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THE CONCEPT OF DISASTER IMMUNITY TO ENCOURAGE ADAPTATION TO DISASTER HAZARD INTENSIFICATION

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SYNOPSIS

We introduce a new "disaster immunity" concept in place of conventional "disaster management capacity" that reflects dynamic transitions in society and nature more accurately than the fixed conventional "disaster management capacity" concept. Because awareness deeply impacts on disaster management, the new concept captures disaster dynamics and could play an important role in disaster reduction. Since global warming involves disaster hazard intensification, it is not enough to simply strengthen existing measures. As an example, Japan responds to particular temperate zone patterns through long-term disaster management infrastructures. Society and nature in Japan have disaster management capacity matching typical temperate zone hazards. A rapid transition to subtropical climate patterns within the next several decades to a century is expected to generate large gaps between disaster hazards and disaster management capacity of human society and nature, leading to an imbalance. Under unstable conditions, society and nature have become increasingly vulnerable due to decreased "immunity." Increasing "disaster immunity" is thus an urgent and important issue.

INTRODUCTION

Recent years have seen an increase in disaster hazards such as intensified torrential rains, droughts and typhoons, presumably caused by global warming. Japan's infrastructures and disaster-management facilities built during rapid post-World War II economic growth are now widely decrepit, and their repair and improvement are hobbled by purse-string tightening among public works purveyors. Public works budget reduction could be acceptable to some degree if disaster hazard levels remained constant, but they are certain, in the view of the Fourth Assessment Report by Intergovernmental Panel on Climate Change (IPCC), to increase (1). Declines in Japan's disaster management capacity in the face of disaster hazard intensification suggest that urban and other areas in Japan will become increasingly vulnerable to disasters. We introduce a new "disaster immunity" concept in place of conventional "disaster management capacity" that reflects dynamic transitions in society and nature more accurately than the fixed conventional "disaster management capacity" concept. Because awareness deeply impacts on disaster management, the new concept captures disaster dynamics and could play an important role in disaster reduction. Increasing "disaster immunity" is thus an urgent and important issue.

IMMINENT THREAT OF INTENSIFIED DISASTER HAZARD

"Disaster Immunity"

Disasters occur in principle when disaster hazards exceed disaster management capacity. If the gap between them becomes too large, disaster scope and severity increase. Where they remain comparable or if disaster hazard exceeds disaster management capacity slightly, no significant damage is expected. If disaster management capacity declines and/or disaster hazard intensifies in the future, disaster-triggered damage quality and quantity would be changed greatly, making society significantly vulnerable to disaster. Disaster consequences are thus determined based on not the disaster hazard but the relationship between disaster hazard and the disaster management capacity. Under ongoing long-term exposure to natural hazards such as storms and floods, nature adapts to weather conditions and society strengthens anti-disaster measures by raising public awareness, applying knowledge and information, and improving infrastructures, giving nature and society additional disaster resistance. The ever-changing relationship between the two elements is comparable to that between pathogenic bacteria and bodily immunity, so we propose the "disaster immunity" concept for disaster management capacity relative to disaster hazard. The "immunity" concept clarifies how disasters occur under climate change and points up the need for public preparedness. "Immunity" here follows Mochizuki's understanding of "immunity" (2):

(a) Endogenous capability formed and acquired following "external force or stimulus (virus or vaccine)." Virus or vaccine is equivalent to disaster experience.
(b) Strengthening by repeating external stimuli.
(c) Adaptation (acquisition of immunity) through exposure to external effects
(d) Vulnerability and devastating damage without immunity
(e) Immunity decreasing over time due to reduced external stimuli
(f) Disaster management infrastructures appearing to be unrelated to "immunity." Societies frequently exposed to disaster invest in infrastructures raising disaster management capacity, essentially making disaster management infrastructures a part of immunity. Disaster management infrastructures deteriorate over time. The absence of external stimuli, i.e., disasters, tends to weaken routine maintenance and improvement of facilities, weakening immunity. Infrastructure Asset Management should thus be taken into account in evaluating "immunity."

