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APPLYING FMEA & FTA TECHNIQUE TO IDENTIFY KEY RISK ELEMENTS ASSOCIATED WITH DISASTERS AND THEIR INTER-RELATIONSHIP

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Abstract: This paper mainly focuses on natural disasters which may be defined as any serious disruption to the functioning of a community or a society that is capable of causing a widespread human, economic or environment loss which is beyond the ability of the affected community or society to cope up with. It can also be defined as a function of the risk which results from the combination of hazards, increase in vulnerability and insufficient capacity or measures to reduce the potential negative consequences of risk.

The main aim of the paper is to formulate a mechanism to help the Government Agencies to prepare a systematic process that integrates risk identification, mitigation and transfer, as well as disaster preparedness, emergency response and rehabilitation or reconstruction to lessen the impacts of hazards.
There has been a rapid increase in the number of natural and manmade disasters and increase in the loss of human life & property due to the increased vulnerability of people and also substantial increase in risks associate with different types of hazards.
The main purpose of this paper is to analyse the various risks associated with different types of disasters and find out the critical relationships between them using the Failure mode and effect analysis technique (FMEA) and Fault Tree Analysis (FTA) technique. The top ten factors having highest risk priority number (RPN) are identified from FMEA and these factors are structured into a comprehensive systematic model portraying this complex issue which identifies the crux of the problem using FTA.

1. Introduction

Disaster Management & strategies for the reduction of the impact of these disasters are a combination of assessment of vulnerability of the existing population of the area and the risks associated with the most probable hazards and the detailed assessment of institutional & legislative framework existing in the area.

A risk associated with a hazard may be defined as the relative probability of any harmful consequence or loss (loss of live, property, economy, or livelihood)resulting due to the interactions between any natural and manmade hazards along with the assessment of the coping up capacity of the people of the affected area.

A very critical factor which helps to determine the reliability of a Disaster risk assessment technique is the reliability of the historic data available and the precision with which the data is collected and also the accuracy with which the collected data is analyzed.

This paper mainly concentrated of the risks associated with natural disasters which may be defined as those disasters which are of sudden occurrence and have a widespread impact.

An effective disaster Management system should be designed in such a way that it works in consultation with the local, regional as well as National Authorities and also if found effective and beneficial shall be incorporated in Disaster Management framework of the Country.

2. Research methodology

Disaster risk Management is a methodical procedure of utilizing the systematic decision making policies, optimizational procedures, operationability skills, implementation of policies and overall strategic development and providing assistance to the affected people in order to enhance their capabilities of the people for coping up with any kind of a disaster.

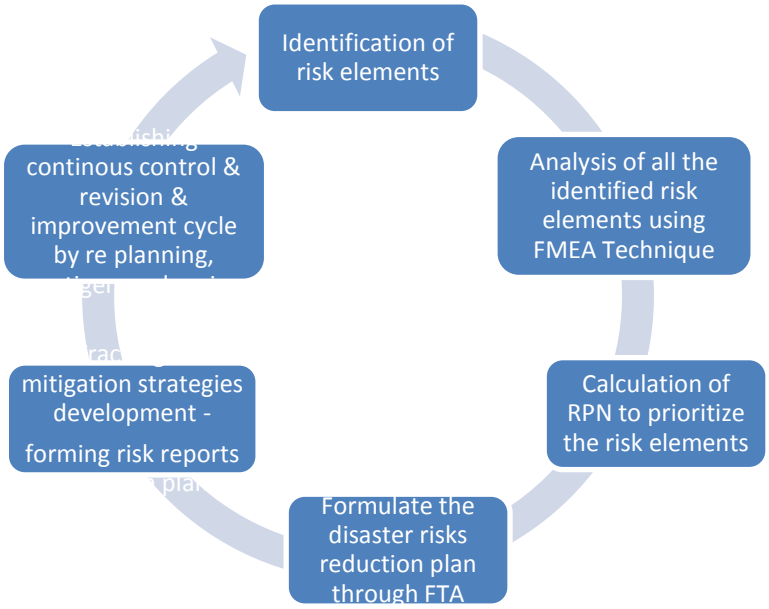
For this purpose the Author has firstly tried to formulate a Disaster risk index (DRI) using the Failure Mode and evaluation analysis technique (FMEA) which will help to compare the risks of mortality rates of different countries across the World.

