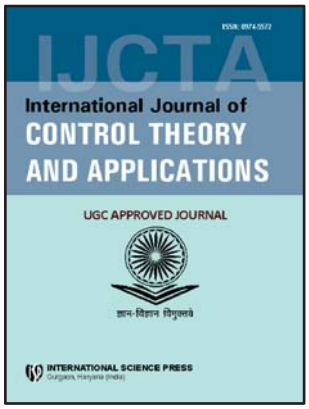

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Implementation of Fuzzy Logic Control for Flood Analysis

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Abstract : A number of major cities in India were affected by flood related disasters. In 2015, due to abnormal rain we faced so many problems. Eventhough the climatic change plays an important role in the reason for flood all over the world, apart from Urbanization and a few human decisions have created extra impact on the same. In this paper we have discussed about the important factors of Chennai floods (during Nov-Dec 2015). Applying Fuzzy Logic Controls (FLC) to find the remeidel means inorder to be attentive and slightest from disasters.

Keywords: *Urbanization, Fuzzy Logic Control, Flood, Global Warming, Remedial Measures*

1. INTRODUCTION

Tamilnadu state is the southern region of India. Chennai is the capital of Tamilnadu as well as the commercial, administrative hub of South India. Chennai has a total area of 426 km^2 which is equivalent to 0.328 % of land area of total Tamilnadu. The population is 9 million (survey 2015). The geographical basin has an annual rainfall of about 140 cm (55 inch), most of the rainfall occurs for the period of north-east monsoon between mid-October and mid-December. The mean annual temperature at Chennai is 35-40°C (95-104°F) in the hottest period of a year. It happens between late May and early June known regionally as Agni Nakchatram or as KathiriVeyyil and the coolest period of the year is entire January with the least minimum temperatures between 19-25° C (66-77° F).

During the year-2015, Chennai received a heavy rainfall which was three times higher than the average rainfall in the month of November and of course the average rainfall for the whole month of December was received on a single day on December 1st. It made the whole metro sinks in the flow water.

Usually flood occurs when a sudden influx of water, submerges land areas, causing danger to the life and property of people living there. People living in low-lying areas in the river basins suffer the most and lost until not an iota.

2. LITERATURE SURVEY

Khusboo sandiphai Desai et, al.(2015) applied fuzzy logic controls to determine the probability through the different parameters for efficient flood control. Dragon Pamucar et, al. (2014) tested flood hazard assessment by application of fuzzy logic. Jayawarden et,al.(2014) tested the performances of Mamdani, Larson and TSK fuzzy logic models. Saravanan and Naveen Chander et al. (2015) has analyzed about the Chennai floods and possible solutions based on the manmade factors of other developed countries. It can be simply concluded that natural disasters can be smoothly handled with growing civil engineering technologies exists around the world. Chennai Metropolitan city needs to overcome the losses caused by recent heavy floods. This study is an attempt in reconstructing, recovering from flood 1st, Dec, 2015, through field investigation in Chennai. The purpose of this study is to demonstrate the applicability of fuzzy logic approach as a flood disaster factor for the Chennai basin.

3. DESCRIPTION OF STUDY AREA

The south Indian floods during 2015 resulted a heavy rainfall caused by the annual northeast monsoon in November-December 2015, they affected coromandel coastal region of the south India, Andhra Pradesh, and the union territory of Puducherry and TamilNadu. The entire urban of Chennai metro were hard hit for the most part. More than 500 people were killed and over 18 Lakhs people were displaced. The estimation of damages and losses have been calculated ranging from 50,000 crore to 1, 00,000 crore of rupees.

Chennai had its natural drainage system, there were many trees, plants and open areas around the city, through this the rain water had easily been absorbed by the ground itself, Because of unplanned infrastructure, illegal construction, over recent 5-10 years causes blocks the nature flow of water. Thus we could not expect the nature censure for this havoc; there are other reasons for the same.

The main marshland in south chennai is Pallikaranai marshland. It had 250 Sq.km of wetland around the city in the years eighties. This 5000 hectares (ha) marshland has shrunken to 600 (ha) during the survey 2010-11; the only reason was rapid urbanization. The marshland is filled with buildings in Chennai metropolitan area (CMA), Most of marshland in Chennai and all other wetlands became sites of waste disposal, housing, commercial and Industrial purposes. We may see the growth of occupancy at marsh lands.

Table 1
Source: Vencatesan, J, 2007, Protecting wetlands, Current Science

Change in the area of the Pallikaranai marsh between 2003 and 2005

Segment	*2003*	*2005*
Garbage dump	50.25 ha	57.24 ha
Area impacted by garbage dumping/sewage	58.75 ha	132.25 ha
Northern segment	227 ha	150.56 ha
Southern segment	284 ha	279.65 ha

Also, The State government Authorities of respective departments may kick off hard rules to maintain and to preserve the values the marshland and the water body or the wetlands which became land for waste disposal. Let us discuss the important factors, which cause the flood;

4. MAIN DISCUSSION FOR FLOOD DISASTER

4.1. Natural Reasons for Disaster

These types of disasters occur because of natural phenomena such as El Nino, Climate change, Floods, Cyclones, Tsunamis, Droughts etc.