Disaster hazard resistance depends on four factors:

a) Social disaster management infrastructures

Society invests in improving large-scale disaster management infrastructures over time. In planning, objectives are set based on disaster potential. Flood control facility capacity, for example, is determined differently in Kyushu, which has much rainfall, than in Hokkaido, which has little. Nonstructural disaster reduction infrastructures have come into more focus based on the recognition that infrastructures cannot cover all disaster management aspects. A nonstructural disaster reduction infrastructure is one of the social disaster management infrastructures.

b) Disaster reduction awareness among residents and recovery capability of local community

As disaster hazards grow, residents will suffer concomitant damage, which will raise awareness of the need for disaster reduction. Faced by unprecedented catastrophe, however, residents will suffer extensive personal and financial loss. Recovery capability of local communities plays a vital role in swift recovery from disaster. Local construction companies which work mainly in each seat also play a vital role.

c) Societal facilities and tools with common people

Resistance to disaster depends also on societal facilities and equipment. When heat waves hit Europe in August 2003, Paris recorded temperatures exceeding 38℃ for over 10 days. All told, some 15,000 people died in France alone due to heat stroke – about half of all such deaths in Europe (3). Normal housing without air conditioning offered no protection against such heat. The outcome would have been different in another city where it is normally hot in summer and air conditioner is equipped with almost every house. In another example, some 90% of all buildings in Okinawa, which is frequently hit by typhoons, are built of reinforced concrete to guard against strong wind – very different from other regions in Japan and demonstrating social adaptation to local disaster hazard patterns.

d) Resistance of nature to disaster

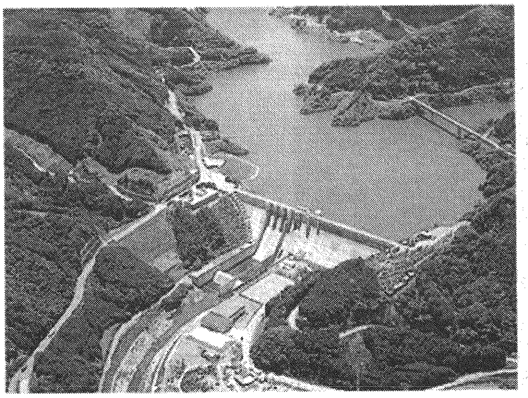
Exposure to severe storms and floods makes nature more resistant. Taking the example of sediment disaster, areas prone to landslides have already collapsed in regions exposed to sediment problems, while remaining areas have increased resistance to storms and floods. In 2003, precipitation exceeding 300 mm within 24 hours due to Typhoon No.10 in the Saru and Appetsu River basins in Hokkaido triggered numerous mountain landslides (Photo 1), which in turn triggered down wood debris that damaged infrastructures by washing away bridges, for example (4). Such heavy damage would not occur in Kyushu under the same conditions because Kyushu regularly experiences heavy precipitation. Even in Kyushu, however, torrential rains of 113mm an hour caused extensive damage (Photo 2).

Photo 1 Landslides in Saru river basin caused by torrential rains in Hidaka, Hokkaido, in 2003 (4).

Photo 2 Landslides caused by Typhoon 5 in August 2007 in the Okue mountain range, Nobeoka City, Miyazaki Prefecture (photograph by Mainichi Newspapers).

In another example, Typhoon No. 18 in 2004 caused extensive tree falls in Sapporo City in Hokkaido, where maximum winds exceeded 50 m/s. This would not happen, however, in "Typhoon Alley" Okinawa, where tree species differ and trees are firmly rooted.

In Photo 3 Yabakei Dam in the Yamakuni River in Oita Prefecture is shown. This is a multi-purpose dam for flood control and water utilization. An annual maximum discharge is shown in Fig. 1, which indicates a large flood occurred in 1993. Thereafter there were two middle floods occurred. Fig. 2 shows the volume of sediment deposit per year and the cumulative total volume in the dam reservoir. It is clear that the slope (a rate of increase) of the total volume of sediment deposit varied in 1993 and got gentler thereafter. The watershed of the Yamakuni River produced much sediment due to the large flood occurred in 1993. But thereafter it decreased the supply of sediment through the experience of a large flood. The properties of the watershed are different with/without a big event.