The key indicator in this DRI is the overall relative regional vulnerability which will help to indicate the total number of people who have died in a Country due to a disaster or a particular hazard with respect to the total number of people actually exposed to that particular disaster or hazard.

Putting in place the relative vulnerability concept and for calculating the disaster risk index which will be obtained after applying FMEA, the Author has identified twenty four critical risk parameters which have the potential to effect a large scale of population and adversely increase the vulnerability of the population of the area under consideration and also poses a great risk to the society & population. Further using the concept Failure Tree Analysis the author has analyze how these factors are inter related and what is the impact of these critical factor

Through this paper the Author has tried to formulate a risk and vulnerabilty analysis cycle which will help the Authorities to identify the acticities which form a major and most critical part of the risk and vulverabilty analysis.This will also help the Authorities to focus more on the continouus motinoring and updation of mitigation strategies
The paper shall also depict the interrelationship between the various parameters associated with the risk & vulnerability analysis of disasters. The first and the most critical parameter is the shall be applied to prioritize the risks based on their likelihood of occurrence, detection and their potential impact through application of FMEA technique to the identified risk factors.
After the application of FMEA Technique and identifying the top ten most critical risks, the risk reduction strategies for their risks needs to be formulated, however there is a continuous need for the tracking of these methodologies and improvising and modifying the mitigation strategies from time to time as with the type of disaster the risks associated with them also keep changing.
The FTA (Failure tree analysis)technique has been applied further on the ten critical parameters which will help to understand the interrelation and interdependency between the various critical risk parameters and help to get a clear picture of the risk drivers. Also it will clearly indicate the dependency of risks on other elements.

FIG1 RISK & VULNERABILITY ANALYSIS CYCLE



The Fig 1 above depicts the interrelationship between the various parameters associated with the risk & vulnerability analysis of disasters. The first and the most critical parameter is the shall be applied to prioritize the risks based on their likelihood of occurrence, detection and their potential impact.
After the application of FMEA Technique and identifying the top ten most critical risks, the risk reduction strategies for their risks needs to be formulated, however there is a continuous need for the tracking of these methodologies and improvising and modifying the mitigation strategies from time to time as with the type of disaster the risks associated with them also keep changing.
The FTA technique helps us to understand the interrelation and interdependency between the various critical risk parameters and help to get a clear picture of the risk drivers.

Failure Mode	Failure Causes	Failure effects	Likelihood of occurrence	Likelihood of detection	Severity	Risk priority No.
Poor Infrastructure	Building Codes and specification not followed.	Additional work, loss of life & property	4	8	7	224
	Poor quality of materials	Additional work, loss of life & property	6	7	7	294
	Lack of public services	Loss of life & property	7	7	6	294
	No spatial planning & land Management	Additional work, loss of life & property	8	5	6	240
Climate/ Weather	Variations/fluctuations in Climate	Increased susceptibility to disaster, more impact, loss to life & property	9	5	9	405
	Adverse Weather conditions	Increased susceptibility to disaster, more impact, loss to life & property	9	5	9	405
	Poor environmental Management	Increased vulnerability, more impact, loss to life & property	7	6	7	294
Population	Very large population	Increased vulnerability, more impact, loss to life & property	8	7	9	504
	Very large rural population	Less awareness, more stringent mind sets.	6	6	6	216
	Racism/sex discrimination	Stringent mind sets of people, less involvement of people, more suseptible to impact	6	5	6	180
	Poverty	Increased vulnerability, more impact, loss to life & property	8	6	8	384
	Less public involvement	Increased vulnerability, more impact, loss to life &	8	6	8	384

