### **Environmental Influences on Disaster Management**

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#### Abstract

The study of the impacts of environmental changes on different disaster categories as well as the degree of severity of a disaster with different environmental conditions is presented in this paper. Evaluations of these impacts pose a challenge to decision makers in the field of decision support systems. With rapid advancement in decision support systems development for disaster management, we introduce the concept of different environmental changes that might affect the severity of a disaster within the framework of decision support systems. This paper provides a new approach towards the development of a Decision Support System (DSS) model for disaster management and demonstrates how environmental conditions can significantly affect the severity or intensity of disasters. The argument is that central changing environmental conditions are an important factor in analysing the degree of severity of a disaster.

#### 1. Introduction

Disasters, both natural and man-made, have been occurring with increasing frequency and cause considerable loss of human life and property. The frequency of occurrence and impact of disasters may be greater or less when viewed within the context of environment they occur in. Although the disaster affects may varv. all disaster shares common characteristics including a triggering agent and vulnerabilities [1]. We highlight that the affects of disasters may vary and the severity may increase or decrease with changing environmental conditions. This paper considers the following:

- The development process for a DSS model for disaster management focusing on the environment effects.
- The implications for the environment in case of a disaster
- How disasters and their affects can vary with respect to a change of environment
- The role of different environmental conditions in the disaster management

• The mapping of different disaster categories and environmental characteristics.

This paper highlights an important fact that the degree of disaster severity may change with the change of environment and this could be used to better design DSS for disaster management. The objectives of the paper are as follows:

- 1. To discover what extent environmental characteristics and issues influence disaster management
- 2. To determine the relationship between environmental characteristics and disaster management activities.
- 3. To propose a DSS development process for disaster management making use of environment.

Disaster management involves a variety of activities which address various aspects of disasters including their causes and affects. We have previously proposed a layered framework to develop a DSS model for disaster management [2]. This paper extends our previous work and examines environmental issues that might be useful for the development of a DSS for disaster management. It is important to place this issue in the proper context by highlighting that disasters may have diverse impacts with changing environmental conditions.

The structure of rest of the paper is as follows: Section 2 describes a well-structured development process to build a hybrid DSS model for disaster management. Section 3 explains environmental issues and characteristics within the context of disaster management. In Section 4 disaster categories are explained. In Section 5 these categories are mapped with environmental characteristics. Finally conclusions are discussed in Section 6.

#### 2. A DSS Model Process for Disaster Management

To design and develop an appropriate DSS model for disaster management, a wellstructured development process needs to be adopted. Figure 1 illustrates such a development process. An important challenge is to develop a DSS model that, on one hand,



Figure 1: A DSS Model Development Process for Disaster Management

takes the advantage of all existing modular subroutines/modules but, on the other, is closely matched and compatible with the current situation and the desired user DSS needs. The development process is composed of multiple phases: the first is a traditional phase, which begins with the identification of user specific DSS needs, which are basically the process of understanding the requirements of the particular application domain of interest, such as disaster management in this case.

The identified DSS needs can be further decomposed into sub-needs if required. Then it maps the user-specified DSS needs to fundamental pre-defined DSS needs in the disaster management. This is a fundamental step as the predefined DSS needs of the application domain ultimately become part of the problem definition module. The other part is composed of the environment module. Therefore, the current problem definition is constructed by combining general DSS needs with environmental conditions supported by the environmental database. The need for an environmental database arises because a huge volume of data and information related to the environment is generated.

The identification of current problem definition forms the explicit requirement for DSS model construction. Suppose E is the environmental conditions, DSN is the decision

support needs and M is the number of subroutines required to construct the model then

Decision Support Needs + Environmental Conditions → Modular Modules

The environment module provides the basis for this paper and is discussed separately in the next section (see Figure 1). In the last phase, of the DSS development process, the current problem description is defined and passed to the layered framework (previously proposed in [2]), which improves the efficiency and reusability of traditional DSS developed for disaster management by considering the commonalities of decision support needs.

The layered architecture, which was previously proposed and mentioned above, is composed of three different layers such as independent DSS models, dependent module and disaster category. The following steps demonstrate the flow of layered architecture:

- 1. identify the common decision support need from the example DSS
- 2. apply a modular decomposition technique [3] to the exiting models to make smaller subroutines and generate a modular database ( Independent DSS Model Layer)



**Figure 2: Hierarchical Chart of Environmental Characteristics** 

- 3. obtain the data for a new disaster instance (from Disaster Category and Instance Layer)
- 4. invoke the necessary "dependent module" (From Dependent Module Layer) to perform the necessary conversion and formatting to interface with a matching sub-routine of the modular database
- 5. pass the resultant subroutines to the disaster category and instance layer

Whenever environmental conditions change from one location to another in one or different disaster, some of the routines or modules of a developed model can be re-used to generate a new model. For example, a DSS developed for flood and drought management may contain flood and drought forecasting models respectively. We try to make use of common sub-routines within both forecasting models and investigate some of the subroutines which might be used in another disaster forecast model such as a tsunami.

