SOCIETY, PREDICTION AND WARNING: CURRENT ASSUMPTIONS ON THE IMPLICATIONS OF EARTHQUAKE FORECASTING

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ABSTRACT:

Earthquake prediction and warning is a newly-developing technology, the potential of which may have profound effects on the amelioration and mitigation of one of nature's most destructive hazard-agents. As yet, this new technology is largely untested in the western world. The politico-socioeconomic consequences of earthquake prediction and warning are uncertain - there have been some who have suggested this new technology may produce more devastation than the earthquake itself. This paper summarises recent social science research on the problems of earthquake prediction technology, the economic, legal and social effects that may accrue as a result of forecasting earthquakes, and draws attention to the difficulties which scientists face at present with regard to the new development.

INTRODUCTION:

Since ancient times, earthquakes have been regarded as one of the most formidable natural threats to human life and property. It is estimated that since the year 1,000 A.D. more than five million people have perished in earthquakes, although the numerical estimates vary widely between sources[32]. The average annual number of victims since the beginning of the twentieth century may be about 24,000. The material losses due to earthquakes are difficult to express in accurate figures because of the lack of precise statistics, variations in exchange rates, inflation, and living standards. However, as an example of such losses, nine earthquakes, from the 1963 Skopje, Yugoslavia earthquake, to the 1972 Managua, Nicaragua tremor, have produced a figure totalling $U.S.3,296,000,000[32]. To this purely material damage must be added the direct and indirect economic consequences: abandonment of home-sites, forced unemployment, production losses and additional costs of health and social services. The human misery and individual losses are immeasurable in money terms - anxiety, stress, injury, disablement, death, grief, the development or exacerbation of phobic tendencies, loss of individual and social heritage - all are possible and likely consequences of a devastating earthquake.

Because of the far-reaching effects earthquake prediction technology may have upon existing features in our society, prediction may introduce more problems than people generally realize. Social science statements referring to the possible effects of an earthquake prediction and warning on social interactions, societal functions and processes, can only be conjectural at present. This is primarily because there have been no major earthquakes that have been successfully predicted in the western world for anyone to empirically assess the effect and consequences this new technology has on existing social arrangements. The purpose of this paper is to summarize the assumptions of the more significant research conducted by social scientists relating to the social implications of earthquake prediction.

At present, there are six adjustments that can be employed to counter the earthquake threat: land-use control; seismic resistant construction; prevention of secondary hazards; preparation of emergency services; relief and rehabilitation; and insurance. Because of the infrequency of damaging earthquakes in any one locality, few, if any communities utilize all six of these adjustments to the maximum. According to Haas and Mileti[14] it is rare for any one of these adjustments to be fully developed and implemented within any one city. They describe it as a 'classic case of underutilization of available prevention and mitigation measures'.

By 1973, accumulating empirical evidence had made the prospect of earthquake prediction credible[30]. Earthquake prediction, however, does not replace any of the existing mitigation devices that are available to society; but it may supply information allowing society to make a more complete analysis before selection of the alternatives most appropriate to the conditions and goals are made.

PROBLEMS ASSOCIATED WITH EARTHQUAKE FORECASTING:

Blundell[6] states there are real problems in forecasting earthquakes that differ from forecasting other natural hazards:

1) There is a relatively long time uncertainty, and no society can afford to have the routines and functions of life disrupted for weeks or months on end;

2) the danger is not over if no earthquake occurs when forecast. It is difficult to terminate a false alarm.

3) The general public usually have no independent means of assessing the accuracy of a forecast until the earthquake occurs;

4) the general public and authorities generally have little or no previous experience of a major earthquake;

5) the issuing of a public forecast or warning months ahead of an expected earthquake may have deleterous effects; the concomitant social and economic consequences that some have assumed will occur may negate the positive effects of knowing that an earthquake will occur beforehand*.