4.1.1. EL Nino

EL NINO a Spanish word, means "Little Boy" is a weather occurrence that leads to multiply in sea surface temperature above normal by 0.5°C and heating up of water off the western coast of South America which in revolve transform the wind pattern in central-eastern equatorial pacific and trigger floods and droughts in diverse parts of the world. El Nino re-emerges after a gap of 3 to 5 years in central and East Pacific Ocean and ruins in outcome on an average of 12 months to 2 years.

4.1.2. Global Warming

Global warming is a steady process of uninterrupted rise in the level of Earth temperature. Global warming has turn out to be one of the biggest problems faced by the world now. It is acknowledged that increasing level of carbon dioxide gas and other greenhouse gases are the major reasons of increasing the heat in atmosphere. If it is not noticed and solved immediately by the efforts of all countries worldwide, Global warming would be the major and only reason of rising sea level, flooding, changes in weather patterns, storms, cyclone, epidemic diseases, lack of food, death, etc. The merely solution to this subject of global warming is nothing but the individual awareness on social responsibility. People must be conscious of its meaning, reason, bad effects and other critical things of global warming. To get it eradicated worldwide and create the possible of life on earth forever as usual. The graph given below represents global mean surface temperature change (increase) from1880 to 2015.

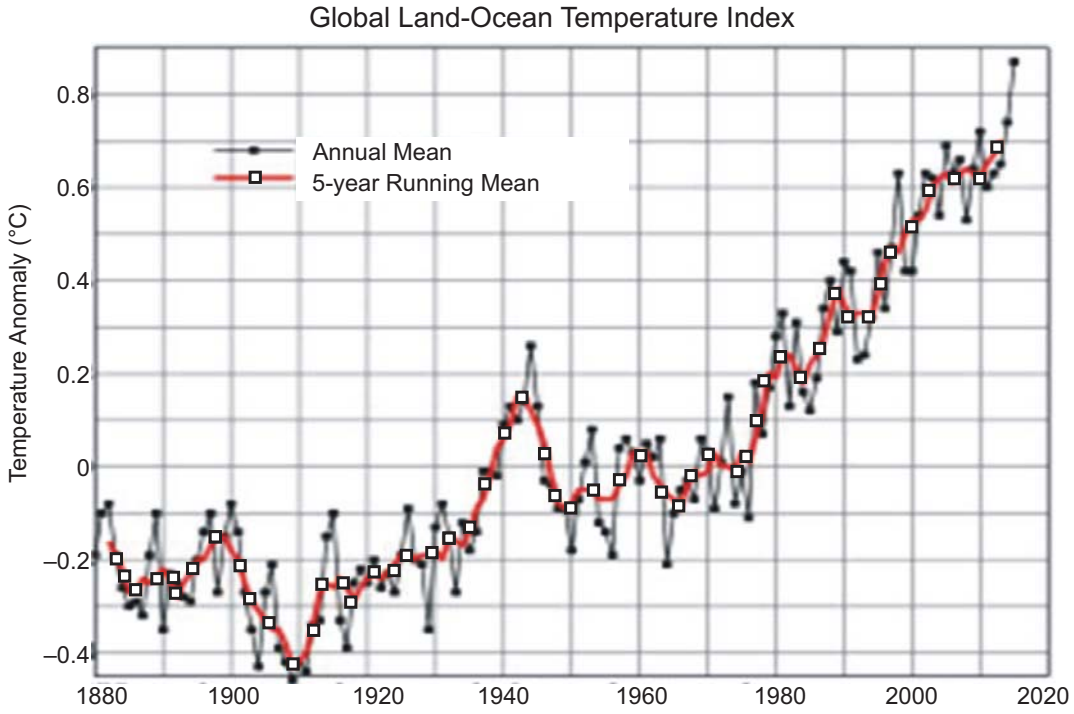


Figure 1: Global mean surface temperature change from 1880 to 2015 (Wikipedia, the free encyclopedia)

4.2. Man-Made Disaster

This type of disaster is caused by human beings, deliberately or by mistake.

1. Illegal Construction
2. Unplanned Infrastructure or Unapproved Project
3. Land Maphiya
4. Environmental Pollution,etc.,

1. Illegal Construction : Illegal constructions were found on most of the flood affected areas. Chennai corporation analyses that there are more than 1, 50,000 illegal structures (mostly Multi-storeyed apartments, huge industries, etc,) in and around the city. Which are adjacent to the water bodies. Over 300 water bodies disappeared due to these constructions (Buildings). Below shows rural and urban development from 1988 to 2014.

