D S V: Disasters, a Systemic Vision

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Abstract

Disasters are occurring with continually increasing frequency and magnitude. The Tsunami of December 2004 in Indonesia caused more than 280,000 deaths and material losses surpassing 5 billion dollars. Nevertheless, disasters could be prevented and mitigated through a systemic, holistic, and integrated approach such as that presented in this article. This approach consists in analyzing the inputs, outputs and feedback of the process which occurs when a set of extraordinary natural or man-made phenomena occurs, in response to which people are generally not prepared to react quickly and efficiently enough. This paper analyzes some of the most important factors that propitiate disasters and recommends preventative and mitigating measures. Elements analyzed include: civil protection plans, programs and committees; scientific research and technological development; education, training and awareness; early warning systems; evacuation drills; urban development plans; resistant buildings and infrastructure; medical emergency services; and others..

Keywords: Disaster prevention & mitigation; systemic approach; education, training & awareness; scientific research & technological development; civil protection & citizen participation; risk maps & urban development plans.

Introduction:

The more than 280,000 deaths and material damages surpassing five billion dollars provoked by the Tsunami of 26 December 2004 in southeastern Asia could have been largely prevented and/or mitigated if a systemic warning and preparation approach had existed on the part of authorities and residents of the affected regions.

We know that extreme natural phenomena can not be controlled by humans. Earthquakes are one of such phenomena which no one can control or avoid. What people can do is prevent and/or mitigate the disaster originated by these extreme phenomena.

General Systems Theory can help us begin to envision a better approach to disaster prevention and/or mitigation in high risk areas.

The systemic approach addresses the phenomenon or process as a system with inputs, outputs, and feedback, as illustrated in Figure 1.

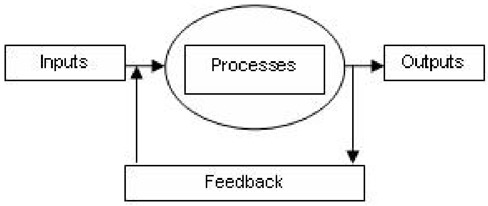

Fig. 1- Systemic approach to solve complex problems

Several inputs must be considered to analyze the process of disasters originated by extraordinary natural phenomena. Several results or outputs are obtained, and process feedback must also be analyzed.

In reference to inputs, Table 1 presents a minimum list of those to be considered:

Table 1- Process inputs to be considered for disaster prevention and/or mitigation.

No.	Concept
1	Civil protection plans, programs and committees
2	Scientific research and technological development
3	Education, training and awareness
4	Early warning systems
5	Building evacuation drills
6	Urban development plans
7	Resistant buildings and infrastructure
8	Emergency medical services

Table 2 presents the expected results or outputs.

Table 2- Desired outputs of the disaster prevention and/or mitigation process.

Num	Concept
1	Increased community capacity to prevent and/or mitigate disasters
2	Possibility to foresee the impact of extreme natural and anthropic phenomena with sufficient anticipation
3	Ability to minimize the impact of natural and anthropic phenomena through mobilization of necessary human and material resources
4	Infrastructure sufficiently resistant to the effects of extreme phenomena
5	Capacity to quickly recover following presentation of the phenomenon
6	Other

The feedback consists of evaluating the process, detecting deficiencies, and correcting them. For example, upon implementing evacuation drills in a building, insufficient stairways and/or exit doors may be detected for the number of people to be evacuated, or people may not move quickly enough. In response, building infrastructure or the people's physical condition should be improved.

Civil Protection Plans, Programs and Committees

Each urban or rural region should be diagnosed in reference to its level of risk to suffer a disaster caused by natural phenomena or man-made causes.

Disaster risks of different natures exist virtually everywhere on earth. Some places present high seismic risks, others are vulnerable to volcanic eruptions, and others are susceptible to hurricanes, tropical storms, and/or their consequences in the form of mudslides and/or flooding. Other regions may be prone to fires, heat waves, droughts, or extreme cold spells. Almost no one is exempt from suffering the effects of a disaster anyplace on the planet Earth. Life is a constant risk and that fact must be accepted. But life can be safer if pertinent precautionary measures are taken against relevant risks through the systemic approach outlined in this article.