To this list of Blundell's may be added a sixth problem, also possibly unique to the earthquake prediction situation; because the general public do not have the resources, experience, or expertise to reach their own independent conclusions concerning the validity of a prediction, or even whether an earthquake is imminent or not, they are totally reliant on the scientific community for any information concerning a forthcoming earthquake. Thus a special relationship must be established and must co-exist for the appropriate dissemination of information from one group to the other. A high level of understanding and trust must be created between the general public, on the one hand, and the seismologist, the geophysicist, the geologist, and the engineer on the other (see also Allen[3]). This degree of mutual understanding and trust is not a characteristic of our society[35]. The power to predict earthquakes carries with it a responsibility for the scientific community to communicate findings and mitigatory actions intelligibly, and to ensure that those who instigate policy decisions based on predictions and warnings understand the value and limitations of forecasts.

Because of the long periods between major earthquakes for any one area, every prediction is likely to be the first such experience for most of the population, and for most of the personnel charged with preparing for the event. Therefore, there is little hope of accumulating experience within the local community for dealing with predictions of significant earthquakes. Within the foreseeable future, it is unlikely that predictions can be made with a high degree of certainty, and it is also likely that earthquakes will occur without being predicted. It is likely then, that earthquake prediction will be troubled with problems of public credibility. There are other problems that may result in a net disadvantage. For instance, the availability of an earthquake prediction and warning technology may lull communities into a false sense of security since no prediction may be interpreted as a message of safety. Land-use planning and strict adherence to building codes may well suffer if this is how the new technology is interpreted. As such, the disadvantages of additional losses resulting from the relaxed adherence to other adjustments may outweigh the gains.

ECONOMIC IMPLICATIONS:

The response of economic institutions to predictions and warnings may have far-reaching consequences; however, we do not know if there will be large-scale economic disruption when a prediction has been issued.

* A few investigators, like Hardin[15] ('...we need an earthquake prediction facility like we heed a hole in the head...') suggest the side-effects of a prediction might be worse than the benefits, and that accordingly, the goals of forecasting earthquakes should be abandoned[1,2,13,19].

We do not know how economic decision-makers will react to information regarding an earthquake prediction and concomitant warning. As Giminez[12] states, given that the western world has had no successful prediction of a major earthquake to date, our knowledge of the socio-economic and political consequences of earthquake prediction is necessarily tentative and incomplete.

The economic response will probably be more difficult to determine than predicting the popular response. We have no empirical model of sufficient precision and richness to describe the probable interactions of the different segments of the economic community with confidence. Most economic decision-making models assume that individuals seek to maximise expected gains and minimise losses, after adjusting the value of gains and losses by the probability of their occurrence. These models, however, may supply a poor guide to economic response to earthquake prediction because of three reasons:

1) None of the probabilities can be specified with much precision. Until we are able to gather data on the consequences of predicted earthquakes, we are not in a position to accurately estimate probabilities;

2) Empirical studies of response to uncertainty suggest that decision-makers employ highly simplified models of the real world. The most frequent goal of popular economic decision-making is to attain an adaptive level of outcome compared to the maximization of gains;

3) Research on economic response to natural hazards suggest that potential gains or losses may be disregarded unless a very high probability is initially assigned to the predicted event.

Cochrane[10] states that

'Simple economics tells us that predisaster disruption flows from three main sources: One, the choices of the residents and industry to stay or leave; two, the choices of individuals to buy or not to buy; and three, the choices of financial institutions to lend or not to lend. Of course, changes in government expenditure, both at a national and local level, play a role, but for the most part only a secondary one. The severity of disruption can be pinned directly to these three factors. What is not clear however, is the extent to which these three factors can be linked to the costs and benefits of a prediction.'