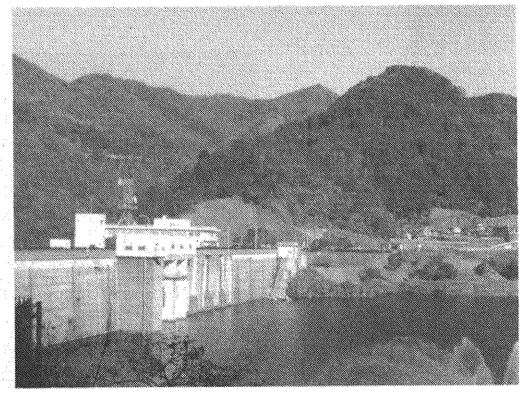


Photo 3 Yabakei Dam

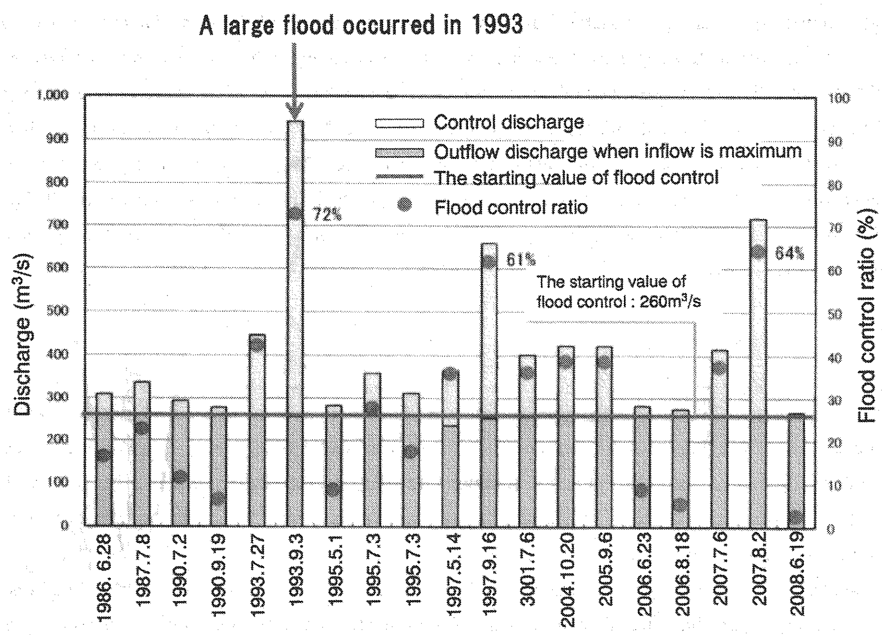


Fig. 1 Annual maximum discharge

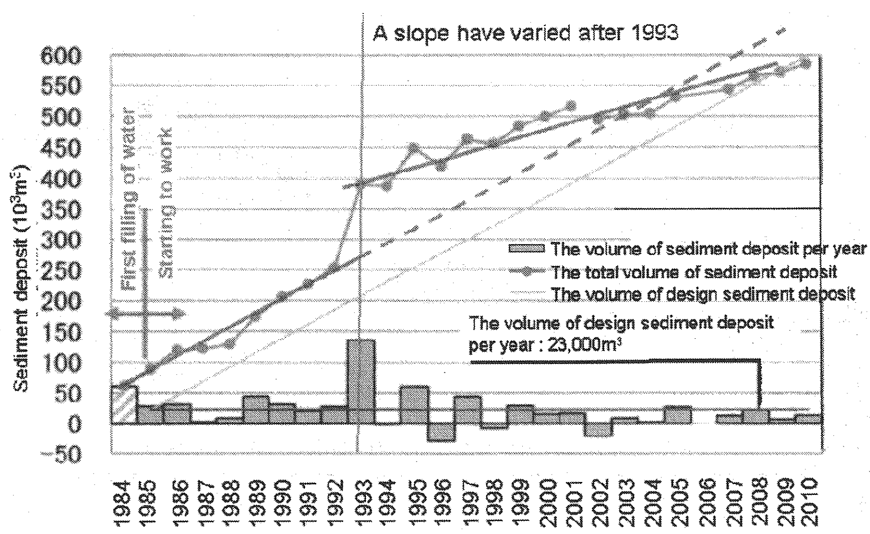


Fig. 2 Annual maximum discharge Volume of sediment deposit in the dam reservoir

These four factors – social disaster management infrastructures, disaster reduction awareness among residents and recovery capability of local community, societal facilities and tools with common people, and resistance of nature to disaster – thus increase disaster resistance through experience.