A first step toward a progressively safer life is to carry out a study to diagnose the problem as it exists in each location. Risk maps or atlases are the names given to geographic maps which indicate the type or types of risks existing in each area of a country.

Risk maps should be elaborated by experts, supported in the experience of the local population. Many people remember disastrous events of the past. History generally repeats itself, and therefore those details should be taken into close account. An area which has suffered a hurricane will probably be struck again, and the same is true for seismic regions. Figure 2 illustrates a risk map for earthquakes in the Mexican Republic

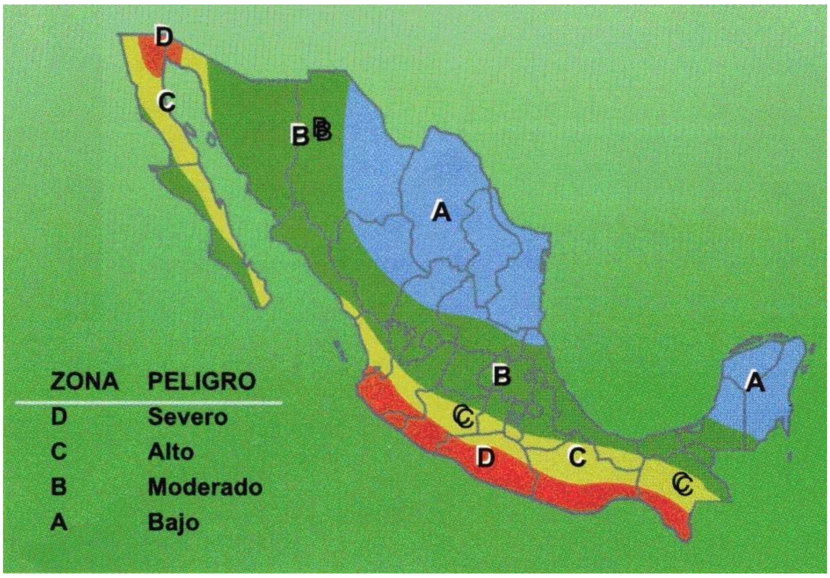

Fig. 2 Earthquake risk map for the Mexican Republic (Source: CENAPRED, Mexico)

Pertinent civil protection plans and programs may be established based on a given location's risk diagnosis. These plans and programs should be implemented by civil protection committees integrated by highly motivated and trained authorities and citizens.

Civil protection committees are key to achieving a duly prepared community or region. Experts diagnose possible risks on the one hand and train necessary personnel on the other. Civil society participation is vital to maintain the entire population informed and prepared for any contingency.

Civil protection committees are recommended at all social organization levels: federal, state, municipal or township, neighborhood, block, and especially at the family level. It is important that every family have at least one young member who is in charge of the family's civil protection and serves as the contact with other civil protection system levels.

Each member of the civil protection committees should be fully aware of the importance of his or her work and trained to organize and carry out all pertinent actions to prevent and mitigate disasters.

In general, this personnel should be volunteer, i.e. they should carry out the work motivated by their belief in its importance. Such personnel should only receive remuneration when occupying official posts and dedicated full-time to this activity.

We are convinced that when people carry out civil protection activities out of personnel conviction, solidarity, and philanthropy, they perform better than when they do so for profit motives

Scientific Research and Technological Development

Research on natural phenomena, how they unfold, and how they can be predicted and mitigated is very important considering that with such knowledge it is more feasible to develop and implement disaster prevention and/or mitigation plans. Some scientific theories feasible for development include: the tectonic plates theory to predict earthquakes, hurricane theory to predict the path and intensity of tropical storms and hurricanes, and tsunami theory to predict the intensity and direction of seaquakes.

The technological development of devices, apparatus, or structures capable of better resisting the effects of natural phenomena is one important way to obtain elements to help prevent and mitigate disasters. Some feasible technological developments would include equipments to alert the population to the imminence of an extraordinary natural phenomenon such as an earthquake, tsunami, volcanic eruption, hurricane, flood, fire, etc.