Cochrane continues that losses are not necessarily tied to the issuing of a prediction. It is also possible that certain unrelated events may inflict disruption on a community, the net result being unemployment or economic downturn. Shifts in economic activities, downturns in sales patterns and production could take place prior to the issuance of a prediction. These factors may be exacerbated by the declaration of a prediction. Also, as a result of a prediction, the business community will be sensitive to the potential decline in production and sales, and thus a downturn may occur prior to the impending disaster. Any over-reaction which accelerates economic and social disruption may be pinned as a dysfunction stemming from a prediction. If, on the other hand, prediction instills no over-reaction or under-reaction, disadvantages will follow.

Cochrane proposes what he calls a 'catatonic theory of change'[10] - the more change that the market must internalize the more it reacts, the greater the volume of information that is generated. This information - barrage then must be absorbed by businesses and home-owners alike. If the volume of new information becomes excessive and conflicting, confusion results. Confusion breeds inaction, or worse, an effort to 'disadvantage' (sic) oneself of long-lived assets (i.e. liquidate capital). Hence the market system may well provide information about the coming event, and the data may be accurate - however, there is a cost to such information if generated in a fashion too rapid for businesses and residents to absorb.

Attempts to suppress information regarding the prediction could well generate rumours though, and lead to excessively speculative behaviour. An open-information policy to keep the public informed could minimize damaging speculation, but may well exacerbate Cochrane's 'catatonic state'.

Giminez[12] suggests that predictions will always have economic effects besides the social and political, which will vary according to the particular structure of productive activities characterizing the area that will be affected by the prediction. Economic effects will also vary depending on the length of the lead-time; the problems arising from predictions with short lead-times will probably be very different from those predictions associated with a long lead-time.

LEGAL IMPLICATIONS:

There has been very little research related exclusively to the legal implications of earthquake predictions and/or warnings. Suggestions on areas that require recommendations or policy decisions are more numerous that empirical research (see, for instance N.A.S.[22,23]). One of the few papers that is devoted exclusively to the legal implications of earthquake prediction is that by Driscoll[11]. Driscoll suggests that the legal implications extend to a number of quite distinct areas of legal policy. Some of the measures that seem warranted for mitigating earthquake destructiveness will, if taken, have a negative effect on other community values, and conflicts of legal priorities

will no doubt rise. For example, the State's interest in controlling the use of land or buildings in the area of the hazard is likely to conflict with property rights guaranteed as 'inviolable' by the national constitution.

Driscoll states that whatever the respective merits of the argument concerning responsibility for issuing earthquake predictions, there is a strong case for governmental participation in evaluating the prediction's scientific merits. This is so because it cannot be assumed that municipal authorities will undertake rigorous and systematic hazard-reduction programmes by themselves, and many of the legal controls that could be adopted to mitigate the predicted effects may be constitutionally challenged on the grounds of their arbitrariness or unreasonableness. Establishing a scientific panel of inter-disciplinary scientists, incorporating key governmental decisions-makers (similar to the United States Advisory Committee on Emergency Planning) would be an appropriate device for evaluating and recommending policy based on earthquake prediction and warning, in the hope that a balance between acceptable counter-measures be implemented of the level, type, and degree that the national economy and political institutions can withstand.

'Every hazard preparedness programme must deal with the same central legal issues: It must clearly outline the duties placed upon governmental and non-governmental agencies and individuals; it must ensure that there are no jurisdictional loopholes so that no disaster-prone area is without a preparedness plan; and it must also deal with any necessary problems of interjurisdictional co-operation. The plan must also ensure that agencies which are assigned particular tasks have sufficient legal power to carry out the recommended and required measures.'[11]

RESPONSES OF DECISION-MAKERS:

Little work has been done specifically on the impact of earthquake prediction on institutions(see 4,8,20,27,29,31). However, there are several assumptions we can make about the possible impact, based on a knowledge of institutional processes. The emerging of earthquake prediction, according to Anderson and Thiel[4] should be viewed as a potential discontinuity to institutions as they accommodate their practices and relationships to a radically new technology. The current approaches that have evolved to provide appropriate hazard protection are enmeshed in, and, in the main are masked, by other social, institutional, and hazard issues. The emergence of this new, very publicly visible technology provides an opportunity to re-examine the approaches of the past and reformulate responses and goals that are responsive to current and expected future needs and technological capabilities.