These four factors become extremely defenseless, however, if a disaster is extraordinary or a disaster hazard is alien to its area. This corresponds to disease immunity as the factors are similar with immunity of living body in this respect. "Disaster immunity" is more suitable than conventional "disaster management capacity" for the disaster prevention field. Generally speaking, "disaster management capacity" is regarded as the factors *a)* and *b)*, or possibly *a)* to *c)*. In this paper, the factor *d)* "resistance of nature to disaster" which is expected to increase as a consequence of "intensification of disaster hazard" in the future is also included in "disaster management capacity." "Resistance of nature to disaster" sounds incongruous with conventional "disaster management capacity" because "resistance of nature to disaster" eventually increases through the nature endogenous capability according to the stimulus (disaster) from outside. After all "disaster management capacity in a broad sense" including all the four factors is considered equivalent to "disaster immunity." The disaster immunity concept expresses the dynamics of society and nature more accurately.

Transition from balance to imbalance

In the case of Japan, to make a long story short, society and nature have raised disaster immunity by adapting to small and medium disasters, reaching a fairly balanced state except in the case of infrequent, unprecedented disasters. This balance could largely be lost due to the increased occurrence of disaster hazards expected to be caused by global warming (Fig. 3). In the last century, average global temperatures rose 0.74℃, and the difference between maximum and minimum annual temperatures in Japan reached 40-50℃. Although the 0.74℃ rise is quite small compared to the annual temperature range, the climate – a delicate system balanced through the complex interaction of many factors – has already begun changing (1), and transition from one climatic, environmental and societal regime to another could involve unexpectedly intensive influences making measures for adapting to global warming urgent and indispensable.

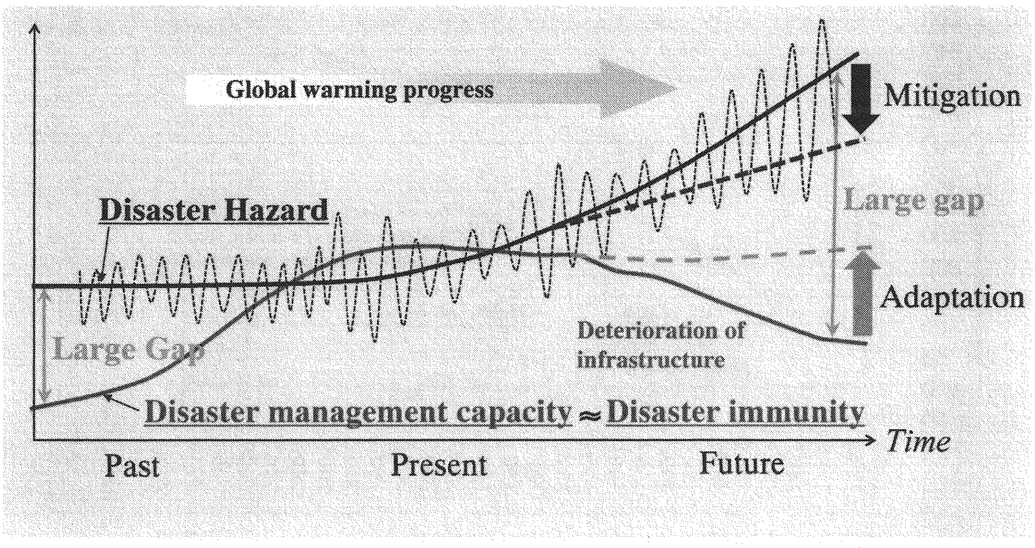


Fig. 3 Relative decline in disaster immunity

Risk of gap caused by lack of "Immunity"

It is expected to take a long time, much money, and a high disaster victim toll before improvements will be made in the above four "disaster immunity" factors. In fact, increased disaster management capacity may not be able to match the speed of disaster hazard intensification. The large gap between a disaster hazard and disaster immunity could generate an undesirable imbalance.

Such rapid imbalance within several decades to a century would, of course, render society and nature vulnerable due to decreased "disaster immunity." As a result, it is highly possible that the horrible disaster beyond our assumption will hit us in the future. In discussing the topic of global warming, the situation emerging after the considerable progress of warming process is often taken up. For example, it is argued that mandarins will be cultivated in Tohoku in northern Japan, instead of current apple crops, and apples would be harvested in Hokkaido (5). Such argument will be only useful after a future balanced state will be established in the post warming process. The real challenge is how we adopt the confronted risk during the imbalanced state.

