Multiple Attributes Decision Making Method on Social Stability in Nuclear Accident Scenario

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ABSTRACT

The Chernobyl nuclear accident made Europe and even the whole world clearly aware of the threats posed by nuclear accidents. When the Fukushima nuclear accident happened in Japan, the "Rush for Salt Affair" took place in some Chinese cities. Meanwhile, large numbers of anti-nuclear parades were held in many Western countries, such as Germany and the United States. Nuclear accidents have a much more serious impact on society than does an ordinary disaster, due both to the nature and characteristics of nuclear accidents, as well as asymmetric in the general public's access to reliable information. By analyzing the mechanisms and characteristics of the impacts on social stability of a nuclear accident, this paper develops a multi-attributes decision making method based on index system of social stability factors in nuclear accident scenarios.

Keywords

Nuclear accident, social stability, multi-attributes decision making

INTRODUCTION

A nuclear accident (such as an explosion at a civilian nuclear power station), accompanied by a leak of radioactive substances into the atmosphere, is a horrific event, not only because of the accident's direct effect on human beings and the environment, but also because of the effects the accident has on people's psychology and social stability. Due to the fact that much of the harm caused by radioactivity to the human body is invisible, people can't make reasonable reactions through subjective perceptions. Fear, anger, and distrust of the public will always follow a nuclear accident. The accident's impact on the local population and society in general is more profound and long-lasting than would be the case with an "ordinary" disaster. This is why a serious nuclear accident ultimately evolves into a social problem.

In the Three Mile Island nuclear accident, the government's original response plan required the evacuation of only 2,500 people, but actually, about 144,000 people spontaneously fled the area. After the Chernobyl nuclear accident, about 10 percent of the central staff in the immediate area spontaneously fled, including officers, staff and teachers. There were many long queues to purchase train tickets and airline tickets, causing traffic congestion and social chaos. Some neighboring areas were correspondingly affected, causing panic buying of food, iodine pills and anti-radiation drugs (Guo, 1994). On March 11, 2011, as the Fukushima nuclear power plant began to spill radioactive substances into the environment, rumors about the disaster were spreading in some of China's coastal cities, causing panic buying of iodized salt. Salt prices soared and stocks of salt were quickly sold out. Later, as soon as the government clarified rumors of the effects of iodized salt and salt pollution, salt price quickly went back to normal (People's Daily, 2011).

Existing theoretical impact analyses of nuclear accidents focus more on the direct consequences of the accident rather than the psychological and social impacts on society. The study of a nuclear accident's impact generally concentrates on the area covered by the emergency planning zone, such as a radiation ingestion emergency planning zone and plume emergency planning zone. The relationship between nuclear accidents and social stability, however, is rarely studied. Lindell and Perry studied the public's acceptance after a nuclear accident. However, the intangible effects caused by a nuclear accident, such as the effects on social mechanisms and social psychology, are rarely studied (Lindell and Perry, 2006). Slovic studied the perception gap between radiation and risk. The macro-analysis of a nuclear accident's impact on social stability is very important and

necessary to avoid social panic and chaos, and should be further investigated (Slovic, 2012).

RESEARCH METHODS

1 The Mechanism of Nuclear Accident.

Nuclear accidents influence society (the hazard bearing body) by means of energy, substance and related information. On the one hand, social emergency mechanisms and measures mitigate the consequences of the hazards posed by a nuclear accident. On the other hand, social psychology, material factors and social order are dramatically influenced, resulting in the reduction of social stability. Social order includes social control, socio-economic and external social impacts. The immediate results of a nuclear disaster may indirectly effect social order, but social order is directly impacted by the consequences of a nuclear accident, such as human casualties and environmental contamination, as well as psychological fear, distrust, etc. The relationships between these key factors are extremely complicated. The impact is analyzed in Figure 1.

