Ultra Scientist Vol. 24(3)B, 497-504 (2012).

Fuzzy analysis of the ravages and losses caused by Tsunami at Karaikal region

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(Acceptance Date 30th October, 2012)

Abstract

In this article the authors attempted to identify the part of the coastal area affected much and to ascertain the group of affected people (based on region) due to Tsunami in Karaikal district during the year 2004.

Key words : Fuzzy matrix, average time dependent matrix (ATD matrix), Refined Time Dependent Data Matrix.

1. Introduction

"A disaster is defined as a basic disruption of the social context within which individuals and groups function"[1] Natural disasters result in symptoms of post-traumatic stress disorder, depression, anxiety and physical ailments[2,3,4] Norris *et al.*, 2002.

During the last decades the frequency and severity of natural disasters like earthquake, landslides, floods, Tsunami have significantly increased. Even though there is great improvement in science and technology the natural phenomena affect the socio economic conditions of all regions considerably. It is possible to minimize the disastrous hazards by taking decisive steps towards protective measures .The fuzzy logic approach is an appropriate tool for risk assessment.

To describe situations mathematically which are vague or fuzzy in nature Zadeh, introduced the theory of fuzzy sets. Fuzzy relations and fuzzy relational equations have important application in pattern classification, clustering, fuzzy information retrieval, preference and so on. In system models based on fuzzy sets, one often uses fuzzy matrices to define fuzzy relations.

"A Fuzzy matrix is a matrix with elements having values in the fuzzy interval".

In this article, the unit interval [0,1] and the interval [-1,1] are called fuzzy intervals.

The aim of the paper is to assess the highest damage invoked by the regions of Karaikal district using the available information and the expert knowledge due to Tsunami in 26th December 2004. This is our first step to

study about the vulnerability caused by Tsunami. The obtained results depicts the area highly exposed to such a natural hazard.

2. Description of the problem :

On 26th December 2004, a major earthquake of magnitude 9 on the Richter scale occurred in the Indian ocean on the northern tip of Sumatra island. This led to fast moving, giant Tsunami waves that lashed the coastal line. The Tamil Nadu and Pondicherry caused severe damage. Similar Tsunami waves had occurred in Tamil Nadu coasts during 1881 and 1941, but the details of damage were not available. However in 2004, the Tsunami savaged the coastal areas and those living in the coastal districts in multiple ways. There was a colossal loss of life and assets, damage to soil and water in agricultural lands, loss of cattle and cash crops. Nagapattinam district was the worst affected area in relation to human hood, agriculture and livestock[5].

Damage caused by Tsunami in Agriculture and live stock sector in Tamil Nadu

S.No.	DISTRICT	AREA(in hectors)	LIVESTOCK CATTLE AND GOAT (in numbers)
1	Nagapattinam	9567.09	128121
2	Kanniyakumari	12.00	131501
3	Cuddalore	1681.22	1068
4	Kancheepuram	750.00	4
5	Villupuram	13569.29	0
	Total	25579.6	260694

Source: area G.O.Ms.No. dated 23.03.2005 Livestock, cattle and goat – post Tsunami sustainable livelihoods programme for coastal communities of Tamil Nadu- Design document.

The main area under our study is Karaikal which is a union territory, lying in Nagapattinam district.

Being the coastal area, 75% of population are fisher folks, the sudden attack of giant waves emptied the shores and some inland parts of the area under study. So many people – men, women and children of both categories died, fisher folk and other were badly victimised.

PICTURES

The accurate details from Fisheries Department in the year 2005, Karaikal.