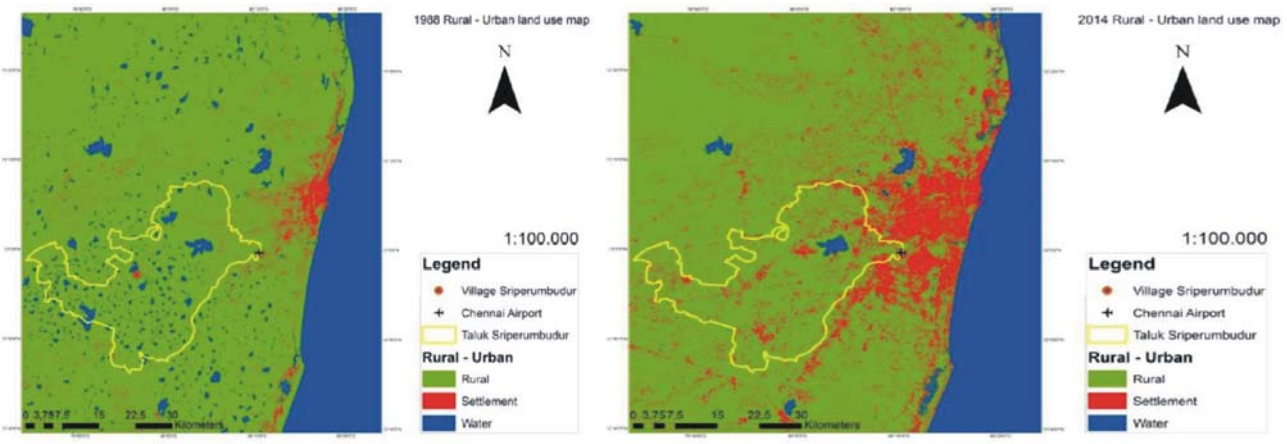


Figure 2: Year 1988 and Year 2014

2. Unplanned Infrastructure or Unapproved Project : There are lot of state and central Government projects which are not properly designed. For example, the Chennai bypass road (outer Ring road) connecting NH45 and NH4 blocks the east flowing drainage water totally. It affects areas like Anna Nagar (*w*), Porur, Vanagaram, Maduravoyal, Mugappair and Ambattur etc. During all the rainy seasons.

3. Land Maphiya : One of the other major factors of flood is landmaphiya. Centre for science and environmental research reveals that, in 1980's, there were 650 Lakes spread across the city. Urbanization has let to shrinkage of water bodies and wetlands. Out of 650,only 27 water bopdies are now on good condition. An IISC analysis says that built-up area increased from 29.53 percent in 1991 to 64.4 percent in 2013.

4. Environmental Pollution : Environmental pollution is one of the biggest problems today. It is an issue that troubles us economically, physically and routines of our lives. The contamination, pollution of the environment is also being linked to some of the diseases that are around us currently. Yet, most of us do not know about this problem. This shows that the environmental pollution is becoming increasingly worse and worse. And it needs to be taken care of as soon as possible; many factors are present for why environmental pollution has become such a large issue in the world. Over the years, environmental pollution has become more of a problem for a number of reasons. "Due to the great increase in the world's population, which is at 6.1 billion, energy use, and the number of

vehicles on roads make air pollution a greater threat than ever. Because of this, "air pollution kills eight thousand people a year due to respiratory related problems "Also, 40% of the world's deaths are being attributed to environmental factors. With such a number of people dying a year due to air pollution. One can see how much the environmental pollution is affecting us. This dilemma is made worse due to the current means of disposing nuclear waste. "Until 1993, Russia would resort to the dumping of its high and low level radioactive waste by dumping it into the Arctic seas and any other low-level waste into the Seas of Japan. "Radiation from nuclear waste is known to cause a series of reactions in body tissue those results in damage to the body's cells. This can cause disease, such as cancer, injury, or death. The effects on the human body make the situation even worser for the people of the world.

5. METHODOLOGY

5.1. Fuzzy Logic Controller (FLC) Method

The cause factor is one of the major inputs which are used as crisp values into fuzzy values. In this stage all the cause factors are fuzzified. On the next stage of FLC, this fuzzified factor is then used by the inference engine to evaluate the control rules stored in the fuzzy rule base method. The result of this evaluation is a fuzzy set which is defined on the universe of possible actions. In the final stage, unique value is obtained as a step of defuzzification. This leads to the final decision of the problem distinctively.

The basic structure of fuzzy logic control modeling, which is known as fuzzy inference system (FIS), is a rule –based or knowledge-based system, consisting of three conceptual components: a rule base that consists of a collection of fuzzy if-then rules; a database that defines the membership function (MF) used in these fuzzy rules; and a reasoning mechanism that combines these rules into a mapping routine from the inputs to the outputs of the system to drive a reasonable output. There are basically two types of rule base system, namely, the Mamdani (Mamdani and Assilian, 1975)type and the Takagi-Sugeno-Kang(TSK) type (Takagi and Sugeno,1974,1985).In the Mamdani type, the fuzzy rule is expressed in linguistic form. In the Takagi-Sugeno-Kang rule system, the fuzzy rule is expressed as a mathematical function of the input variables which is more appropriate for neuro-fuzzy systems (Sen, 1998).