# 3. Environment Overview and Common Issues

What is the environment? It can be defined as the "sum total of all conditions affecting the existence, growth and welfare of an organism or group of organisms on earth" [4].

It is also defined as the totality of surrounding conditions; it contains all the external conditions affecting humans and other living systems [5].

This definition of environment is very general and does not relate to the concept of disaster management. We give another dimension to the definition which helps us make a connection between disasters and the environment. An environment can be defined within the framework of disaster management as:

Environment is composed of all external and as well as internal conditions that may affect the severity of disasters and these conditions could be the same for different categories of disasters.

An external condition, for example, is global warming and an internal condition is local temperature. In addition, a change in these environmental conditions in a disaster can cause more devastating impacts. From the disaster management perspective, environment can be divided into six categories [1], as follows:

- 1. Physical (infrastructure)
- 2. Social (knowledge about disasters and healthcare facilitates)
- 3. Economical (economical issues)
- 4. Cultural (public behaviour towards disasters)
- 5. Political (support for disaster programmes)
- 6. Technological (for example, computers and electrical equipments)

Consider an example of a disaster such as drought in agricultural land which is caused by low rainfall. Some of the typical adverse effects are as follows:

• Reduced income for farmers

- Loss of livestock
- Increased prices and lack of food
- Community break-ups
- Higher inflation rates
- Shortage of drinking water

- Migration of inhabitants
- Famine
- Illness and deaths
- Deterioration of nutritional status

Weather	Man-made	Transport &	Medical	Major	Energy
		Communication		disturbance	
Floods	Structured fire	Telephone	Epidemic	Civil	Fuel shortage
		systems	_	disturbance	_
Hurricanes	Hazardous	Major road	Mass	Sabotages	Major power
	materials	accidents	poisoning		failure
Earthquakes	Building	Aircraft crash	Water supply	Labour unrest	
	collapse		contamination		
Bush/Forest	Power failure		Major	Bomb threats	
Fire			accidents		
Volcano	Explosions				
Tidal wave	Terrorism				

Table 1: Disaster Categories and Types	5   6, 7	
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If the same disaster occurs in a non-arid area and the location is dependent on different weather conditions (environmental conditions) for water resources, then most of the abovementioned adverse side-effects are eliminated. That is, the same disaster event can have different side effects and impacts with a change of environmental conditions.

Disaster management is typically divided into the response and subsequent recovery phases. This approach is too simple and is one reason why we are so vulnerable to frequent disasters. With the addition of environmental issues, our disaster management approach intends to address the more complex issues of vulnerability, hazard assessment, prevention, mitigation, response and recovery.

A catastrophic event such as an earthquake can be considered as an example to support our argument. Population and urbanization close to an earthquake's origin increase losses compared to far off places. Some environmental characteristics for any kind of disaster are as follows:

- a. Location (Type and Structure)
- b. Nature of Terrain
- c. Ground Conditions
- d. Water Sources and Ecosystems (Physical Environment)
- e. Social disruption (e.g. displacement of inhabitants)
- f. Timing
- g. Human Impact
- h. Climate
- i. Atmospheric parameters
- i. Population size
- k. Resources

Figure 2, shows a hierarchical breakdown of major environmental characteristics. It also shows the dependency of a few characteristics for example, *nature of terrain* is a sub-

characteristic of the main characteristic *location*.

Because of the different characteristics of an environment, disasters of all types can have different impact and make the prevention and mitigation phases of the disaster management life cycle much harder and take longer to Changing implement. environmental conditions is the dependent component of disasters, which is determined by the degree of severity. These conditions can increase or decrease the probability of disaster intensity and potential losses. There may be positive or negative impacts of a disaster with changing environmental conditions. Therefore, we raise the importance of environmental conditions in the context of disaster management.

#### 4. Disaster Management Categories

The major disaster categories and their types are shown in Table 1 [6, 7]. Disasters can also be generally categorized under the following main groups:

- Sea (for example, cyclones, typhoons )
- Land (for example, droughts, heat waves, landslides)
- Population (for example, epidemics, famine, food shortage)
- Others (any other unusual phenomena)

In the literature [8], the environment is considered to be another category of disaster described as "environmental emergencies". An environmental emergency is defined as a sudden threat to public health, or the well being of the environment, arising from the release or potential release of oil, radioactive materials or hazardous chemicals into the air,

	Floods	Earthquakes	Tsunami	Fire	Drought	Bomb Blast
Location	X	X	Х	X	Х	X
Nature of Terrain		X	Х		Х	
Ground		X	Х			
Conditions						
Water Resources	X				X	
Social Disruption	X	Χ	Х	X	Х	Χ
Timing						Χ
Human Impact	X	X	X	X	X	X
Climate	X			X	X	

Table 2: Mapping of Disaster categories and Environmental Characteristics

land or water [8]. Environmental emergencies can arise due to natural or man-made events. In the past, disasters have been categorized according to their types and the environmental contribution has been ignored. We argue that environmental conditions play a critical role in triggering some disasters.