AFFECTED REGIONS IN KARAIKAL DISTRICT	TOTAL POPUL-ATION	TOTAL NUMBER OF AFFECTED PEOPLE	FISHER FOLKS	OTHERS	DEATH TOLL			
					M	F	C	TOTAL
1. MANDAPATHUR	366	130	120	10	5	14	19	38
2. KALIKUPPAM	539	190	185	5	5	2	13	20
3. AKKAMPET	309	147	142	5	1	5	9	15
4. KOTUCHERRY MEDU	1112	320	231	89	0	3	7	10
5. KEEZHAKASAKUDY MEDU	1092	350	234	116	5	21	32	58
6. KILINJAL MEDU	2344	620	608	12	2	8	13	23
7. KARAIKAL MEDU	2979	730	723	7	4	15	16	35
8. AMMANKOVIL PATHU	620	121	0	121	1	10	17	28
9. MATHAGADI	1260	357	77	280	3	3	1	7
10. AKKARAI VATTAM	3992	887	0	887	1	2	0	3
11. KARUKALACHERRY	1044	400	380	20	3	10	5	18
12. PATTINACHERRY	1217	565	555	10	19	54	87	160
13. VADAKKU VANJUR	558	250	245	5	6	2	14	22
14. PARAVAI PET	350	50	0	50	0	0	0	0
15. NADUKALAM PET	250	50	0	50	0	0	0	0
16. THIRUVETTAKUDY PET	155	20	0	20	0	0	0	0
17. VADAKATTALAI	1250	250	0	250	1	0	0	1
18. MARIYAMMAN KOVIL PET	1500	300	0	300	0	0	0	0
19. KEEZHAYUR AYYANAR KOVIL PET	90	53	0	53	0	0	0	0
20. ANTHONIYAR KOVIL PET	391	100	0	100	0	0	0	0
21. KEEZHA VANJUR	1175	215	0	215	1	0	0	1
22. INDIRA NAGAR SETHILAL NAGAR	1418	300	0	300	0	0	0	0
23. VETTAIKARAN MEDU	231	64	0	64	0	0	0	0
24. RAJIV GANDHI NAGAR	440	88	0	88	0	0	0	0
25. M.G.R.NAGAR	605	121	0	121	0	0	0	0
26. EDATHERU	250	50	0	50	0	0	0	0
27. LINGATHADI	250	50	0	50	0	0	0	0
28. KALLARAIPET	1000	200	0	200	0	0	0	0
29. POOVAM MATHAKOVIL PET	410	82	0	82	0	0	0	0
30. KATTAPILLAI MARAIKAR THOTTAM	1500	300	0	300	0	0	0	0
TOTAL	**28697**	**7360**	**3500**	**3860**	**57**	**149**	**233**	**439**

3. *Application of fuzzy matrix :*

We attempt to identify the most affected area regarding the loss of people due to the disastrous hazard. To analyse this problem we extracted the accurate details from the fisheries department and divided the range into eight categories regarding the total number of people both affected and died. Then we divided the affected people as three categories has follows.

P_1- number of fisher folks affected.

P_2-number of people affected other than fisher folks

P_3-Death toll (men, women and children)

Based on the range of population the area is grouped into eight categories as below:-

RANGE	NUMBER OF VILLAGES	POPULATION
0-500	12	3492
501-1000	5	3322
1001-1500	10	12568
1501-2000	-	-
2001-2500	1	2344
2501-3000	1	2979
3001-3500	-	-
3501-4000	1	3992

By taking above eight categories as rows and number of people affected-fisher folk, others and number of people died as column, a 8x3 initial raw data matrix called Time Dependent Matrix (TD) was formed.

RANGE	NO. OF VILLAGES	TOTAL POPULATION	TOTAL STRENGTH AFFECTED	AFFECTED FISHER FOLKS	OTHERS AFFECTED	DEATH TOLL			
						M	F	C	T
0-500	12	3492	937	262	622	6	19	28	53
501-1000	5	3322	952	430	452	12	14	44	70
1001-1500	10	12568	3612	1477	1880	32	91	132	255
1501-2000	-	-	-	-	-	-	-	-	-
2001-2500	1	2344	643	608	12	2	8	13	23
2501-3000	1	2979	765	723	7	4	15	16	35
3001-3500	-	-	-	-	-	-	-	-	-
3501-4000	1	3992	890	-	887	1	2	-	3

The initial raw data matrix has been converted into average time dependent matrix (ATD matrix) by dividing each entry with the width.

ATD Matrix

RANGE	FISHER FOLKS	OTHERS	DEATH TOLL
0-500	0.524	1.244	0.106
501-1000	0.860	0.904	0.140
1001-1500	2.954	3.760	0.510
1501-2000	-	-	-
2001-2500	1.216	0.024	0.046
2501-3000	1.446	0.014	0.070
3001-3500	-	-	-
3501-4000	-	1.774	0.006

The average (μj) and standard deviation (σj) of every column were worked out as follows :

AVERAGE	0.875	0.965	0.1098
STANDARD DEVIATION	0.948	1.237	0.1587

Using the average (μj), Standard Deviation (σj) and a parameter α from the interval [0, 1], a fuzzy matrix called the Refined Time Dependent Data Matrix[1] (RTD Matrix) was formed. The RTD matrix with entries eij, where eij ∈{-1, 0, 1}, was formed using the following formula [1] :

If aij ≤ (μj α*σj) then eij =-1 else if aij ∈ (μj α*σj, μj + α*σj) then eij = 0

else if aij ≥ (μj + α*σj) then eij = 1,

where aij's are entries of Average Time Dependent Matrix.

