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The Risks from Flooding: Which Risks and Whose Perception?

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Four main groups are considered in relation to the risk from flooding: the engineers involved in the design of flood alleviation schemes, emergency planners, the public, including both the population at risk from flooding and the rest of the population who will bear all or most of the cost of flood alleviation schemes and the researchers, such as geographers and economists concerned with flood hazards and scheme appraisal. It is argued that these different groups vary significantly in their selection and definition of risks from flooding as a focus of concern and that their definition of risk influences their expectations about future events and the appropriate response to those events. But the different groups share two tendencies: the expectation that the future will be a replication of the past; and the neglect of "uncertain uncertainties" in favour of known uncertainties of risk.

Different groups in a population choose different risks from flooding as their focus for concern. These definitions of risk are largely unconsciously selected, are generally based upon untested assumptions and influence, in turn, expectations about future events and the appropriate response to those events. Whilst different groups have different perceptions of risk, they have two tendencies in common: the expectation that the future will be a replication of the past; and the neglect of "uncertain uncertainties" in favour of known uncertainties, or risk.

Norbert Weiner argued (1920) that the assumptions that scientists bring to the design of their experiments are far more interesting than conclusions they draw from them. Similarly, which aspects of a risk are selected by different groups in the population is generally more interesting than their perception of the magnitude of that risk (Douglas, 1986).

Four main groups need to be considered in relation to risks from flooding.

1. Engineers involved in the design of flood alleviation schemes.
2. Emergency planners.
3. The public, including
   (a) the population at risk of flooding; and
   (b) the rest of the population who typically bear most or all of the cost of flood alleviation.
4. Researchers.

These groups, differ in (a) the risks they select for attention; (b) their views about likelihood, causation and outcome; (c) their expectations about their own roles and those of others; and (d) the process whereby they refine their beliefs. There are also common features, in particular a tendency to concentrate upon "certain uncertainties"

(i.e. uncertainties which can be defined) and upon defining the problem in terms of features of the situation which the individual or group can control.

ENGINEERS

Outside the UK and Australia, the traditional term for engineering works designed to reduce the risk or consequences of flooding is "flood control", with the connotations of managing, limiting and binding the unruly forces of nature to our will. Similarly, until a few years ago, the term "river improvement" was used in the UK for engineering works to straighten and reshape the channel to reduce flood risks: these works generally destroyed the ecological or environmental value of the river (Purseglove, 1988). In the context of flooding in Zambia, Namafe (1989) has also argued that the terminology of the overseas consulting engineers, who have advised on flood control works, is quite alien to local cultural traditions. These local traditions imply a much greater degree of adaptation, instead of opposition, to flooding and a less threatening perception of flooding.

Engineers view risk as equivalent to statistical probability. They estimate the risk of flooding in terms of the return period of a flood of at least a given magnitude: a 50 year return period event is one for which there is a 1 in 50 chance that it will occur in any one year. By fitting one of a variety of distribution functions to historical streamflow records, the hydrologist attempts to estimate the flow which is associated with a given return period. Predictions of future floods are then based upon whichever distribution function is the best behaved. In the UK, the average length of record is 16 years and it is generally considered that the most extreme event it is possible to predict reliably corresponds to twice the length of record. Since flood alleviation schemes are typically designed to withstand the 50 or 100 year return period event, considerable uncertainty already exists at this stage (Boorman, Acreman and Packman, 1989).

Longer records would, in theory, reduce uncertainty but only in so far as each additional year of record is a replication of conditions in previous years. Any change in climatic or land use conditions limits the value of longer records. More generally, any estimate of a probability is strictly a conditional probability: its validity depends upon the prior conditions upon which it is based being true. It is thus customary to differentiate between *parametric uncertainty* and *systemic uncertainty* (Blockley, 1980). The former refers to the inherent inaccuracies resulting from measurement error or data availability. Systemic uncertainty refers to the degree to which the model, upon which the conditional probabilities are based, is incomplete or inaccurate. Parametric uncertainty is then a measure of "what you know you don't know" whilst systemic uncertainty refers to "what you don't know you don't know".