Cochrane[10] states it is possible that an earthquake prediction will have little value as far as property losses are concerned, at least under existing institutional arrangements. There are some measures that may be undertaken, the net result of which would reduce property losses. These include such actions as lowering water levels in reservoirs, turning off gas and electricity mains, and the like. But none of these actions are directly related to the earthquake itself; they are actions which diminish losses resulting from the secondary hazards of an earthquake. Nowhere in the western world has there yet been any major institutional adaptation or change that has been based on knowledge acquired from earthquake prediction studies.

Government institutions at all levels can be expected to assume key roles in both earthquake prediction and earthquake warning activities. The responsibility of government will be to maximise the benefit of prediction technology while at the same time minimising the negative consequences[4]. Earthquake hazard management, however, as with all natural hazard management actions and initiatives, whenever and wherever possible, should be incorporated into existing organisations, institutions, legislations, regulations, building codes, relief procedures, and loan requirements, so that they become part of the established activities, and not superimposed as separate and additional procedures.

Institutional commitment is necessary; without institutional intervention it is likely that individuals and groups will possess different levels and types of information on risk assessment capabilities. Different groups within the social milieu (for example, the elderly, the handicapped, the lower socio-economic status groups, minority groups) may be less likely to respond adequately to the warning for a number of reasons - they may not receive the warning, or may not understand it, or they might not trust it (8,12,14,16,22,25,28,30).

Institutionalized hazard-reduction procedures may also work in opposition to the newly evolving prediction/warning technology. Evidence from research in the United States suggests that holding earthquake insurance for some decision-makers may constrain decisions to reduce the vulnerability because of a prediction. Corporations and businesses which are insured against earthquake losses are not likely to take actions to further reduce vulnerability[20]. If this behaviour can be extrapolated to the New Zealand situation (and there is no evidence to the contrary[7,8], then the New Zealand government-initiated Earthquake and War Damage Commission may have as many negative attributes as it has positive. Given this proposition, industrial decision-makers may not voluntarily redeploy resources to provide earthquake counter-measures because of the assumed 'cover' they are provided with through levies paid to the Earthquake and War Damages Fund. Because

acquiring earthquake insurance is mandatory in New Zealand (it is a concomitant to every fire insurance policy), it can be suggested that a more complacent attitude may prevail in this country towards the earthquake threat than might otherwise be expected.

Appropriate responses to a prediction will only proceed on the basis of accurate images of prediction consequences. What decision-makers think will happen if the predicted earthquake occurs will be a major factor in changing institutional arrangements[8]. Unfortunately, evidence suggests that the images decision-makers have at present are inaccurate and inconsistent in regard to both what earthquake prediction will achieve in ameliorating earthquake effects, and also how the population of a human settlement will react to disseminated knowledge following a prediction and warning. Policy-makers must consider the option that earthquake warnings will not be taken seriously, especially where there is a major cultural gap between those issuing the warning and those receiving it, and where attitudes towards the administration are ambivalent or hostile. Even where the credibility of those issuing is high (and much thought must go into how the warning is presented to the different sections of a community[8]), it may not be taken seriously because people do not wish to believe that such a threat hangs over their heads. It cannot be assumed that people will voluntarily leave their homes after receiving earthquake warnings which are unaccompanied by visible signs of an impending destruction. Until we have information to the contrary, public policy should be based on this assumption.

INDIVIDUAL AND GROUP RESPONSES:

The present knowledge of individual and collective response to earthquake prediction and warning is incomplete and based largely on analogies from warnings of other types of natural disaster agents. This knowledge and the findings from studies of imagined responses to hypothetical situations must be rapidly replaced with knowledge from studies of responses of actual prediction situations. At present, however, very little research in this area is being undertaken. As Turner[31] succinctly states:

'The effectiveness of earthquake prediction as a tool for reducing the hazard of earthquakes depends upon developing community response plans that can be implemented when predictions are issued. The development of such plans depends, in turn, on understanding how individuals and groups will respond to the news of an earthquake prediction/warning, and to public efforts to carry out hazard-reduction programs.'