Figure 3 illustrates the different velocities of primary waves (rapid and less destructive) and secondary waves (slow but destructive), which can serve to alert the population to the imminence of an earthquake. In the case of Mexico City, warning can be emitted up to 30 to 60 seconds before an earthquake hits, depending on the distance from the epicenter. This characteristic is being taken advantage of by researchers of the Upper-Level School of Physics and Mathematics of the National Polytechnical Institute (Escuela Superior de Física y Matemáticas del Instituto Politécnico Nacional — ESFM-IPN) to develop a seismic warning system, which does not require sensors located in other places as occurs with the official alert system, sponsored by the Mexico City government.

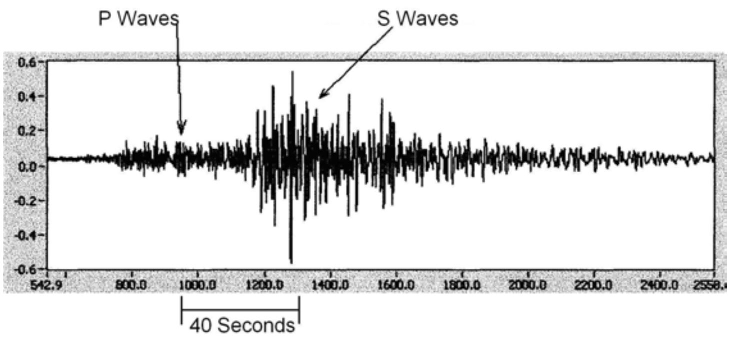

Fig. 3- Graph of the velocity of P waves (primary) and S waves (secondary) originated by an earthquake

Figure 4 illustrates an analogical simulator of variable-intensity earthquakes which can emulate earthquakes of different intensities, with which-scale tests can be carried out to evaluate the performance of structures and buildings, and which can also be used as an instrument to educate, train and build awareness among the population.

Similar to the earthquake simulator presented in Figure 4, there is potential to develop other simulators of extraordinary natural phenomena such as tsunamis, hurricanes, tropical storms, floods, landslides, fires, etc.

Fig 4. Simulator of earthquakes with variable intensity developed at the ESIME-Z-IPN

Education, Training, Awareness And Culture

Nothing can be done to prevent or mitigate disasters if people are not aware of the danger, and educated and trained to react adequately in the face of imminent danger or risk. The population must be sufficiently motivated, aware, and trained to act and to re-act.

How is risk awareness achieved? By appealing to people's survival instinct, which is one of the strongest human instincts. Sharing stories from the past in which people suffered the onslaught of nature and had human and material losses is one way to begin to establish awareness among the population.

In addition, if the news media communicates almost instantly the effects of natural phenomena in other places, intuitively or instinctively people begin to worry and develop awareness.

But the best effect can be achieved in schools, where children prepare for life in society. If the topic of disasters and their prevention and mitigation is discussed starting in primary school, it is more feasible that these students later as adults will participate more in disaster prevention and mitigation actions.

Building evacuation and other disaster preparedness drills are better carried out in primary and secondary schools than in factories and other work places. Since (virtually) everyone goes through primary and secondary school, it is more feasible in these places to build awareness and instill training to respond to disasters, through written material and practical exercises to know what to do in the case of natural or anthropic phenomena which may provoke disasters.

Education is the basis of practically all the social actions which can help resolve human survival threats. Figure 5 illustrates some instruction signs on what to do in case of an earthquake.

Fig. 5 Instructions on what to do in case of an earthquake.

Early Alarm System

There are prototypes of equipment which can provide from several seconds up to several hours of early warning to give people time to move away from the impact area of a tsunami, earthquake, hurricane, etc.

For such systems to have a true impact, the technological action must be complemented by social action. The population must carry out evacuation or preparation drills at least once a year in anticipation of extraordinary phenomena, so that when such an event occurs the evacuation or preparation is quick and smooth.

Figure 6 presents several types of earthquake early warning prototypes developed at the ESIME-Z-IPN with low-cost materials.