The predicted flow must then be converted into flood extents and flood depths through hydraulic modelling. Such hydraulic models must be calibrated against known events but the data to calibrate them are typically sparse and of uncertain reliability.

There is some evidence to suggest, however, that these models (Linsley, 1986), and indeed engineering practice itself, are biased towards conservatism: in this case, towards the overestimation of flood flows. Engineers, and perhaps especially water engineers, have a culture of social responsibility and caution; of providing for the good of society (as defined by engineers).

Engineers have traditionally been taught to design safe structures, ones which do not fail, and this cultural tradition explains engineering approaches to setting acceptable levels of failure (Green, 1984). They have sought to determine probabilities

which are so small as to be "negligible" or indistinguishable from zero (Starr, 1969). This is a futile exercise (Green, 1980b; Green, 1988b) but one which can be regarded as an attempt to reconcile the new probabilistic methods of engineering with existing engineering ideologies.

Thus dams, which would pose a risk to life if they failed, are required to have an overflow spillway capable of carrying the Probable Maximum Flow (PMF). The PMF is the flood flow "that would result from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region" (Committee on Safety Criteria for Dams, 1985). But, dams and other engineered structures fail from a great many other causes, including human error (Blockley, 1977). In the case of earth embankment dams, a primary cause of failure is "dry weather failure": erosion or slippage of the embankment and core (Clifton *et al.*, 1985). Estimation of the exact probability of the failure of an individual dam is not susceptible to engineering analysis. Consequently, a case can be made that hazard management strategies should be focused upon the potential causes of failure about which there are the greatest uncertainties, rather than upon those which yield to statistical analysis (Bossman-Aggrey, Green and Parker, 1987). That is, instead of concentrating upon engineering down those probabilities which can be calculated, hazard management should concentrate upon limiting the consequences of failure, since the probability of failure is uncertain.

To overstate the case, the engineers' bias is to focus upon "certain uncertainty", or risk, rather than upon uncertainty. They also tend to concentrate upon reducing the risk rather than the consequences of a failure, and to engineering the risks down to any reasonable level demanded by the public. The public is restricted to making a decision about "acceptable levels", and is kept away from the choice of the technical means to achieve those levels (Green, 1984). Whilst any decision about risk is a choice between limited available options to involve the public in the choice of means as well as ends would concede a much greater part of the professionals' role. In the debate about the acceptability of risk, the problem has been defined in such a way as to give the public a passive role.

The British approach to democracy is that the public should be seen to vote but should not be heard from: democracy is about choosing who is to rule and not about governing. Engineers in Britain are, therefore, probably being no more than British when they seek to involve the public only when a preferred scheme option has been selected. Public consultation is then about "scheme promotion" (explaining why the scheme proposed is the best option), rather than about "scheme selection" or the definition of criteria for scheme selection. Consultation is thus about legitimising the decision rather than the process of decision making. The literature suggests, however, that consultation should occur early on, before major choices have been made (Bruton, 1980; Kasperson, 1986; Krimsky, 1984) and before the choice has been narrowed down to a preferred option (Tunstall and Fordham, 1990).

In general, the public are regarded as a force to be placated rather than involved, on the "let sleeping dogs lie" principle. Engineers have traditionally defined their social responsibility as providing the public with what they *need*: the redefinition by engineers of their social responsibility as providing the public with what they *want*, and are willing to pay for, is comparatively recent.

EMERGENCY PLANNERS

Expectations of what will happen can trap emergency planners into inappropriate responses in the same way that they can trap the individual (Green, 1980a). In the UK,

emergency planners are frequently more concerned about the risks of public response than about the risks of flooding. One fear is of giving warnings which are not followed by floods, the "cry wolf syndrome" (Breznitz, 1984), coupled with concern about legal liability for warnings (Parker, 1989). Another fear, often put forward as a reason for not instituting a public awareness and warning programme for dams (Parr, 1990; Rofe, 1988), is that the public would be frightened and would react adversely to the implied threat to property values. Again, there is an undercurrent of letting sleeping dogs lie.