Earthquake predictions and warnings will be of little value to society unless that society is prepared to act in a positive way to them. In earthquake prediction, we are dealing with a technology that, by its very nature, demands a unique relationship to institutional processes if it is to be developed. Earthquake prediction will provide people with information: If they are to benefit from that information, people must learn how to use that information.

Responses from earthquake predictions and warnings will vary. Communities whose residents have had recent experience with a disaster, especially those who have experienced an earthquake disaster, are more likely to respond constructively to warnings[8]. 'Disaster subcultures' develop in areas exposed to recurrent disaster threats - people in these areas show a high degree of sensitivity to the disaster threat[21,34].

Popular disbelief and inaction will be enhanced if public officials or government representatives delay the issuing of warnings, or suppress predictions until they can be quite certain that the danger is real. Both scientists and officials are concerned that false alarms might affect the credibility and future effectiveness of earthquake prediction. This is compounded by another 'worry' that afflicts these officials: because the predictions, warnings, and the responses are all human actions, the clear mandate of sympathy for the victims that is usually experienced by way of extreme altruism for the victims of a natural disaster may be muted by the confusion[24] over who is responsible for the outcome of the warning (whether the earthquake occurs or not) and blame and scapegoating may occur - the embodiment of which may be the scientists and the public official. This is an unjustifiable concern however; research suggests that scientists and public officials would not be blamed for a false earthquake prediction, or the damage and death caused by an actual earthquake. Conversely, however, if scientists and officials had sufficient information which made them aware an earthquake may occur at a certain time and place, and if a prediction and warning was not issued, and if the anticipated earthquake did occur, the public would become extremely critical and demand compensation.

Experience in the United States with tsunamis and other natural hazard threats indicate an uncertain public response to government-ordered evacuation of areas, and the vacating of designated buildings. With a long lead-time, and no visible threat, coupled with the acknowledged uncertainty over the prediction and the earthquake's effect and with the possibility that evacuation might last for weeks or months, evacuation plans might well be impractical and politically controversial. The social, psychological, and historical ties to a neighbourhood may over-ride definitions of self-preservation in terms of safety[25]. Massive evacuation, in all likelihood, will be an unacceptable strategy because of the crippling effect on the threatened community; the difficulty in locating a suitable host community, or establishing one; the demoralizing consequences of

separating family members and removing dependants from familiar surroundings at a time of stress; and the direct cost of evacuation processes all suggest this to be an impractical mitigatory measure as an initial resort. Selective evacuation, however, and the systematic vacating of unsafe structures may be implemented with minimum disruption.

With long lead-times, studies could be initiated to identify areas and structures where hazards cannot be ecomonically reduced, and evacuation plans can be implemented for these locations. With a shorter lead time, plans could be applied to more obviously dangerous localities such as those areas downstream from potentially unsafe dams; major industrial areas, particularly oil and petroleum installations; areas susceptible to unmanageable fires; areas prone to landslips; and the area especially vulnerable because it has been designated as the epicentre. Evidence from other life-threatening situations, however, suggests that most inhabitants of an area will attempt to continue life as usual. It appears that outmigration will only occur in those areas where damage is forecasted to be heavy[31]. Furthermore, such a tendency will be accentuated if a sizeable proportion of the population is contemplated relocating prior to the prediction. This finding is consistent with previous hazard research which indicates that a disaster tends to accelerate any ongoing changes within the community. Added to this is the awareness that destructive earthquakes seldom recur in the same location except at intervals of decades[31], thus long-range commitment to an area is unlikely to be weakened by the short-term danger.