		property				
	Stringent Mind sets of people	No involvement leading to less awareness, increasing the vulnerability	8	7	8	448
	Poor health facilities	Increased suseptibility to disaster, more impact,can lead to loss to life & property	7	7	7	343
	Low GDP per capita	Increased suseptibility to disaster, more impact,can lead to loss to life & property	7	6	7	294
Development	Low human development Index	Increased suseptibility to disaster, more impact,can lead to loss to life & property	7	6	7	294
	Lack of public awareness	Increased suseptibility to disaster, more impact,can lead to loss to life & property	8	8	9	576
	Non developed early warning systems	Increased suseptibility to disaster, more impact,can lead to loss to life & property	8	7	9	504
	Lack of education & training	Increased suseptibility to disaster, more impact,can lead to loss to life & property	8	7	8	448
Legislation	No institutional framework	No accountability, no nodal point of contact for emergency purposes	8	7	8	448
	No legislation and & community support	No accountability, no nodal point of contact for emergency purposes	7	7	9	441
	Socio economic constraints	No accountability, no nodal point of contact for emergency purposes	6	6	6	216

TABLE1. FAILURE MODE AND EFFECT ANALYSIS

TABLE 2. 10 MOST CRITICAL RISKS ASSOCIATED TO ALMOST ALL TYPES OF DISASTERS (BASED ON FMEA)

Sr No	Critical Risk Parameter
1.	Lack of public awareness (LPA)
2.	Very large population (VLP)
3.	Non developed early warning systems(EWS)
4.	Stringent Mind sets of people(SMS)
5.	Lack of education & training (E&T)
6.	No institutional framework (IF)
7.	No legislation and & community support (L&C)
8.	Adverse Weather conditions(WC)
9.	Poverty (P)
10.	Less public involvement (PI)

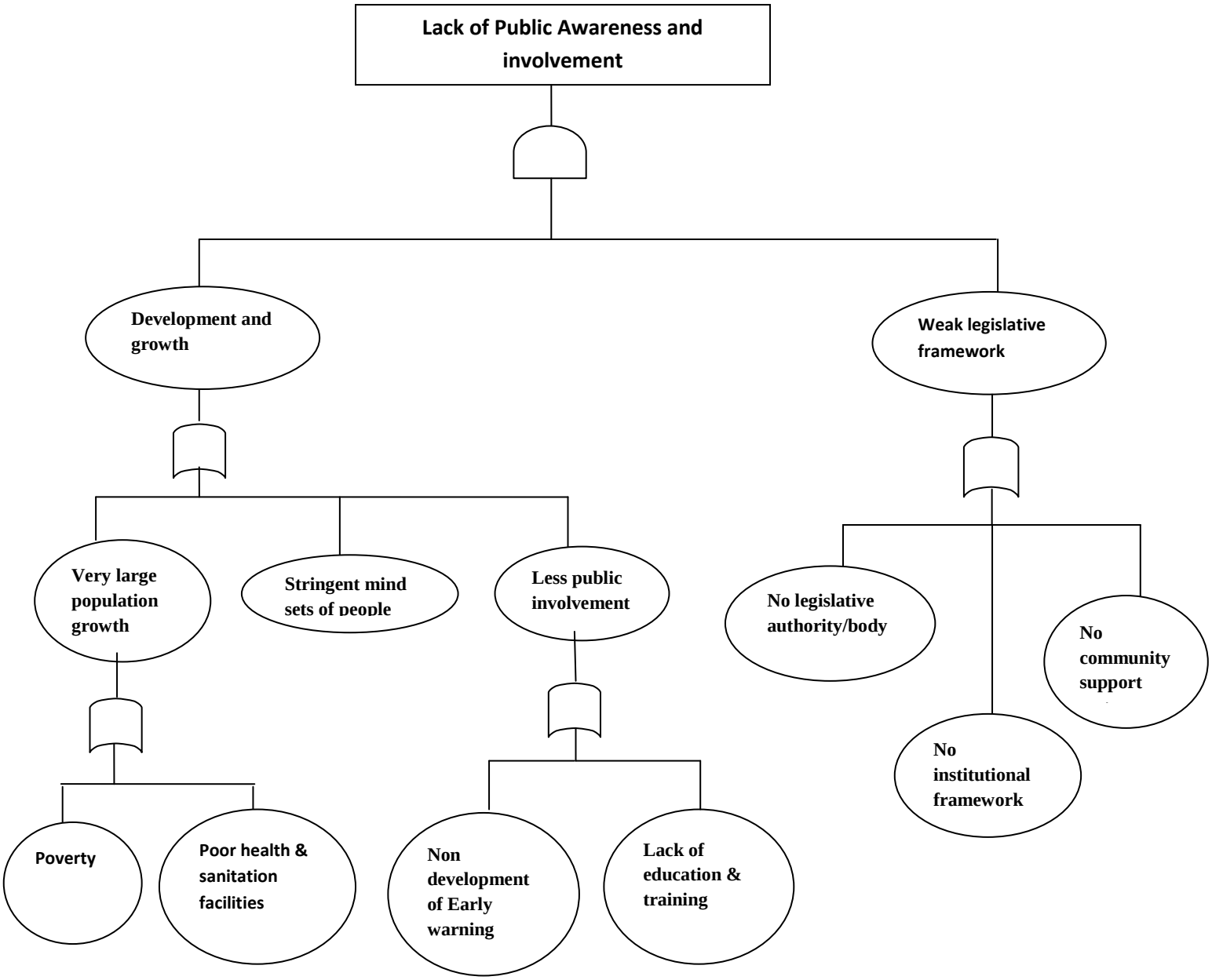
Table 3.STRUCTURAL SELF-INTERACTION MATRIX (SSIM)