5.2. Mamdani Fuzzy Inference System

5.2.1. Step 1

Fuzzification of input : Classifying and scaling of inputs from 0 to 1 by using a set of input membership functions.

5.2.2. Step 2

Evaluation of the antecedent: If the antecedent of the rule has more than one part a fuzzy operator is applied to obtain a single membership value that represents the result of the antecedent for the rule.

5.2.3. Step 3

Creating fuzzy rules formation : Finding the position of existence by formulating fuzzy rules. Generally, the rules formation needs the background knowledge in judgment, which is derived from the historical occurrences, to make the fuzzy inference. The definition of the fuzzy operator (AND or OR) is used to obtain a single number that represents the results of the antecedent evaluation.

5.2.4. Step 4

Aggregation: Procedure that integrates the output fuzzy set of each rule with the implication step. Some of the most commonly used aggregation operators are the maximum, the sum and the probabilistic sum operators. The operator combines various output of fuzzy sets associated with each rule, using the fuzzy aggregation operators.

5.2.5. Step 5

Defuzzification : This is the last procedure in the fuzzy inference process and it consists in fetching the normalized output by using the defuzzification method. Five commonly used defuzzification method exist: Centroid of area (COA) or Centroid of Gravity method (COG), Bisector of area (BOA), Mean of maximum (MOM), Smallest of maximum (SOM), Largest of maximum (LOM). The COG method is used for the defuzzification process discussed in this paper as it is the most used, prevalent and physically appealing of all the defuzzification methods

6. MATHEMATICAL MODEL

Using Fuzzytech software, applying below factors to find the solution of problem. Our first factor F1 discussed ElNino and our second factor F2 discussed Global warming. These F1 and F2 are natural and unavoidable reason for flood. Man made flood factors are, third factor F3 is illegal construction, Fourth factor F4 is unplanned infrastructure or unplanned /unapproved project, Fifth factor F5 island maphiya, Sixth factor F6 is environmental pollution. The above factors are described using linguistic scale defining from 1to 3 how serious the flood disaster is: low, medium, high.

For example if the flood disaster output is medium then the affected area is not dangerous, it is under control.