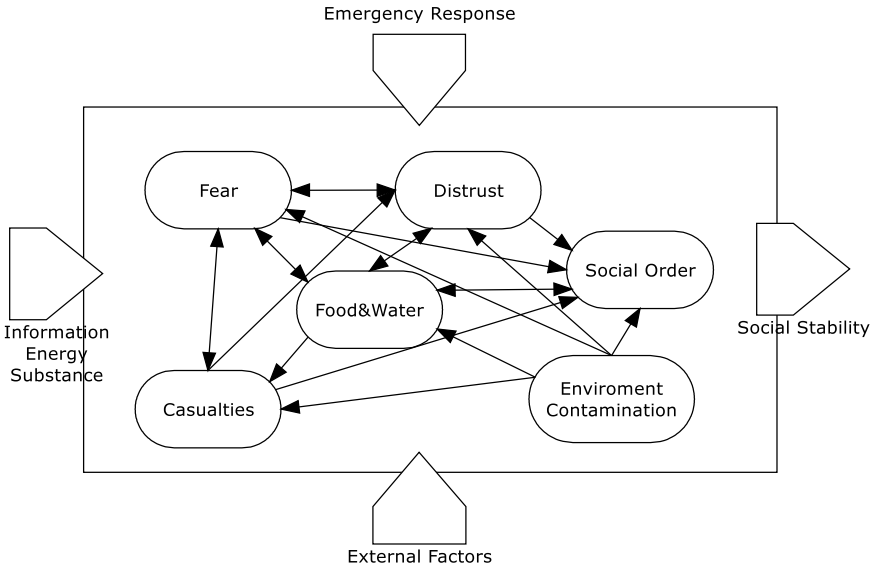

Figure 1.The Mechanism of Nuclear Accident Impact

1.1 The methodological characteristics of nuclear accident hazards.

Society will be influenced in the event of a nuclear accident by the superposition of substance, energy and information. Radioactive substances circulate through the soil, water, air, plants and animals. The actions of radioactive substances are invisible. Below a certain dose, people can't even perceive that they've been exposed to radiation over a short period. Because the pathology mechanism is unclear and treatment is as yet underdeveloped, the effects of radioactivity cause fear in people. The mass fear, anxiety and other psychological problems caused by Information asymmetry after a nuclear accident will combine to produce a major impact on local society and the global masses.

1.2 The time and spatial characteristics of nuclear accident hazards.

The scope of the influence of a nuclear accident is much larger than we expected. Up to September 4th, 2008, 25,000 aftershocks had taken place after the Wenchuan earthquake, but the actual losses and casualties were concentrated in the specific area where the earthquake actually happened. The Chernobyl nuclear accident led to European society even the entire world under panic. Nuclear accidents have more profound impacts than do ordinary disasters. The hazards caused by nuclear accidents will continue to exist as long as the radioactive sources exist. The Chernobyl nuclear accident happened more than 20 years ago, but the 30 km restriction area around the nuclear power plant has still not been lifted, and residents are still not allowed to return home.

2 Characteristic of Social Stability in Nuclear Accident Scenarios.

Social stability can be expressed and defined in multiple dimensions, but social stability as proposed in this paper is: the extent of the impact on social order and public safety, which concludes the social psychological problems, material resources, social mechanisms and a series of public level factors related with the nuclear accident. Due to the methodological characteristics of the hazards caused to social stability by nuclear accidents, it is not only necessary to consider the material factors but also to consider the impact of non-material factors in a nuclear accident scenarios. Due to the spatial characteristics of the hazards caused to social stability by nuclear accidents, it is not only necessary to consider the social stability factors in the emergency plan zone but also to consider the social stability factors in society on a larger scale. Due to the time characteristics of the hazards

caused to social stability by nuclear accidents, it is not only necessary to consider the short-term impact of those factors but also to consider the medium-and long-term impact of those factors.

3 Multiple Attributes Decision Making Method.

Indexes that are key factors for social stability are main goal in making decision. When we develop a model to make decision under nuclear threaten, we can use these indexes as decision attribute in order to keep society stability. Liner allocation method (LAM) just requires orders of plans under each attribute instead of accuracy data. LAM has wide application with many advantages such as less parameters and simplicity, so we use LAM in this filed.

3.1 Establishment of index system of social stability.

Indicators was determined by the reference9~11 and mechanism of nuclear accident. Psychosocial Indicators: In terms of an atomic bombing, people who don't have a basic knowledge of nuclear radiation and the hazards of radiation are afraid of radiation. So" Public Opinion" is key factor. The differences between the perceptions of laypersons and those of experts cannot be attributed in any simple way to their respective degrees of knowledge. It is clear that more and "Risk Communication" about radiation and its consequences is needed. Material Impact Indicators: The actual hazards of a nuclear accident are the dispersal of radioactive substances into the environment and the dramatic physical and chemical changes caused by nuclear facilities. We should in the first instance consider the actual damage caused by the substances released in a nuclear accident. We need "Emergency Resource" response to accident in order to relief the loss. We also need "Living Resource" protect people against damage. Social Order Indicators: Social order is also an important performance indicator of social stability in a nuclear accident scenarios. Social order mainly refers to the performance of various social aspects. "Economy" is the foundation of social stability. "Social Control" is the necessary conditions for stability of the society. Compared with the other two factors, the social order-related factors are abstract and implicit. Social order is also affected by the superposition of both material factors and intangible factors. As society is not isolated from the outside world, we must also take "External Assistance" into consideration. Shown in table 1.