Whether earthquake prediction leads to adaptive responses depends to a large extent on whether the threat is seen as one to be dealt with on a strictly individual and family basis, or is a situation requiring some type of collective attack. Doubt has been expressed whether an earthquake prediction would produce an intensification of community solidarity, in the absence of which, an attitude of every individual or family for themselves might impede constructive collaboration to cope with the earthquake hazard. Turner[31] stated that collective responses to an earthquake prediction and warning could be either supportive or resistive, the dependent factors being the cost of hazard mitigation steps; absence or presence of a disaster subculture; community pride and autonomy; community solidarity or absence of that solidarity; legislation; cultural and educational backgrounds; group attitudes towards authority; equal access to pertinent information; and awareness and understanding of required mitigatory actions and consequences of the earthquake prediction.

Additional to Turner's factors are the following: The prevailing politico-socioeconomic structure may regard the consequences of a natural hazard as being the respnsibility of the individual (i.e. the family), or the responsibility of the State - whichever one the government legitimizes will profoundly affect collective response to the disaster-situation; response can also be affected by the presence or absence of accepted myths concerning earthquake effects, their frequency, periodicity, and the behavioural responses of potential victims; the presence or absence of existing earthquake countermeasures; and, the accepted degree of efficiency and necessity for the prevailing earthquake countermeasures.

The desirability of earthquake prediction technology lies in the promise it holds to facilitate the achievement of two already existing and ongoing pursuits. One is to reduce earthquake vulnerability, and the other is to increase emergency preparedness. Both goals exist independently of earthquake prediction and are pursued by other earthquake hazard mitigation adjustments. The utility of an earthquake prediction technology lies in the added specificity of information on which can be mounted more intense efforts to reduce vulnerability and increase preparedness. This additional information and the increased preparedness that earthquake prediction can offer is of little benefit on its own, however. There must be more research conducted that will provide empirically-substantiated information on how people will utilize, internalize, and adapt to this new technology. Social scientists should be concerned with discovering through research not only what individuals, groups, and organizations would be likely to do in case a credible earthquake prediction and warning becomes possible, but should also look at the structural constraints that make these responses possible or unacceptable. Research findings may thus provide data to assess the existing positive and negative features of the current socioeconomic system and its ability to cope constructively with earthquake prediction.

THE DILEMMA OF THE SCIENTIFIC COMMUNITY:

Stallings[29] argues that a simplistic, and unrealistic attitude has developed amongst the scientific community in relation to earthquake prediction. He proposes that many scientists assume an earthquake prediction will be believed in direct proportion to its scientific validity, and in inverse proportion to the level of ignorance about such things in the population. Based on this premise, Stallings suggests that these same scientists assume that in order to redress this imbalance, increased spending to improve the state of the art of earthquake forecasting and the launching of mass education programmes in the natural sciences would improve the credibility of predictions. Stallings does not adhere to these assumptions - and with good reason: His paper presents numerous examples of the complexity of the decision-making process, dissemination, and adoption of related strategies that need to be borne in mind when the implementation of earthquake prediction technology is undertaken - and

such implications require more skill, knowledge, and awareness on the part of every person in the earthquake prediction and warning process, much more than simplistic and unrealistic beliefs can offer.

There has also been talk amongst scientists - and by less-informed public and private officials - that earthquake prediction may cause more social and economic disruption than it can prevent. This talk, Hutton et al[16] suggest, and this author concurs, is at the level of professional gossip, rather than an expression of policy or reality, especially on the part of the scientific community. Because of the inadequacy of supportive data to confirm or negate the proposition that earthquake predictions and warnings will present more problems than it will alleviate; and because the natural hazard literature indicates that the general public will, at worst, disregard the prediction and warning, the suggestion that such a new technology will be more devastating than the actual event should be seen only as scientists trying to view all the variables as 'knowns' - contingencies that may become possibilities, rather than actualities.