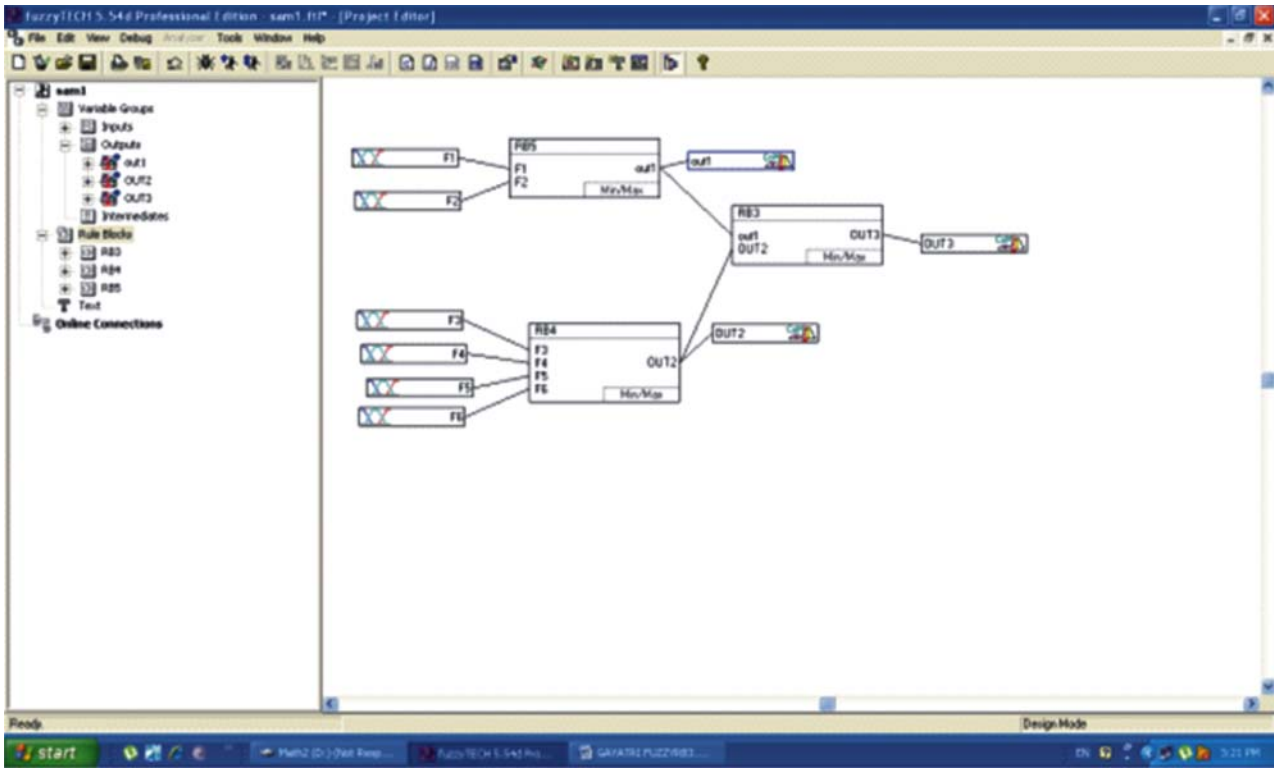
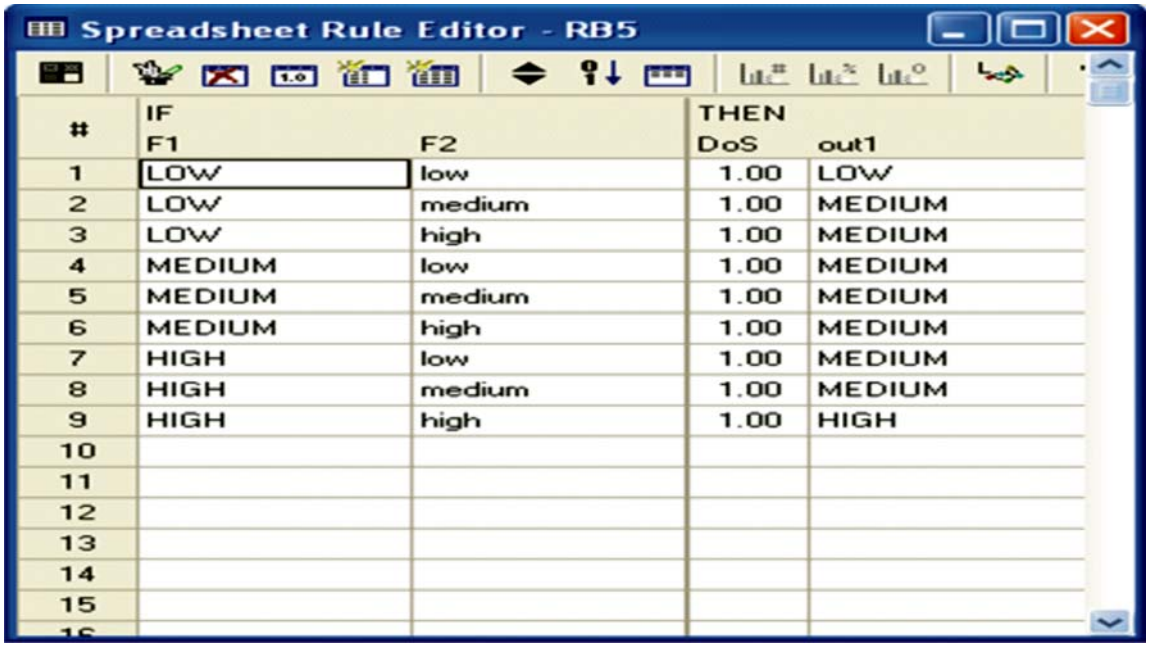