Fig. 6. Prototypes of early warning systems in case of earthquakes, developed in the ESIME-Z-IPN

Building and Infrastucture Norms

Legislation in the matter of locations at high risk of earthquakes, such as Mexico City, is increasingly strict. Current norms require building structures and physical infrastructure to be capable of withstanding earthquakes of up to 8.5 degrees on the Richter scale.

Technologies also exist for the construction of buildings capable of resisting the onslaught of the waves of a tsunami. Such buildings are sufficiently resistant in their support structures, but their walls, doors and windows are easily removable with the force itself of the tsunami, resulting in the loss of these latter elements but the preservation of the building structure.

Some civil engineering and architectural options also exist designed to resist hurricanes, tropical storms, floods, etc. In this regard, please consult the Catalogue of appropriate technologies for disaster prevention and mitigation included in the bibliography.

Urban Development Planning

If a history of floods exists in a given area, urban planning should avoid the construction of homes and other buildings there. If there is a known tsunami risk, the location of both permanent and temporary structures should be carefully planned in order to reduce the risks brought on by the waves. Permanent buildings can usually be located at a prudent distance. On the other hand, wave breakers or other devices can be installed to mitigate the destructive force of tsunami waves caused by seaquakes.

All rural and urban development should be planned out with the purpose of preventing disasters. The noted risk maps or atlases can be of great use for this planning. Figure 7 illustrates a municipal urban development plan.

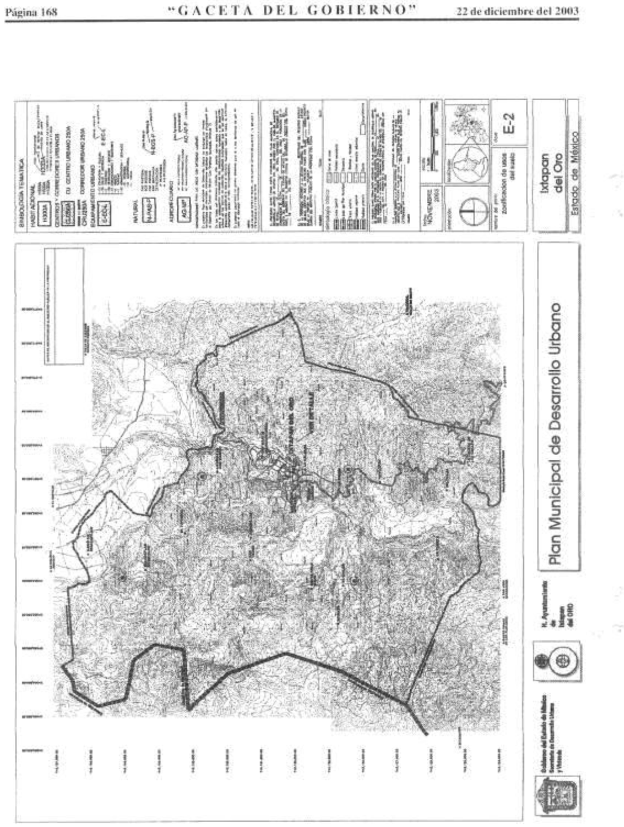

Fig. 7 –Municipal urban development plan

Based on these urban development plans, some flood-prone areas, such as riverbeds which are usually dry, can be designated as sports fields or recreation parks used only during seasons which do not pose risk. Human settlements should never be located in these highly risky areas.

Bumper areas or mitigation belts should also be maintained between urbanized areas and risk zones in order to reduce the risk for the inhabited areas. For example, mangroves or wooded areas along water's edge should be maintained to help mitigate the destructive force of tsunami waves, at a low cost and with positive impacts on the scenic landscape.

Emergency Services

Once the extraordinary natural phenomenon occurs and begins to provoke damages in the form of human injuries or deaths, medical and paramedical teams and related types of intervention are required to attend to the injured, bury the dead, and direct the hygiene campaigns oriented to prevent epidemics of infectious diseases which are favored by the destruction or lack of sanitary and drinking water infrastructure.