Moreover, the police, the lead emergency response agency, frequently adopt a public order model of response rather than an enabling model: they tend to expect the public and others to wait until they are told what to do and then do it. UK emergency plans are typically based upon such a passive response model: until recently people were advised by the government to whitewash the windows of their houses and to build shelters in inner rooms in the event of a threatened nuclear exchange.

The expectation of panic, or of causing unnecessary anxiety, is still a significant constraint on emergency planning in the UK. Because of this expectation, people living in risk areas are not generally informed of the possibility that they might have to evacuate their homes in the event of a dam failure (N. Parr quoted in *New Civil Engineer*, 8 February 1990, p. 13). It follows that the risk of causing public anxiety is seen as greater than the risk that, if a dam failure does occur, evacuation will fail to be successful because of public ignorance. According to conventional wisdom (Mileti, 1975), the provision of information in advance to the population at risk is necessary if evacuations are to be successful.

The fear of "panic" by the public is reported elsewhere to have delayed decisions to evacuate (Drabek, 1986). If this fear is prevalent in an organisation, the tendency will be to defer a recommendation to evacuate until it is certain that it is essential. Because warning and evacuation take hours to complete, this delay could severely erode the available time margins.

Whilst a number of successful evacuations have been reported (Stanbridge, 1980), it is not clear whether these were simply precautionary nor how successful they would have been if lives had been seriously at risk. That is, the time required for evacuation may well have exceeded the time available for evacuation in the event of a real crisis (Prugh, 1985).

Although it is very difficult to operationalise the term "panic" (Drabek, 1986) and although the phenomenon itself is very seldom observed, "panic" is commonly used not only by the media in describing what happened in a disaster but also by survivors to describe their own behaviour. We have tested a scale to measure the stress caused by a flood event, most of the statements included in this scale being derived from the physiological responses associated with stress (Green, 1988a). One of the statements we used was "I panicked" and agreement with this statement was significantly associated with agreement with a number of others.

These other statements can be grouped into two sets. The first set is made up of statements relating to the fear and risk perceived to exist. The second set is made up of statements which all relate to not knowing what to do or being unable to cope with the situation. So, when people use the term "panic", they seem to be referring to the level of fear they experienced and their perceived inability to cope with the situation. We cannot tell from these data whether the associations are causal or descriptive but we strongly suspect that they were using the term "panic" either to describe the behaviour which they consider to have been inappropriate or because they did not know what to do.

Another finding was that men are more

likely than women to agree with the statement, "I panicked" (Green, 1988a). We suggest that this is because their self-image demands that they *do* know what to do and *are* in control of the situation. Studies of behaviour in fires, for example, show that men are both more active than women and generally do not accept a woman's report of a fire, but have to confirm it for themselves (Canter, 1983).

THE PUBLIC

It is a truism that all of us spend more time being members of the public than being experts and that there is not one "public" but many (Rayner, 1986). We find that the likelihood of flooding is analysed by the public in causal terms (Tunstall, Fordham and Green, 1990), as opposed to the engineer's probabilistic conception of likelihood. If a flood occurs, this is often interpreted as the result of some human cause and if floods have not happened recently, this is because something has been done. We have found no indication of public perceptions of floods as following cyclic patterns as reported by other authors (Burton, Kates and White, 1968).

Those who have been flooded have generally developed a model of the causes of flooding which they can use to predict the likelihood of flooding in the future. We have found, for instance, that in areas where tidal flooding has occurred, a not uncommon adaptation is to buy a Tide Table. If there is a gale in winter, the Tide Table is consulted to see if there will be a high tide: floods are correctly understood only to occur when both factors are present.