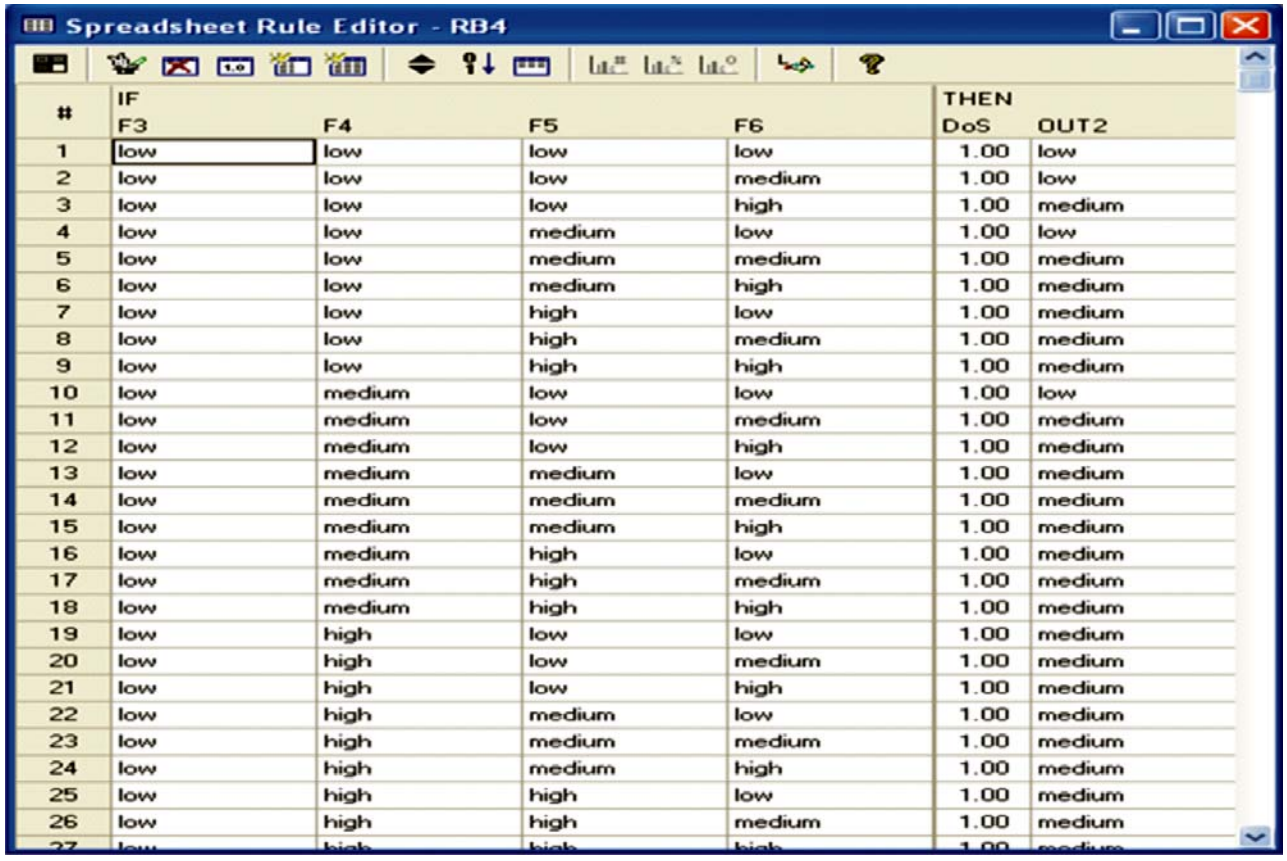
Figure 3: Input and Output diagram



Spreadsheet Rule Editor - RB5

#	IF F1	F2	THEN DoS	out1
1	LOW	low	1.00	LOW
2	LOW	medium	1.00	MEDIUM
3	LOW	high	1.00	MEDIUM
4	MEDIUM	low	1.00	MEDIUM
5	MEDIUM	medium	1.00	MEDIUM
6	MEDIUM	high	1.00	MEDIUM
7	HIGH	low	1.00	MEDIUM
8	HIGH	medium	1.00	MEDIUM
9	HIGH	high	1.00	HIGH
10				
11				
12				
13				
14				
15				