As possible disaster which will occur during the period of the imbalanced state, large-scale flood, large-scale sediment disaster, break of dam formed naturally by sediment, accident in existing dam, storm surge, large-scale heat wave, storm disaster caused by intensification of typhoon etc. could be supposed. And the unexpected, localized and intense torrential rain which is recently referred as "guerrilla torrential rain" by mass media has caused significant damage especially in the urban areas, because human society is not furnished with any "immunity" to this new kind of torrential rain. It is forecasted that national and economic strength will decline due to dwindling birthrate and aging society in the future in Japan. Under the current financial situation where it will become more and more difficult to improve the structural infrastructures, the viewpoint of "raise of disaster immunity" considering the increase of "resistance of nature to disaster," at the same time will have more significance. The researchers and engineers concerned have the obligation to make every effort to prevent at least large-scale disaster and keep safety and security at the certain level even under the limitation of budget.

IMPLEMENTING SCIENTIFIC FORECASTING OF ENVIRONMENTAL CHANGE AND DISASTER

As stated, a long time, much money, and a high disaster victim toll will have to occur before improvements in the above four disaster immunity factors result in a balance between disaster immunity and disaster hazard intensification. Rapid transition to an imbalanced state over several decades or a hundred years will render society and nature vulnerable to disaster due to the lack of immunity. To prevent the large-scale disaster beyond our assumption, a new system of scientific studies and technology should be established. For the system it is recommendable to quantitatively evaluate disaster immunity factors as soon as possible to determine environmental change and disaster based on the slight precursory indications in society and nature accompanying global warming. For these purposes, we propose the two following approaches:

(a) Research must grasp detailed natural and social environments, social and living infrastructures related to "disaster immunity" as global warming progresses. To do so, data until now on disaster, topography and climate, social and living infrastructures, and disaster reduction awareness of the public in different climate areas must be collected and analyzed. For example, we focus on the following four regions: South East Asia as a tropical zone, Taiwan as a subtropical zone, Kyushu as a temperate zone, and Hokkaido as a subarctic zone (Fig. 4), and specify characteristics in each region in order to estimate universal characteristics based on each climate. Factors in environmental change and disaster immunity developing after transitions from subtropical to tropical, temperate to subtropical, and subarctic to temperate zones must then be quantitatively identified and evaluated.

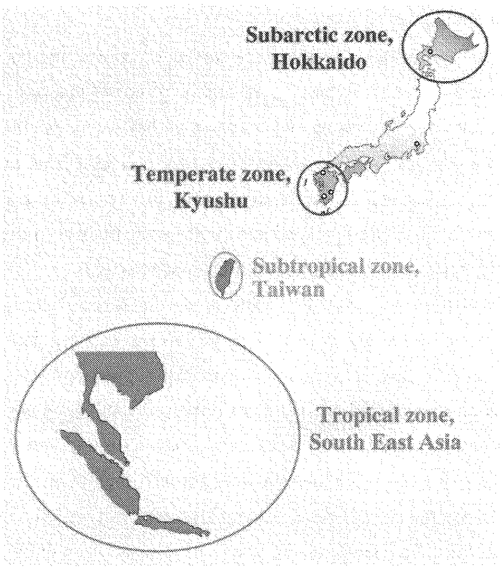


Fig. 4 Identification of environmental change factors through regional data comparison

(b) A new system of scientific studies must be established for forecasting severe disasters based on advanced clues derived from slight precursory indications accompanying climate change using the above-mentioned research (a).

PREVENTING LARGE SCALE DISASTERS

While large-scale disasters due to collapse of natural or existing dam must be prevented, rainfall over 1,000 mm in several days is not rare in recent years such as large amount of precipitation by Typhoon Nabi or heavy rainfall in the Kagoshima Prefecture Sendai River basin in 2006. What kind of measures can be effective to possible large-scale disasters?

Measures against dam disaster

In the upper reaches where natural sedimentation dam is likely to be formed by slope failure due to abnormal rainfall, water level gauges measuring also large water depths are recommended to be installed at appropriate intervals. The data from gauges are transmitted to the relevant offices in real-time to analyze them. Occurring normal flood, the water levels rise similarly. Blocked river course, water level upstream from a natural dam rises rapidly, while that downstream from it drops. Accordingly abnormal condition can be easily detected using the devices (Fig. 5). Normally it takes 2 to 3 hours until the natural dam collapses in Japan and therefore emergency evacuation warning can be issued to evacuate the residents in the lower reaches. It costs not much.