Those who have not been flooded do not appear to underestimate the severity of the consequences of flooding compared to the relative severity of different potential household diasters. Furthermore, their expectations of their ability to cope with flooding appear fairly high although somewhat optimistic. Whilst 74 per cent of those households who had not been flooded agreed with the statement "I could cope", 70 per cent of a sample of flood victims agreed with the corresponding statement "I knew I could cope", as did 44 per cent and 57 per cent of the two other groups of flood victims (Tunstall and Bossman-Aggrey, 1988). There is, however, a significant difference between the responses of those who had previously been flooded and those for whom it was their first experience. Whilst 74 per cent of those who had been flooded before agreed with the statement "I knew I could cope", only 54 per cent of those for whom it was their first experience agreed with the statement. Moreover, whilst 63 per cent of those who have not been flooded agreed with the statement, "I would know what to do", only 29 per cent of flood victims agreed with the corresponding statement "I knew what to do" (Green, 1988). Previous experience of flooding did not significantly affect the proportions of flood victims who agreed either with the statement "I didn't know what to do" or the statement "I knew what to do".

Having been flooded provokes a rush of adaptations designed not merely to give warning of potential flooding in the future but also to protect against flooding. At the most extreme, a number of occupiers of bungalows at Uphill, a village which suffered relatively extreme tidal flooding, reported having installed a ladder to the attic (Green *et al.*, 1985). Adaptations of one sort or another are frequent, as they have been found to be in all parts of the world (Halcrow Fox, 1988; Paul, 1984).

The use of such precursor events as predictors of flooding is sufficiently common that it can be used to develop a measure of the anxiety or worry caused by the risk of flooding (Green, 1988a; Penning-Rowsell, Parker and Green, 1984). The disadvantage of such a scale is that it must be tailored to the indicators used locally and hence it is difficult to make comparisons between different sites.

The degree of worry individuals express is related both to their judgements of the severity of flooding which they experience and to their judgements of the likelihood of flooding (Green *et al.*, 1987). In turn, the degree of worry and the adaptations adopted, as measured by the revealed worry scale, are highly correlated (Green, 1988a).

The perceptions of and responses to flooding by members of the public who are not subject to flooding are also of concern since they will largely bear the costs of any flood alleviation works. Concern, and particularly anger, seem to be triggered by beliefs that something *could* be done but it is not being done (Green, 1986b). Thus, as Kelly (1955) describes it, anger is a response to the threat to the individual's core beliefs about the nature of the social contract which arises when the individual's expectations about the behaviour of different parties are not met. People's expectations as to the appropriate behaviour and roles of the different participants are thus crucial to their interpretation of what happened and to the allocation of blame.

RESEARCHERS

There is now a substantial body of work by psychologists on the perception of risk (Fischhoff *et al.*, 1978; Green, 1980a; Renn, 1981; Vlek and Stallen, 1981). The weaknesses of this work are, firstly, that it is not based upon any model of the organisation or purpose of beliefs about a hazard (Green, 1986a) and, secondly, that it is based upon cross-sectional rather than longitudinal studies. These studies also generally assume an underlying consensus about preferences or, at the very least, a commonality of perceptions. Further, by using the concept "attitude" rather than "choice", it is assumed that people have a passive role in the decision making process (Green, 1984). "Attitude" defines the issue as one of evaluating single, isolated options rather than deciding between options. In simple contexts, where the choice is only between two mutually exclusive options (e.g., "going to church" versus "not going to church") conventional attitude theory (Fishbein and Ajzen, 1975) is equivalent to a theory of choice. When there are many options, however, a measure of a person's attitude to one of them does not indicate it's desirability, since the same person might evaluate another option more highly.