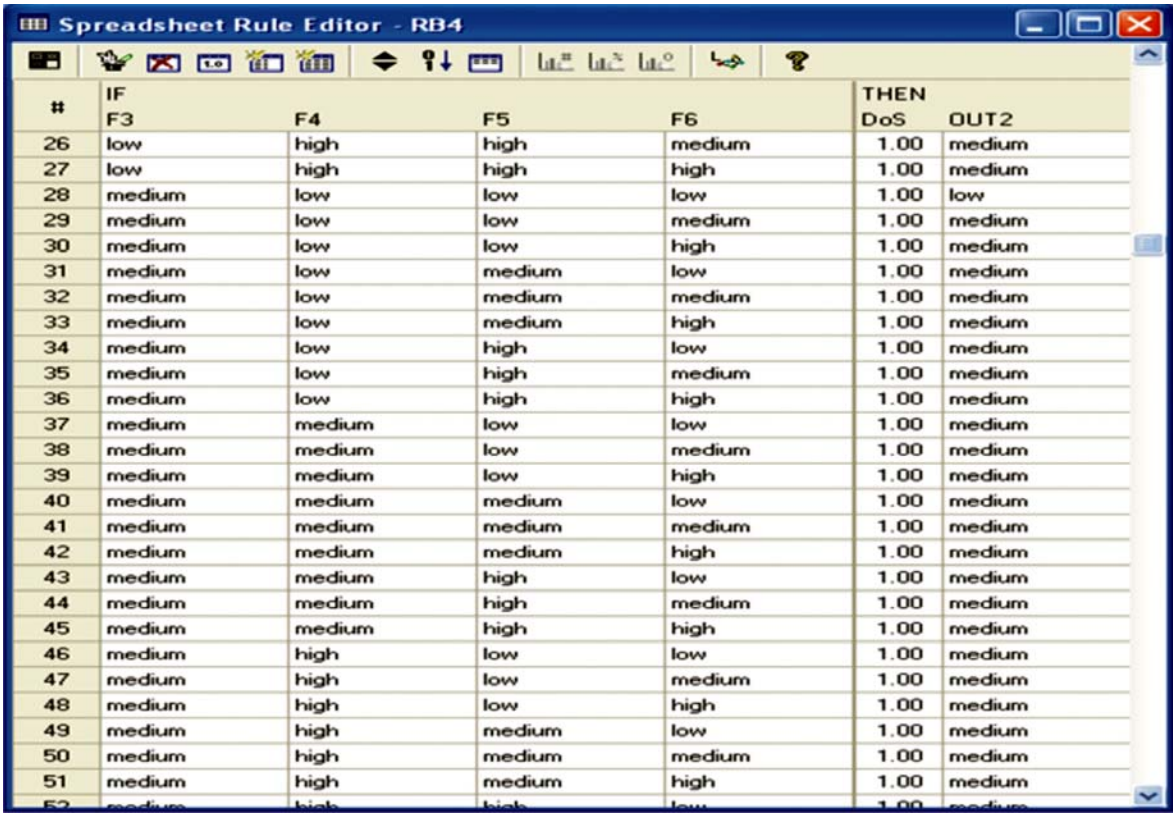
Figure 4: Rule base for Natural factor



Spreadsheet Rule Editor - RB4

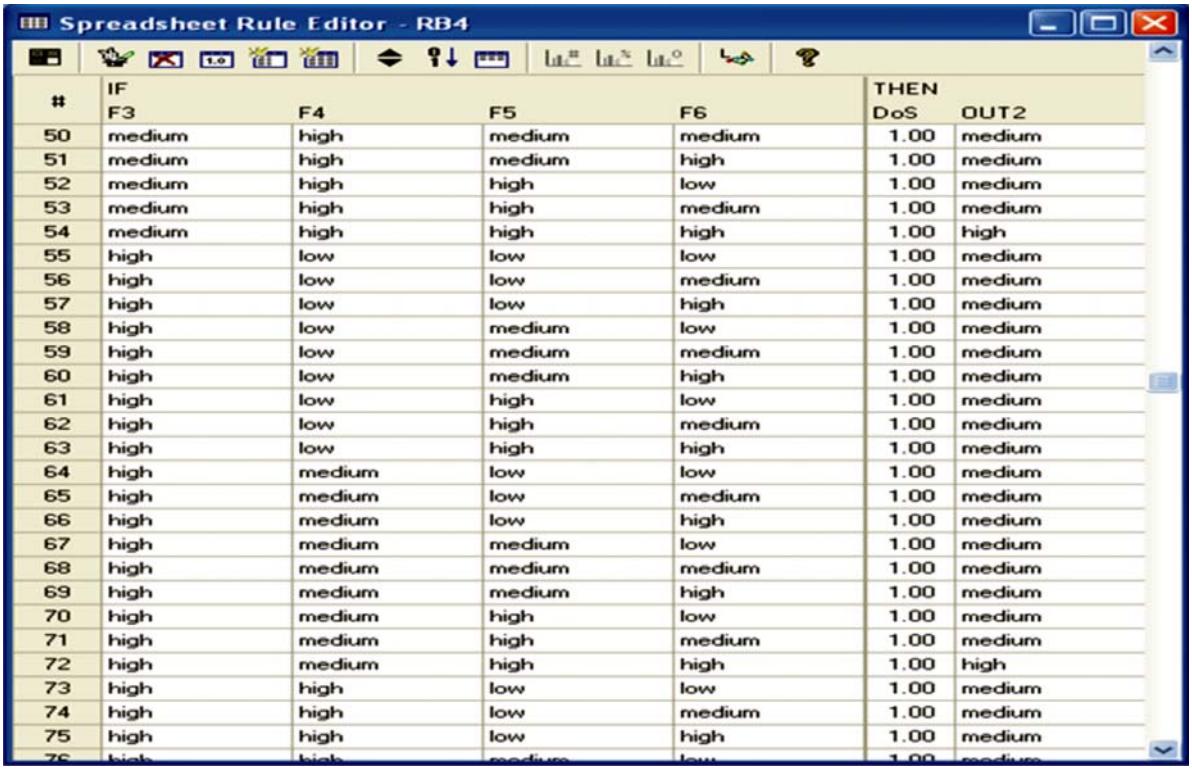
#	IF F3	F4	F5	F6	THEN DoS	OUT2
1	low	low	low	low	1.00	low
2	low	low	low	medium	1.00	low
3	low	low	low	high	1.00	medium
4	low	low	medium	low	1.00	low
5	low	low	medium	medium	1.00	medium
6	low	low	medium	high	1.00	medium
7	low	low	high	low	1.00	medium
8	low	low	high	medium	1.00	medium
9	low	low	high	high	1.00	medium
10	low	medium	low	low	1.00	low
11	low	medium	low	medium	1.00	medium
12	low	medium	low	high	1.00	medium
13	low	medium	medium	low	1.00	medium
14	low	medium	medium	medium	1.00	medium
15	low	medium	medium	high	1.00	medium
16	low	medium	high	low	1.00	medium
17	low	medium	high	medium	1.00	medium
18	low	medium	high	high	1.00	medium
19	low	high	low	low	1.00	medium
20	low	high	low	medium	1.00	medium
21	low	high	low	high	1.00	medium
22	low	high	medium	low	1.00	medium
23	low	high	medium	medium	1.00	medium
24	low	high	medium	high	1.00	medium
25	low	high	high	low	1.00	medium
26	low	high	high	medium	1.00	medium