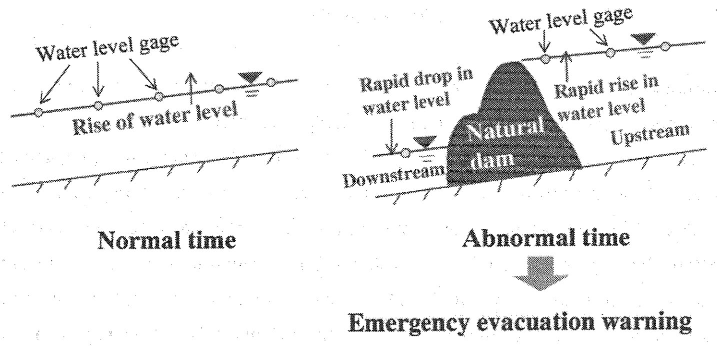


Fig. 5 Measures against flood surge using water level gages

Recommendation of construction of a dry dam

Flood control dam without slide gate in spillway called "dry dam" has been reviewed, planned and built in some sites in Japan. This type of dam was applied to disaster prevention dam for agriculture, but has recently attracted public attention because of its less impact on natural environment (Fig. 6). It has the following characteristics.

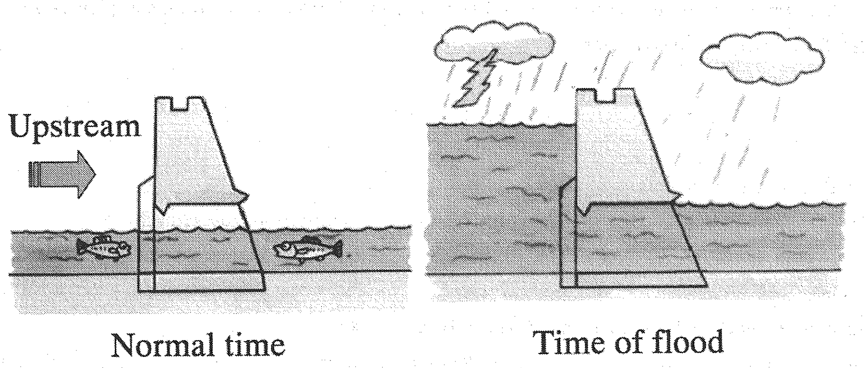


Fig. 6 Construction of a dry dam

(a) Water tunnels are provided at the almost same level as that of river bed, flowing water constantly without impoundment. Accordingly sediment and fish pass through the dam. Under the normal operation it is the exact condition of river without dam, loading little burden on environment.

(b) Dry dam is intended for safety of residents and the consensus for construction can be easily attained among them compared with storage dam.

We recommend active construction of dry dam in the lower reaches of the river for the following reasons:

(c) There is no need for human operation of dam because of the natural regulation of flood. Human operation of dam often leads to the misunderstanding that "dam is the cause of flood".

(d) Natural dam or existing dam collapsing, or large amounts of sediment pouring into reservoir and water overflowing dam, flood surge would be received in dry dam to alleviate damage downstream from dam.

(e) Dry dam can be easily converted into storage dam with low cost and in short period, if water resources problem such as shortage of irrigation water and tap water becomes more serious due to e.g. global warming.

CONCLUSION

Since global warming involves disaster hazard intensification, it is not enough to simply strengthen existing measures. As an example, Japan responds to particular temperate zone patterns through long term disaster management infrastructures. Society and nature in Japan thus have disaster management capacity matching typical temperate zone hazards. A rapid transition to subtropical climate patterns within the next several decades to a century, however, is expected to generate large gaps between disaster hazards and disaster management capacity of human society and nature, leading to an imbalance. Under unstable conditions, society and nature have become increasingly vulnerable due to decreased "immunity." The "disaster immunity" concept we have introduce expresses the dynamics of society and nature more accurately than the conventional "disaster management capacity" concept. Based on the "disaster immunity" concept, disaster degree and nature are determined based on the relationship between disaster hazards and disaster immunity. Disaster immunity thus appears useful in broadening public recognition of the risk of a lack of immunity, because human awareness is deeply involved with disaster management. The overriding need is thus to increase disaster immunity to prevent at least large-scale disasters. This requires new scientific studies preventing disaster by quantitatively identifying and evaluating disaster immunity factors as early as possible and finding clues to disaster or environmental change from precursory indications in society and nature triggered by global warming. Another urgent requirement is the flexible development of less costly new disaster management technology that places little or no burden on the environment. Human resources in the form of researchers and engineers must also be fostered to detect even the slightest information and precursory indications with the help of sensitivity and imagination.

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