Douglas (1986) points out that psychologists' models of risk perception and response make no allowance for the process of selecting hazards for attention and typically assume that the person is an island, self-determined through experience, rather than a product of his or her culture and community. Rayner (1986) has shown that different groups do hold different beliefs about a hazard and different preferences about the appropriate response, although a wholly culturally determined model of risk perception and response is likely to be as partial as an individually self-determined one.

Like most psychological models, the anthropologically based grid-group model (Rayner, 1986) is static in that it does not address the problem of how hazards are selected for attention and integrated into existing frameworks of beliefs. We are increasingly inventing hazards, rather than responding to existing ones, or modifying them so as to change their nature. In these circumstances, we start off as members of the public, either ignorant or with a set of beliefs about the hazard which may no longer be appropriate (Green, 1982). What is required is a model which can map the evolution and change of these beliefs and, ideally, enable us to predict which hazards will be selected as of concern, given that the data with which we are presented will itself be contradictory.

Geographers tend to focus upon the damage that floods cause, to argue that the public misperceive the risks and to be biased

towards non-structural adaptations, such as warning systems and land use control for instance. It is often implied, for example, that floodplains should not be developed. They have typically assumed that annually rising national annual damages are a sign of the mismanagement of a hazard (Platt, 1986) but this does not necessarily follow. It may be that any strategy would be accompanied by rising damages or that a strategy which resulted in stable or reducing damages would do this at the cost of unacceptable penalties. Equally, any strategy which involves restraining development on floodplains may simply displace it to areas where it causes more certain losses. Faced with a choice between developing a floodplain and accepting increases in annual flood losses, or developing an area of outstanding natural landscape value, it is not necessarily irrational to adopt the former option. Again, failure to define the issue as one of choice amongst limited available options can distort evaluations.

Equally, a focus on the losses from flooding detracts attention from the degree and rate of recovery. Recovery from some losses can be both rapid and complete: indeed, with "new-for-old" household contents insurance policies, recovery can be *more* than complete for contents losses. But, for other impacts, recovery can take much longer and may never be completed (Green and Penning-Rowsell, 1986). It is arguable, however, that it is the capacity of the community to recover, rather than the magnitude of the losses, which is important.

The problem for flood plain residents has also been defined by geographers as that of minimising the risk: it may instead be that they seek to minimise the stress, the psychic costs of adapting to the threat (Green, 1990). If denial or acceptance of the risk results in lower adaptation costs in the long term, this strategy may be judged more effective than taking action to minimise the risk.

Economists make very strong assumptions about the nature of both individual and social choice. The theories of microeconomics and welfare economics have been developed from theoretical, as opposed to empirical, analysis of purchasing choice. The implied model of human motivation which is used as the axiomatic base for analyses of such decisions is very simple: Rational Economic Person is selfish in his or her motivation. As Margolis (1982) notes, there is no opportunity to exhibit altruism when buying goods. This model may be grossly inadequate to explain the choices involved in the provision of social goods (Green and Tunstall, 1990).

Equally, the proposed criteria for social choice, the Hicks-Kaldor Compensation Principle or Potential Pareto Improvement (whereby the amounts individuals are willing to pay for a good, such as flood alleviation, are summed and if this sum exceeds the cost then the good is provided) is a model of society as a pile of sand — as an aggregation of individuals. It does not require there to be any social organisation, any concept of a social decision except as the sum of the decisions of the individuals who compose that society.

Economics also concentrates upon economic efficiency. Either economics is said to be about economic efficiency (do the benefits exceed the costs?) and issues of equity have to be considered over and above the results of the economic analysis, or economic efficiency considerations are used as a guide to questions of rights and equity. Thus, Coase (1960) sought to determine who had which rights on the basis of arguments of economic efficiency. Economists also tend to concentrate, as do geographers, upon losses rather than the degree and speed of recovery from a flood.

Flood alleviation schemes have to pass the Potential Pareto Improvement test to be financed in the UK and USA, and the scheme benefits are measured as the value of losses, weighted by their probability of occurrence, which would otherwise have

occurred from flooding. But the losses which have been counted have been those which it has been easiest to evaluate — the direct and indirect damages — rather than those which are most significant to those who are flooded (Green and Penning-Rowsell 1986).