Environmental degradation is the reduction of the capacity of an environment to meet social and ecological needs such as land degradation and deforestation. The human degradation of the environment and the subsequent disturbance of ecosystems results in an increased concentration of surface run-off and causes flooding and other catastrophic events.

We also emphasise that, when managing disasters, understanding of disaster needs are very important. They are not dependent on categories, but arise due to the environment in which a disaster occurs. On December 26, 2004, a massive tsunami swept through the Indian Ocean to several countries which are classified as under-developed countries. The decision support needs for managing such a disaster were different from those that might occur in developed countries.

disaster The management lifecycle contains activities such as prevention, mitigation, response and recovery. In [9], the disaster management lifecycle has been defined; we have extended this lifecycle highlighting the importance of environment. In Figure 3 we outline that all the activities in the disaster management lifecycle affected by The environment environmental factors. occupies a pivotal position when the disaster management cycle is considered. The environment has the tendency to change the severity of any disaster and its impacts. It can also affect the major components of cycle directly and indirectly. For instance, due to environmental conditions the early warning system for a disaster could have different impacts at different locations.

Hassanien and Mondlane [10] discuss the link between environmental risk assessment and disaster risk management as the main task for world sustainable development. In [11], they examine the environmental impacts of the most recent natural disasters and suggest that the magnitude of the disaster (human, physical, material and environmental damage) is not always directly related to the magnitude of the natural event. In most cases, more of the population is affected, in areas of natural risk, such as riverbeds, high slopes, or fragile or marginal soils.

Our proposed work is different from above in two ways; firstly, we identify the relationship between environmental characteristics influencing all disaster management activities and secondly, we establish the important fact that the degree of severity may vary with a change of environmental conditions.



Figure 3: Environment Affects from Disaster Management Perspective

#### 5. Mapping of Issues

In this section, we describe how disaster categories can vary with the change of environmental conditions and characteristics. We have selected only a few categories for simplicity. Table 2 shows the mapping between disaster categories and environmental conditions that affect the disaster categories. For example, if the location changes, it affects, all categories of disaster such as flood, earthquake, tsunami, fire, drought and blast. Similarly, if an environmental condition, such as climate, changes it will only affect disasters such as flood, fire and drought and will have no effect on other categories. The change of climatic conditions at one location might increase the severity of fire or drought disaster as compared to that in another location.

Figure 4 show that each disaster might have high, moderate or low impact depending on the environmental conditions.

Figure 5 illustrates the food impact, which is a typical adverse affect of a disaster as mentioned in section 3, on tsunami affected countries. In Indonesia, infrastructure has been destroyed in the worst affected provinces such as Aceh and Northern Sumatra [12]. In Sri Lanka 60 percent of total rice production was just completed when tsunami hit. Thailand, India and the Maldives are also affected by the tsunami and people are suffering great loss.



Figure 4: Relationship between Disaster categories and Environmental Conditions



#### Figure 5: Food Impacts on Tsunami Affected Countries.

The impact on food is well demonstrated in the graph. They show that the same disaster hit several different countries, each with different impact. The explanation is that the different environmental characteristics in each country make the impact of the disaster different. Therefore, we argue that a disaster such as the tsunami, in different locations with different environmental conditions has different impact and different diasters within the same location might have different impact. Figure 6 shows the relationship between environmental characteristics and disaster management activities. In Table 3 we present an overview for understanding the major characteristics of the environment and the way they can affect disaster severity.



Figure 6: Relationship between Environmental Characteristics and Disaster Management Activities

#### 6. Conclusions

This paper presents development of DSS model for disaster management with particular emphasis on the environment. The importance of different environmental conditions within the disaster management framework is highlighted. It further argues that changing environmental conditions can be considered as an important element in developing a DSS model for disaster management.

We conclude that different environmental conditions are vital to the degree of disaster severity but acknowledge that, these conditions are not the only cause of the severe impact of disasters.

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Environmental Characteristics	Description	Disaster Management Perspective		
Atmosphere	The layer of gases surrounding the	Changes in the atmospheric conditions		
-	earth.	forces the changes on climate, which might		
		affect the disasters severity level		
Temperature Describe changes in expected		Different climatic changes at different		
	conditions	geographic locations will have different		
		disaster impacts.		
Ecosystem Region of land with unique of		Changing ecosystem characteristics cause		
	land, life and soil characteristics	variation in disaster impacts		
Location	Contains terrain nature and ground	Impacts of disaster varies with different		
	conditions	land and soil conditions		
Resources	Composed of water, food,	Each resource varies from one location to		
	organizational, physical and	another that will change the disaster impact		
	economical resources.	at different locations.		
Others	Includes human impacts and timing	Disaster severity depends on human		
		impacts and vulnerability		

 Table 3: A Framework for Understanding Environmental Characteristics in Disaster Management.

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