Research Brief 2

Vulnerability and Environmental Change

From the ESRC's New Opportunities Research Programme on
ENVIRONMENT AND HUMAN BEHAVIOUR (EHB)

environment and human behaviour
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INTRODUCTION

Vulnerability entails two simultaneous processes: a general mode in which everyone is vulnerable and a particular mode of differential vulnerability among peoples and places subject to different stresses. Vulnerability is a dynamic process among actors in socio-ecological networks. Vulnerability operates at multiple scales, often simultaneously. Both qualitative narratives and quantitative methods are required for its assessment.

Vulnerability carries different frameworks of understanding, depending upon what is being examined (eg. climate change, hazards, epidemiology, coastal zones, food systems or free trade). There is no overarching definition of vulnerability beyond its evolving dictionary definition. It should be continually re-defined in the context of new research in each domain.

Two projects from the EHB Programme explored the issue of vulnerability to climate change, one focusing on possible scenarios of rapid climate change, and the other looking specifically at the vulnerability of food systems to global environmental change more generally.

THE MAIN RESULTS

The key impacts in Europe of two possible outcomes of rapid climate change – thermohaline circulation collapse and accelerated climate change – are likely to be on agriculture and crop production (and hence crop prices and rural economies), mortality and ill health, the ability of physical infrastructure (buildings and networks) to continue to operate effectively, and on ecosystems in both northern and southern Europe. Accelerated climate change is also likely to significantly affect the availability of water resources as demand increases and supplies reduce. A third possible outcome, rapid sea level rise, would threaten coastal infrastructure and large parts of many key European cities, and would increase coastal flood losses: this would challenge the viability of insurance against flood hazards, and require very large investment in flood defences. All three changes would see a change in the economic and cultural centre of gravity of Europe, in different directions: following thermohaline circulation collapse the shift would be southwards, following accelerated change it would be northwards, and it would be inland after rapid sea level rise.

Vulnerability of food systems to global environmental change may relate to production, distribution, availability or access. Analysing the vulnerability of food systems needs to involve a combination of macro, meso and micro-scale assessments that would at all times be interlinked. The macro-scale assessment might identify hot spots of concern, based on (for example) population density, infrastructure, ecological fragility, climate, and food and agriculture data. The meso-scale assessments might identify the constraints, challenges and opportunities faced by a range of income groups or 'livelihood systems' and their various sub-groups. These assessments could be made at district level and could gather data on land ownership, health and social welfare, infrastructure, soil and water resources, crop, fisheries and livestock systems, agricultural technology and irrigation, as well as coping strategies and capabilities in the context of climate variability. Neither the macro-scale nor the mesoscale assessments hold any value without continual 'ground-truthing' at the micro-scale. Micro-scale assessments attempt to separate out long and short-term trajectories of food insecurity and vulnerability, and to separate out 'baseline vulnerability' from complementary pressures, such as entitlement failure, political, social and economic constraints and demographic change.

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Exploring Vulnerability to Rapid Climate Change in Europe

The aim of this project was to explore the implications of rapid or abrupt climate changes – defined here to be either a step change in climate regime or a rate of change outside the IPCC range – for Europe.

There has been a great deal of research into the potential mechanisms of abrupt climate change, but there are no published quantitative scenarios. Three characterisations of abrupt climate change were therefore produced for the current study. The first describes the potential climatic implications of a collapse of the thermohaline circulation in the North Atlantic, resulting in cooling across Europe. The second represents an accelerated climate change, caused by the additional release of greenhouse gases from permafrost and the oceans as climate warms. The final characterisation describes the rapid rise in sea level that would result from disintegration of the West Antarctic Ice Sheet.

Managers adapting to gradual climate change accept that change is happening, and look for information on the magnitude of change. Managers concerned about abrupt climate change, however, are less interested in the magnitude of change – they believe it will by definition be extreme – but are more interested in the likelihood of abrupt change occurring. There are, however, no scientifically robust estimates of the likelihood of thermohaline circulation collapse, accelerated climate change or rapid sea level rise, so a survey of expert opinion was conducted to provide some estimates. Difficulties in identifying a large sample of appropriate experts, and unwillingness of some experts to make subjective estimates of risk, meant that the final sample sizes were small. Estimates of the likelihood of thermohaline circulation collapse or accelerated climate change varied significantly between experts, over several orders of magnitude: most experts believed the risk of either to be very low (well under 1%), but a minority assessed the risk as considerably greater.

A detailed literature review revealed that there have been no published assessments of the implications of future abrupt climate change across Europe (a few palaeoclimatic studies have examined past physical responses to abrupt changes, and a small number of studies have explored how civilisations or communities were affected by past anomalies). An initial assessment of the implications of the three characterisations of abrupt climate change was therefore made using a combination of model simulations (for hydrology and crop potential), review of published studies of the effects of gradual climate change and change thresholds, and expert judgement. The main results of this assessment are briefly described under Main Results on p. 01 of this Research Brief.

