through external forces; institutional factors determining both collective responses to extreme events and the baseline of collective vulnerability; and the historical context of vulnerability, both in terms of political economy and in terms of technological and other factors determining physical vulnerability. These last two issues in particular are clear in the study of famine and the study of hazards more generally.

The policy implications of this approach are to direct emphasis onto the underlying causes of social vulnerability at both the individual and collective level, rather than onto infrastructure and planning. Economic growth will not necessarily reduce social vulnerability to climate change, as vulnerability depends on *relative* deprivation and access to resources. Policies relevant in the present to reduce social vulnerability to climate variability include supporting the capacity of vulnerable groups to maintain resources, and the investment in maintenance of these resources in the long run. Further, both formal government and informal social security are relevant to this process. It should be recognised that there may well be a dichotomy between public intervention to reduce long term risk from climate change (say building dikes, regulating rivers), and the intervention to reduce present day risk. In the words of Blaikie and colleagues:

> ‘It is hoped that ... global warming will not require the building of dikes and sea walls to treat a symptom ... The tendency towards heroic engineering responses is always with us’ (Blaikie et al., 1994, p43).

The explanations of vulnerability and prescriptions for alleviating it are inextricably tied to the underlying model of the economic development process. Both famine and other hazards have physical environmental dimensions, in some cases these are directly climatic factors. Defining social vulnerability to climate change does not however rely on extracting the parts of famine and hazard theory which are climate related and formalising them. Rather it involves recasting the notion of vulnerability in the context of a very long run and extremely uncertain physical phenomenon, with prevailing dominant social and economic conditions.

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