	PI	**VLP**	**EWS**	**SMS**	**E&T**	**IF**	**L&C**	**WC**	**P**
LPA	X	V	O	X	X	A	A	O	V
P	O	X	O	O	A	O	O	O	
WC	O	O	O	O	O	O	O		
L&C	O	O	A	X	A	X	O		
IF	O	O	O	V	A				
E&T	X	V	V	X					
SMS	A	O	O						
EWS	V	V							
VLP	O								

There are four symbols used to denote the direction of relationship between the enablers (i and j):
A: enabler i will ameliorate enabler j;
V: enabler j will be ameliorated by enabler i;
X: enabler i and j will ameliorate each other; and
O: enablers i and j are unrelated

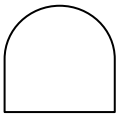
Based on the above study and analysis the following Failure tree has been developed by the Author. This FTA is carried out on the ten most critical risk parameters identified through the FMEA Analysis in order to formulate a logical inter relationship between different risk **elements associated with a disaster.**

Fig2. FAILURE TREE ANALYSIS

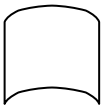

Lack of Public Awareness and involvement
Development and growth
Weak legislative framework
Very large population growth
Stringent mind sets of people
Less public involvement
No legislative authority/body
No community support
No institutional framework
Poverty
Poor health & sanitation facilities
Non development of Early warning
Lack of education & training

The Logic Symbols used in the FTA Analysis

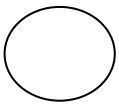
Top Event-Representing the most undesirable Event



AND Gate-Produces a result if all other elements co exist



OR Gate-Produces a result if any one of the parameter coexists.



Basic Event-Initiating Fault or failure.

3. Conclusion

Outcome of analysis

From the above FTA the author has found that the lack of public awareness and public involvement are the key enabler causing the maximization of risks and is the major reason for increasing the vulnerability of the people. This situation may occur due to lack of constructive development in a country, slow growth rate in terms of education, training, early warning systems, stringent mind sets of people, poor health & sanitation facilities, poverty etc or due to a weak legislative framework in which there may be lack of an administrative governing body, lack of decision making authority etc.

This also clearly shows that the Governmental Authorities are lacking in Institutionalization, that there is a lack of a structure to which may be relied on to ensure a minimum impact of the disaster when struck, also they need to assign responsibilities and formulate a team who is ready to take accountability to enforce the set systems into place.

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