Groups of persons must be trained to rescue those in dangerous situations and to provide medical care where necessary. Emergency Medical Technician and Rescue Squadrons must be on hand in sufficient quantity and quality (see Figure 8).

Fig. 8 Rescue and Medical Emergency Squadron Ambulance

The personnel of these services must be duly trained and equipped to safely, efficiently and quickly operation under conditions of extreme pressure. Such personnel should preferably be young (between 20 and 40 years of age), volunteer, semi-professional or paramedic, with at least middle-upper level educations, and must receive permanent on-going training. This personnel should be supported by the local community or government with equipment and a dignified salary which allow them to offer their services in an activity in which they risk their own lives in order to save others.

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Other Aspect for Consideration

Other relevant actions to be considered in disaster prevention and mitigation are the culture and beliefs of the population in question. If someone feels safer with the divine intervention they feel they receive through the image of a holy figure, then they should use it. But praying does not replace hard work on one's own behalf. See Figure 9.

Fig. 9 – Religious image for pleas for help
(Author: Ocampo, O. s/f. "Milagro", Source:
http://www.naute.com/illusionsfr/miraclefr.phtml)

Another important element is to procure that community members maintain harmonious relations among themselves in general, supporting each other in a spirit of solidarity. Although this is now an overused term, it should be rescued to exalt the highest human moral values.

Finally, disaster prevention and mitigation proposal contests can provide a great opportunity to achieve two objectives: awaken awareness among the general population of disaster risks in their area and the need to identify solutions, and foment creativity and inventiveness among students, teachers and the general public for the proposal of viable solutions.

In 2004, the authors of this article organized a very successful contest on the topic of "Disasters." Three first place and two honorable mention prizes were awarded. The authors are confident they will continue to obtain the logistical and financial support needed to continue this effort.

Conclusions

It is a fact that without concerted social participation among authorities and citizens in general, complex problems can not be resolved, such as those which emerge following extraordinary natural phenomena which can originate disastrous outcomes. The threat of an earthquake, tsunami, hurricane, volcanic eruption, flood or landslide demands achievement of the concerted action or reaction of all the citizens and their authorities in order to assure the survival of as many as possible of the population involved.

Implementation of any or all of the recommendations analyzed and illustrated in this article, such as scientific research and technological development, civil protection plans, programs and committees, and adequate norms, can help to prevent or mitigate many disasters originated by natural or man-made phenomena.

It is a matter of rolling up sleeves and commencing work in the solution of these complex problems through the systemic proposal presented here.

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Appendix

The disasters of greatest magnitude occurred over the past 35 years are listed in Table A-1:

Year	Country	Type	Deads	Victims
1970	Turkish	Earthquake	1 086	90 000
1970	Peru	Earthquake	47 100	500 000
1972	Nicaragua	Earthquake	8 00	200 000
1974	Honduras	Hurricane	8 000	350 000
1976	Guatemala	Earthquake	27 000	1 600 000
1976	Italy	Earthquake	955	45 000
1979	India	Typhoon	30 000	250 000
1979	Yugoslavia	Earthquake	98	80 000
1980	Argelia	Earthquake	2 633	400 000
1985	Mexico	Earthquake	10 000	400 000
1985	Colombia	Volcano Eruption	20 000	
1986	El Salvador	Earthquake	1 500	300 000
1988	Mexico	Hurricane	400	400 000
1988	Nepal	Earthquake	721	460 000
1992	U S A	Hurricane	14	
1992	Egypt	Earthquake	561	40 000
1993	Cuba	Storm	5	150 000
1993	U S A	Flood	26	36 150
1993	Japan	Earthquake	163	
1993	India	Earthquake	35 000	
1993	Mexico	Hurricane	62	136 000
1995	Japan	Earthquake	5 000	
1997	North Corea	Flood	100 000	
1998	Honduras	Hurricane	11 000	
2004	Indonesia, Sri Lanka, India, Thailand	Tsunami	320 000	5 000 000
2005	U S A	Hurricane Katrina	1 605	3 000 000