Abrupt climate change challenges the conventional scenario-driven approach to adaptation in two ways. First, it increases substantially the potential range of climate change impacts to be considered, but the likelihood of these extreme impacts occurring is highly uncertain and *probably* very low: unfortunately, it is currently impossible to estimate the likelihood of abrupt climate change. Second, it may be technically or financially difficult to adapt to abrupt change. It is, however, possible that in the face of a recognised abrupt climate change many of the barriers to adaptation, imposed by public attitudes or government policies, would be reduced.

A second approach to adaptation assumes that reducing vulnerability to current climatic variability will make a major contribution to reducing vulnerability to future climate change. Whilst some measures to reduce current vulnerability (such as poverty alleviation, hazard warning and some aspects of land use planning) do also cope with future climatic variability, many others do not. These include measures which are designed to provide some defined standard of services, such as degree of protection against flooding. Abrupt climate change, by definition, involves a step change in climate, and standards-based measures designed to cope with current variability are therefore even less likely to be a reasonable response to abrupt change.

Given the uncertainty associated with abrupt climate change, and the potential major difficulties in actually adapting to change, the most effective adaptation action now is to monitor – in the oceans, atmosphere and ice sheets – for the onset of abrupt change. Despite its characterisation as 'abrupt', abrupt climate change would probably only become clear over a decade, and even then definitive identification of change would be likely to be highly controversial.

Integrating Social Vulnerability into Research on Food Systems and Global Change

Global change will affect food security among vulnerable groups via changes in food production, with further stresses coming about from concomitant changes in national agricultural economies and market trade. An integrated assessment of vulnerability of food systems to these multiple stresses needs to be designed with forethought. The project explored the social theory of vulnerability, and worked with experts to think about practical methodologies. The project developed the methodological progression and associated insights shown in Figure 1.

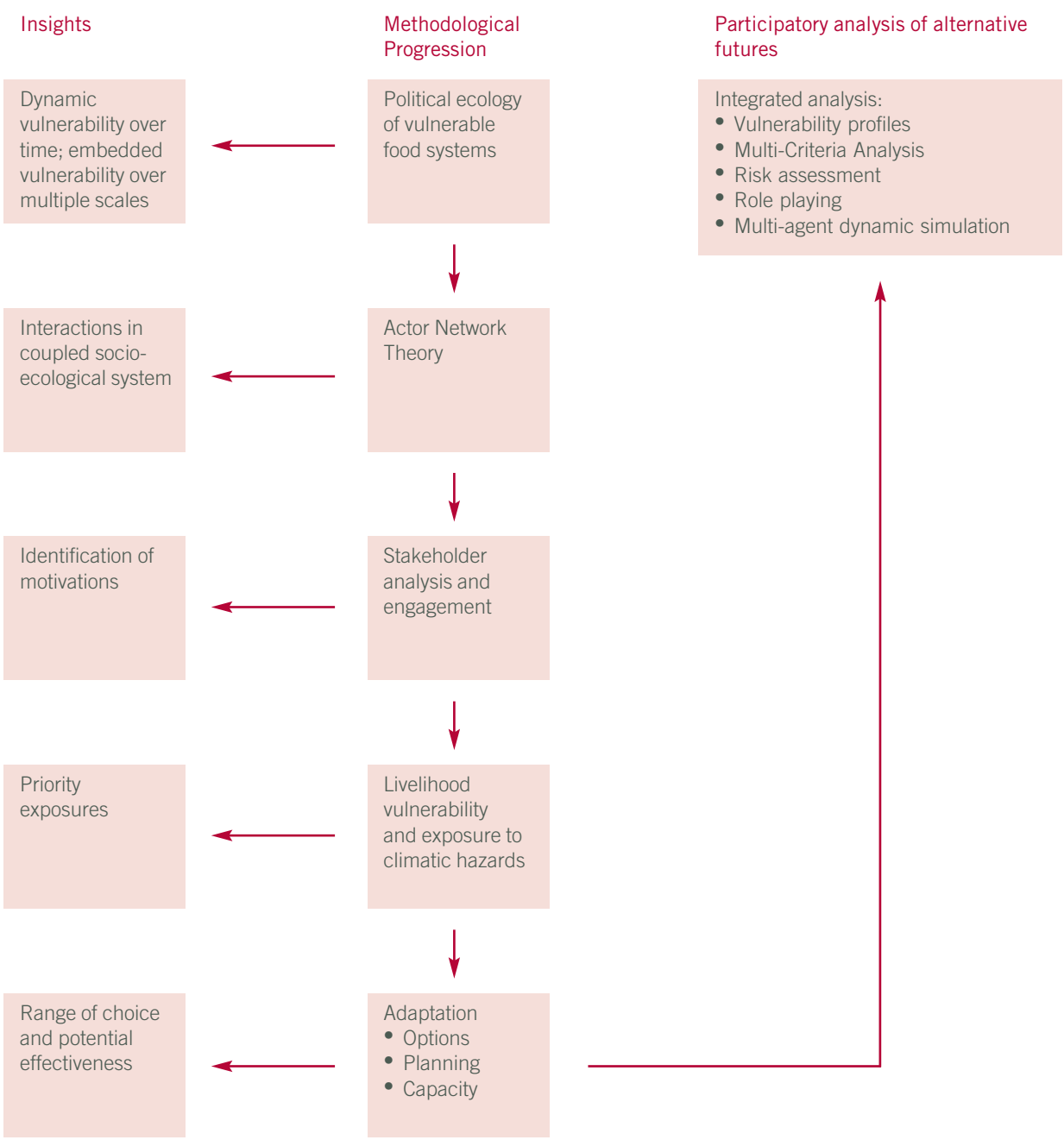
The political ecology of vulnerable food systems is an essential starting point to designing an assessment. The emphasis on the dynamic nature of vulnerability over time and multi-level processes provides an initial canvas for choosing methods. One implementation of political ecology is Actor Network Theory, which seeks to identify the various actors (human, ecological and physical), the boundaries of the system, and the nature of their interactions. This social theory coheres well with the concept of coupled socio-ecological systems and the analysis of resilience.