To those who are flooded, it is almost invariably the other effects of flooding, such as the stress, disruption to life and anxiety it induces which are regarded as the most serious impacts. These non-monetary impacts are normally not evaluated and are excluded from the analysis of scheme benefits and costs. So, economic analysis typically proceeds in precisely the opposite manner to the ideal method of assessing projects which would start with the most significant impacts (Green and Penning-Rowsell 1986).

Whilst engineers tend to estimate future flood probabilities by extrapolating from flood events, so too do economists tend to construe the future as a replication of the past. Analyses are typically based upon the extension of losses which would result from a flood now to those which would result from a flood at some date in the future. The potential for flood damages to change over time is not typically included in the analysis. The economic benefits of reducing flood losses are estimated in terms of the annual average damages that are likely to occur in the future over the life of a flood alleviation scheme (Penning-Rowsell and Chatterton, 1977; Parker, Green and Thompson, 1987). However, we know that this average will be different from the actual damages that will be avoided over the life of a scheme, because the pattern of occurrence of floods in the future will be different from that which has occurred in the past (Arnell, 1989).

CONCLUSIONS

We have argued that there are very wide differences in the risks selected and defined by different groups in a population. In turn, this suggests that risk communication is more appropriately defined in terms of communicating problem definitions and choices rather than numbers. Otherwise, the different participants will try to solve different problems and see other participants as trying to solve irrelevant problems. They also hold different models of each other's roles and different models of the person. They consequently have different expectations of appropriate and likely behaviour. These expectations may not only be inaccurate but may also result in conflict.

We all tend to see the future as a replication of the past and to focus upon "certain uncertainties" rather than true uncertainty. That is, we allow our definition of a problem to be limited by the formal and informal techniques available to analyse it (Green, 1986) and to concentrate our attention upon those issues which are amenable to our techniques. In terms of improving analytic methods, of improving what we can do, the recognition of the limitations of our techniques and the identification of the significant issues that are excluded from our current consideration is crucial.

References

Arnell, N.W. (1989) *Uncertainties and flood alleviation benefit assessment*. Institute of Hydrology, Wallingford.

Blockley, D.I (1977) Analysis of structural failures. *Proceedings of the Institution of Civil Engineers* 62, Part 1, 51–74.

Blockley, D. (1980) *The nature of structural design and safety*. Ellis Horwood, Chichester.

Boorman, D.B., Acreman, M C. and Packman, J.C. (1989) An assessment of flood estimates using the Flood Studies Report. In *Proceedings of the Second National Hydrology Symposium*. British Hydrological Society, Wallingford.

Bossman-Aggrey, P., Green, C.H. and Parker, D.J. (1987) *Dam safety management in the United Kingdom*. School of Geography and Planning Paper No. 21, Middlesex Polytechnic, Enfield.

Breznitz, S. (1984) *Cry Wolf. The Psychology of False Alarms*. Lawrence Erlbaum, Hillsdale.

Bruton, M.J. (1980) Public Participation, Local Planning and Conflicts of Interest *Policy and Politics* 8(4), 423–442.

Burton, I., Kates, R W. and White, G F. (1968) *The Human Ecology of Extreme Geophysical Events*. Natural Hazard Research Working Paper No. 1, Department of Geography, University of Toronto.

Canter, D.V. (1983) *Studies of Human Behaviour in Fire Empirical Results and Their Implications for Education and Design* Department of Psychology, University of Surrey, Guildford.

Clifton, J.J., Holden, P.L., Kennard, M.F., Phillips, D.W. and Webber, D M. (1985) *A Feasibility Study into Probabilistic Risk Assessment for Reservoirs*. Report ER 188, Water Research Centre, Swindon.