The likelihood that predictions and near-predictions may be issued months, years, or even decades before the event, creates problems of sustaining interest and vigilance, and the possibility of unmanageable anxiety[31], while allowing time for selection among a great many possible adaptive responses. For severe earthquakes, the prediction time-window within which the 'quake is to occur may also be weeks or months in length, making precise planning difficult, and short-term evasive responses relatively infeasible. Kerr[18] suggests that this situation may create conflicting pressures on earth scientists. Conflicts can be expected between the desire to communicate data to colleagues, and the consideration for the rest of the country involved when the reliability of the prediction may not have been proven by the scientific community. Earth scientists, because of the unique position they are placed in by their understanding and awareness of a possible impending major earthquake, may find themselves placed in a dilemma: Whether to inform the public immediately, thus possibly increasing public chances of reducing the adverse effects of the earthquake; or to remain quiet publicly and relay the information to colleagues who may also remain silent on the grounds that if the predicted earthquake does not occur, their credibility will be damaged. The best compromise between a scientists freedom to make his view public, and society's need to be protected from costly false alarms is, according to the Californian Earthquake Prediction Evaluation Council[9], to evaluate predictions as soon as possible after they are made: if a prediction is not well grounded in evidence, that conclusion, reached in time, is likely to obviate the costs of a needless social response. If, on the other hand, a prediction is endorsed by knowledgeable members of the scientific community, undertaking an appropriate response to that prediction would then become an urgent task.

There is another problem that is gathering momentum, and is being recognized by some researchers as requiring immediate rectification: public expectations of an earthquake forecasting service is rising faster in some countries than research progress, and scientists are becoming increasingly wary of committing themselves. This expectation could become problematic. Earthquake prediction should be seen at the present time as a potent, yet somewhat future-oriented service. The public should be kept informed of every step in such research areas as forecasting techniques, or scientific progress, and how to deal effectively with the issuance of a prediction or warning. But at the same time, they should also be informed of the present capabilities of the technology, and be made aware of the applications for which the technology can be used effectively at present. This must be presented to the public in a realistic appraisal of the situation. There must be a balance between public expectation of the prediction's effectiveness, and the scientific community's capability of fulfilling those expectations. This ultimately leads to the question of education (keeping in mind, though, Stallings[29] warning). Only if the general populace understands that predictions are probabilities of future anticipated events will their expectations be reasonable.

CONCLUSION:

At present there seems to be no way of preventing earthquakes from occurring, and if it is accepted, as Blundell[5] suggests, that they occur over sufficiently wide and valuable areas of the world that we have to live with them, the question then is to know how best to mitigate their hazardous effects. Earthquake prediction technology is one more device that can be added to the existing earthquake-mitigation techniques that have become available to western societies.

The ability to forecast earthquakes, and to issue warnings containing the timing, the location, the magnitude, the area of possible damage, the degree of probable damage, and an expression of the probability or certainty that the event will occur approximately as predicted[7], also contains the possibility of greater disruption to the social system, regardless of whether the predicted earthquake occurs or not. This 'disruption' need not be seen as a negative concomitant, in the sense that earthquake predictions will produce more destructive consequences than the actual event; but it most certainly will 'disrupt' the established institutional arrangements that exist for reducing the effects of a major earthquake. It is this latter 'disruption' that seems to have been overlooked or downplayed by scientists and policy/decision-makers. The economic, political, and psychosocial effects that a prediction and warning

technology may bring upon the established processes and functions within any social system may be very great indeed. They may necessitate an unprecedented re-orientation of not only a society's established politico-socioeconomic structure, but also of the existing mitigatory techniques that are at present available for the amelioration of damaging earthquakes. The introduction of a prediction and warning technology may also imply a somewhat radical re-orientation of societal priorities with respect to the safeguarding of people within earthquake-risk zones, and will also necessitate a confirmation of many social science assumptions regarding human behaviour in extreme situations; certainly it will suggest and stimulate more areas for study.

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