By varying the parameter α∈ [0, 1], any number of Refined Time Dependent Data Matrices can be obtained. Three of such matrices obtained were as follows:

RTD Matrix for α=0.25 **Row sum matrix**

$$\begin{pmatrix} -1 & 0 & 0 \\ 0 & 0 & 0 \\ 1 & 1 & 1 \\ -1 & -1 & -1 \\ 1 & -1 & -1 \\ 1 & -1 & -1 \\ 1 & -1 & -1 \\ 1 & 1 & -1 \end{pmatrix} \qquad \begin{pmatrix} -1 \\ 0 \\ 3 \\ -3 \\ -1 \\ -1 \\ -1 \\ 1 \end{pmatrix}$$

RTD Matrix for α=0.50 **Row sum matrix**

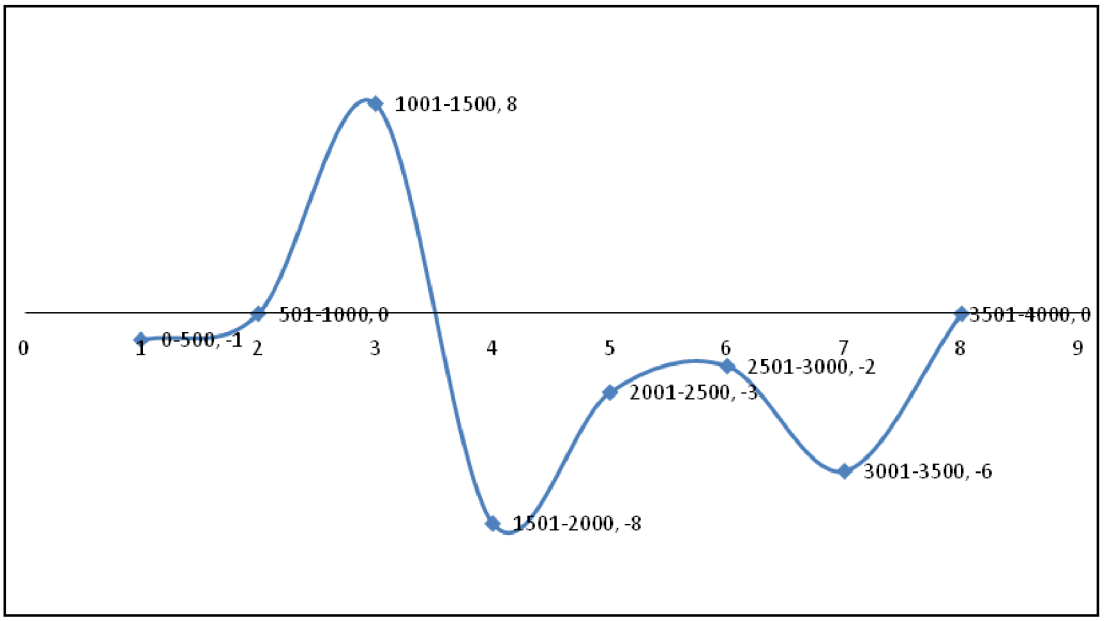
$$\begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 1 & 1 & 1 \\ -1 & -1 & -1 \\ 0 & -1 & 0 \\ 1 & -1 & 0 \\ -1 & -1 & -1 \\ -1 & 1 & 0 \end{pmatrix} \qquad \begin{pmatrix} 0 \\ 0 \\ 3 \\ -3 \\ -1 \\ 0 \\ -3 \\ 0 \end{pmatrix}$$

RTD Matrix for α=0.75 **Row sum matrix**

$$\begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 1 & 1 & 0 \\ -1 & -1 & 0 \\ 0 & -1 & 0 \\ 0 & -1 & 0 \\ -1 & -1 & 0 \\ -1 & 0 & 0 \end{pmatrix} \qquad \begin{pmatrix} 0 \\ 0 \\ 2 \\ -2 \\ -1 \\ -1 \\ -2 \\ -1 \end{pmatrix}$$

By combining all these three matrices, the

The graph as shown below exhibited the group of respondents (based on region) worst affected.



Combined Effect Time Dependent Data Matrix (CETD Matrix), which gives the cumulative effect of all these entries, was obtained as follows :

CETD Matrix **Row sum matrix**

$$\begin{pmatrix} -1 & 0 & 0 \\ 0 & 0 & 0 \\ 3 & 3 & 2 \\ -3 & -3 & -2 \\ 1 & -3 & -1 \\ 2 & -3 & -1 \\ -1 & -3 & -2 \\ -1 & 2 & -1 \end{pmatrix} \qquad \begin{pmatrix} -1 \\ 0 \\ 8 \\ -8 \\ -3 \\ -2 \\ -6 \\ 0 \end{pmatrix}$$

Conclusion

From the graph it is observed that the area having population between 1001-1500 hectors were most affected due to Tsunami in Karaikal and the areas are Kottucherry medu, Keezha-kasakudy medu, Madhagadi, Karuka-lacherry, Pattinacherry, Vadakattalai, Mariyamman kovil pet,Keezha vanjur, Indira Nagar, Kattapillai maraikar thottam.

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