Committee on Safety Criteria for Dams (1985) *Safety of Dams· Flood and Earthquake Criteria*. National Academy Press, Washington D C.

Coase, R.H (1960) The problem of social cost. *Journal of Law and Economies* 3, 1–44.

Douglas, M. (1986) *Risk Acceptability According to the Social Sciences* Routledge and Kegan Paul, London.

Drabek, T.E. (1986) *Human System Responses to Disaster An Inventory of Sociological Findings* Springer-Verlag, New York

Fischhoff, B., Slovic, P., Lichtenstein, S., Read, S., Coombs, B (1978) How safe is safe enough? A psychometric study of attitudes towards technological risks and benefits. *Policy Sciences* 9, 127–152.

Fishbein, M. and Ajzen, I. (1975) *Belief, Attitudes, Intention and Behaviour*. Addison-Wesley, Reading, Mass.

Green, C H. (1980a) Risk beliefs and attitudes. In Canter, D.V. (ed.) *Fires and Human Behaviour*. John Wiley, Chichester.

Green, C.H. (1980b) Revealed Preference Theory: Assumptions and Presumptions In Conrad, J. (ed.) *Society, Technology and Risk Assessment*. Academic Press, London.

Green, C H. (1982) Perceived Risk: Rationality, Uncertainty and Scepticism. In *Living with Uncertainty — Risks in the Energy Scene*. Oyez, London.

Green, C.H. (1984) Risk, Uncertainty and the Nuclear Energy Option. Paper given to the Social Statistics Section, Royal Statistical Society, London.

Green, C.H. (1986a) Reason, choice and risk. Paper presented at the Colloque Internationale de Recherche, *Evaluer et Maitriser les Risques*, Chantilly.

Green, C.H. (1986b) Social choice and benefit-cost analysis In Handmer, J and Penning-Rowsell, E C. (eds.) *Flood Hazard Management: British and International Perspectives*. Geo Books, Norwich

Green, C.H. (1988a) The relationships between the magnitude of flooding, stress and health. Paper presented at the London meeting of the British Psychology Society.

Green, C.H (1988b) The tolerability of risk from nuclear power stations a critque. In Health and Safety Executive, *Comments Received on the "Tolerability of Risk from Nuclear Power Stations"*, Her Majesty's Stationary Office, London

Green, C.H. (1990) Perceived Risk. Past, Present and Future Conditional In Handmer, J. and Penning-Rowsell, E.C. (eds.) *Risk Communication and Response*. Gower, Aldershot.

Green, C.H., Emery, P.J., Penning-Rowsell, E C. and Parker, D.J. (1985) *The health effects of flooding· a survey at Uphill, Avon*. Flood Hazard Research Centre, Enfield.

Green, C.H. and Penning-Rowsell, E C. (1986) Evaluating the intangible benefits and costs of a flood alleviation proposal. *Journal of the Institution of Water Engineers and Scientists* 40(30), 229–248.

Green, C.H., Penning-Rowsell, E.C. and Parker, D.J. (1987) Estimating the risk from flooding and evaluating worry. In Covello, V.T., Lave, L.B., Moghissi, A. and Uppuluri, V.R.R. (eds.) *Uncertainty in Risk Assessment, Risk Management and Decision Making*. Plenum, New York.

Green, C.H. and Tunstall, S.M. (1990) Is the economic evaluation of environmental goods possible? Paper given at the Workshop "Question de Risque et Environnement", Paris.

Halcrow Fox (1988) *Taiz Upgrading Project: Conceptual Design and Planning Report*. Halcrow Fox, London.

Kasperson, R.E. (1986) Six propositions for public participation and their relevance for risk communication. *Risk Analysis* 6(3), 275–281.

Kelly, G.A. (1955) *The Psychology of Personal Constructs*. Norton, New York.

Krimsky, S. (1984) Beyond technocracy: new routes for citizen involvement in social risk assessment. In Peterson, J.C. (ed.) *Citizen Participation in Science Policy*. University of Massachusetts, Amherst.