	1st Grade Index	2nd Grade Index	Interpretation
Social stability	Psychosocial Factors	Public Opinion	The level of public cognition of the nuclear accident
		Risk Communication	Accuracy and comprehensiveness of nuclear accident
	Material Impact Factors	Emergency Resource	The quantity and quality of medical resources to deal with nuclear accident hazards
		Living Resource	Social security capabilities for food and basic living
	Social Order Factors	Economy	Basic commodities price fluctuations compared with normal times after a nuclear accident
		Social Control	Reasonability and effectiveness of the authorities' disaster mitigation policies
		External Assistance	The impact of the situation at home and abroad on the community

Table 1. Instructionof The Index

3.2 Liner allocation method (Zhang and Zhou, 2013).

We can use AHP (Analytic Hierarchy Process) (Saaty, 1990) to determine the weights of index that is the attributes of decision-making. The set of attribute is $A=\{B_1, B_2 \cdots B_7\}$ ={*Public Opinion, Risk Communication, Emergency Resource, Living Resource, Economy, Social Control, External Assistance*}.The set of plan against nuclear accident is $U=\{u_1,u_2,u_3\}$, u_1= *Taking Iodine.* u_2= *Shelter.* u_3= *Evacuation.* Array matrix of plan under each attribute is $Y=y_{mn}(1\le m\le 3, 1\le n\le 9)$. Shown in table 2.

Order	B_1	B_2	$\cdots$	B_7
1st	y_{11}	y_{12}	$\cdots$	y_{17}
2nd	y_{21}	y_{22}	$\cdots$	y_{27}
3rd	y_{31}	y_{33}	$\cdots$	y_{37}

Table 2. Array Matrix of Plan Under Each Attribute

y_{mn} indicates plan u_i is ranked # m under attribute n. So we build the order weight matrix H according to array matrix of plan Y. Shown in table 3.

Plan	1st	2nd	3rd
u_1	h_{11}	h_{12}	h_{13}
u_2	h_{21}	h_{22}	h_{23}
u_3	h_{31}	h_{32}	h_{33}

Table 3. Order Weight Matrix

h_{ij} indicates weight of plan u_i is ranked # j. $h_{ij}(1 \le \mathrm{i}, \mathrm{j} \le 3) = \sum_{n}^{7} a_n y_{mn}$, if $y_{mn} = u_i, a_n = 1$ else $a_n = 0$ .Based on nuclear accident, each plan can only be in one place, Each place also have only one plan.

$$\max \sum_{i=1}^{3}\sum_{j=1}^{3} h_{ij} p_{ij} \quad .s.t. \begin{cases} \sum_{j=1}^{3} p_{ij} = 1, 1 \le i \le 3 \\ \sum_{i=1}^{3} p_{ij} = 1, 1 \le j \le 3 \\ p_{ij} = 1 or 0, 1 \le i, j \le 3 \end{cases}$$

Then we can get a order of plan which indicates priority of plan.

3.3 Numerical example.

There must be some impact on area around nuclear accident according to analysis of social stability. Index weights of social stability is defined as set B, and corresponding plan is defined as set U. Expert can quantify weights of index by AHP. We suppose the numbers are given by experts who get these by AHP, and we can get set B={0.2,0.16,0.08,0.07,0.09,0.20,0.20}.Then experts in various fields discuss the order of plan under each attribute. Shown in table 4.

Order	B_1	B_2	B_3	B_4	B_5	B_6	B_7
1st	u_2	u_1	u_2	u_1	u_2	u_1	u_3
2nd	u_3	u_2	u_3	u_2	u_1	u_2	u_2
3rd	u_1	u_3	u_1	u_3	u_3	u_3	u_1

Table 4. Array Matrix of Plan Under Each Attribute

According to $h_{ij}(1 \le \mathrm{i}, \mathrm{j} \le 3) = \sum_{n}^{7} a_n y_{mn}$, then we build the order weight matrix. Shown in table 5.

Plan	**1st**	**2nd**	**3rd**
u_1	0.43	0.09	0.48
u_2	0.37	0.63	0
u_3	0.20	0.28	0.52

Table 5. Order Weight Matrix

According to $\max \sum_{i=1}^{3} \sum_{j=1}^{3} h_{ij} p_{ij}$, we can get: $u_1 \succ u_2 \succ u_3$. So taking iodine obviously is better plan for social stability in hypothetical nuclear accident scenario.

CONCLUSION

Responses to nuclear emergencies and social stability are complicated system issues. Therefore, we should employ a macroscopic method to research the various issues surrounding nuclear accidents. Creating a system index can also help us to make accurate predictions in order to avoid threats to public safety in a nuclear accident scenario. According to the system index of social stability factors, we can develop LAM methods to get better making-decision.

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