In stakeholder analysis and engagement, experts and stakeholders interact to identify the main actors and drivers of change, which can be readily translated into simple models. A livelihood approach to vulnerability identifies who is vulnerable, to what and to what extent. A livelihood

comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base.

The first task in evaluating adaptive options is to identify and characterise the range of options available. Relevant issues include: finance, information and skills required to implement the option; time required to plan and implement the option; stakeholders who will implement the option; beneficiaries of the option; and conflicts with other options or stakeholders. Techniques to evaluate adaptive options range from qualitative checklists to full cost-benefit analysis. In most cases, some sort of multi-criteria analysis is essential. The intended outcome of the exercise is a participatory evaluation of alternative futures, which can both facilitate choice between and motivate implementation of the most desirable adaptive options.

Figure 1: Methodological Progression and Associated Insights



AVENUES FOR FURTHER RESEARCH

The first of these projects has begun to explore the implications of abrupt climate change in Europe, and provides the foundation for more in-depth studies. Key areas for future research include:

- Quantitative characterisation of abrupt changes in climate: scenarios that can be used to drive quantitative impacts models need to be constructed using current ocean/climate models. In particular, scenarios combining thermohaline circulation collapse with an increasing concentration of greenhouse gases need to be constructed, and model simulations of accelerated climate change are required.
- Quantitative characterisations of the likelihood of defined abrupt changes in climate, under different assumed rates of climate change. This is extremely important, and will involve not only model simulations but also assessment of expert opinion.
- Quantitative assessments of the implications of abrupt climate changes for defined sectors and regions: the only model-based assessments so far conducted were done for the current study and concentrated on physical impacts.
- Identification of "dangerous" magnitudes of climate change which would pose significant challenges to adaptation. In other words, what are the limits to adaptation?
- What are the specific implications of abrupt climate change for adaptation planning in particular sectors? Is it possible to draw analogies from other areas exposed to low-probability, high-impact events, such as military scenario planning or nuclear power station design?
- What probability of abrupt climate change would alter adaptation planning, and what factors influence this threshold probability?

Specific research issues that need to be pursued in understanding the evolution of vulnerability, including that related to the food system, under climate change include:

- What future scenarios of vulnerability are adequate for the reference case of climate change impacts and adaptation? Present development scenarios cover a broad range from underdevelopment to great prosperity. However, they have not been used to frame climate change vulnerability.
- What new forms of vulnerability might emerge? For example, the impacts of exceeding thresholds of temperature extremes that do not occur at present in a region might be outside present coping ranges.
- To what extent are present climate coping strategies able to withstand future threats, for example increasing intensity or frequency of hazards?
- Are there present actions that would increase future climate change impacts? For instance, protection from present storm surges might encourage greater investment in areas that become at-risk with sea level rise.
- Are existing vulnerability frameworks used in development planning (e.g. poverty mapping) adequate for planning climate change adaptation? For example, the IPCC has adopted a different definition and framework for climate change vulnerability that does not sit well with current planning horizons.

FURTHER INFORMATION ABOUT THE PROJECTS AND RESEARCHERS

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