Linsley, R.K. (1986) Flood Estimates: How Good Are They? *Water Resources Research 22(9), 159–164.*

Margolis, H. (1982) *Selfishness, Altruism and Rationality*. Chicago University Press, Chicago.

Mileti, D.S. (1975) *Natural Hazard Warning Systems in the United States: A Research Assessment*. Institute of Behavioral Science, University of Colorado, Boulder.

Namafe, C.M. (1989) The Dutch Hydro-agricultural rice project in Western Zambia: An Assessment. Paper given at *The People's Role in Wetland Management* Conference, Leiden.

Parker, D.J. (1989) Legal and Administrative arrangements for flood warnings in England and Wales: The Case for Change. Paper given at *The III World Conference on Water Law and Administration*, Alicante/Valencia.

Parker, D.J., Green, C.H. and Thompson, P.M. (1987) *Urban Flood Protection Benefits: a project appraisal guide*. Gower Technical Press, Aldershot.

Paul, B.M. (1984) Perception of and agricultural adjustment to floods in Jamuna Floodplain, Bangladesh. *Human Ecology* 12(1), 3–19.

Penning-Rowsell, E.C. and Chatterton, J.B. (1977) *The benefits of flood alleviation: a manual of assessment techniques*. Gower Technical Press, Aldershot.

Penning-Rowsell, E.C., Parker, D.J. and Green, C.H. (1984) *Loughton Brook improvement scheme: assessment of potential benefits*. Reports to Thames Water, Flood Hazard Research Centre, Enfield.

Platt, R.H. (1986) Floods and Man: A Geographer's Agenda. In Kates, R.W. and Burton, I. (eds.) *Geography, Resources and Environment: Volume II, Themes from the Work of G F White*. University of Chicago, Chicago.

Prugh, R.W. (1985) Mitigation of Vapor Clouds. *Plant Operations Progress* 4(2), 95–102.

Purseglove, J. (1988) *Taming the Flood*. Oxford University Press, Oxford.

Rayner, S. (1986) Management of Radiation Hazards in Hospitals: Plural Rationalities in a Single Institution. *Social Studies of Science* 16, 573–591.

Renn, O. (1981) *Man, Technology and risk: a study on intuitive risk assessment and attitudes towards nuclear energy*. Nuclear Research Centre, Julich.

Rofe, B. (1988) reply to risk management and reservoir maintenance. In *Proceedings of the Institution of Water and Environmental Management Annual Symposium "Risk Management in Water and Environmental Services"*. The Institution of Water and Environmental Managers, London.

Stanbridge, E.C. (1980) *Emergency Evacuation: Emergency Planning Officer's Report*, London Borough of Barking and Dagenham.

Starr, C. (1969) Social Benefit vs Technological Risk. *Science* 165, 1232–1238.

Tunstall, S.M. and Bossman-Aggrey, P. (1988) *Waltham Abbey and Thornwood, Essex: An Assessment of the effects of the flood of 29th July, 1987 and the benefits of flood alleviation*. Report to Thames Water. Flood Hazard Research Centre, Enfield.

Tunstall, S.M. and Fordham, M. (1990) *Thames Perception and Attitude Survey: Datchet to Walton Bridge*. Flood Hazard Research Centre, Enfield.

Tunstall, S.M., Fordham, M. and Green, C.H. (1990) Perception of Flood Risk and Attitudes to the Local Environment, River Management Schemes and Public Consultation Procedures. Paper given to the 2nd Meeting of the European Chapter of the Society for Risk Analysis, Vienna.

Vlek, C., Stallen, P.J. (1981) Judging risks and benefits in the small and in the large. *Organizational Behaviour and Human Performance* 38, 235–271.

Weiner, N. (1920) A new theory of measurement: a study in the logic of mathematics. *Proceedings of the London Mathematics Society*. Series 2, 19, 181–205.

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