Figure 5: Rule Base for Man-made factor



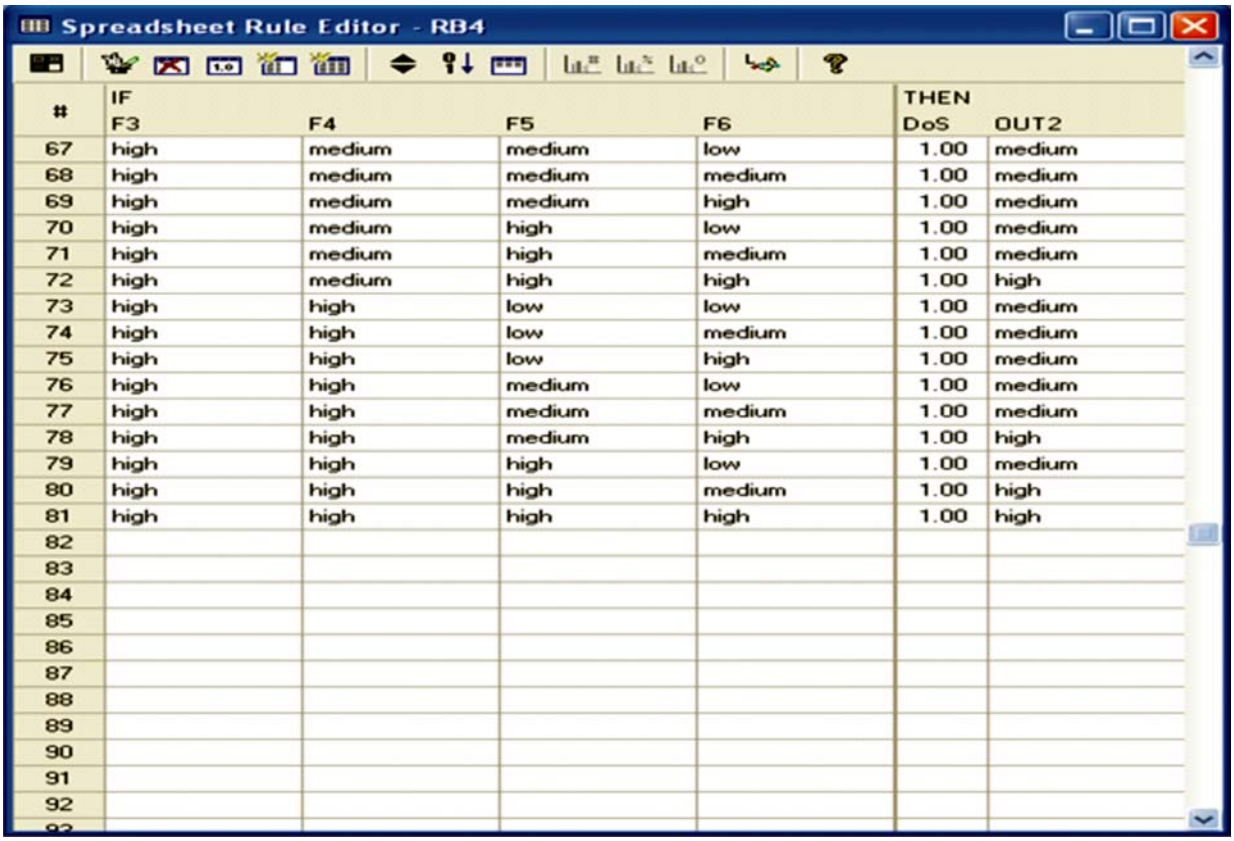
#	IF F3	F4	F5	F6	THEN DoS	OUT2
26	low	high	high	medium	1.00	medium
27	low	high	high	high	1.00	medium
28	medium	low	low	low	1.00	low
29	medium	low	low	medium	1.00	medium
30	medium	low	low	high	1.00	medium
31	medium	low	medium	low	1.00	medium
32	medium	low	medium	medium	1.00	medium
33	medium	low	medium	high	1.00	medium
34	medium	low	high	low	1.00	medium
35	medium	low	high	medium	1.00	medium
36	medium	low	high	high	1.00	medium
37	medium	medium	low	low	1.00	medium
38	medium	medium	low	medium	1.00	medium
39	medium	medium	low	high	1.00	medium
40	medium	medium	medium	low	1.00	medium
41	medium	medium	medium	medium	1.00	medium
42	medium	medium	medium	high	1.00	medium
43	medium	medium	high	low	1.00	medium
44	medium	medium	high	medium	1.00	medium
45	medium	medium	high	high	1.00	medium
46	medium	high	low	low	1.00	medium
47	medium	high	low	medium	1.00	medium
48	medium	high	low	high	1.00	medium
49	medium	high	medium	low	1.00	medium
50	medium	high	medium	medium	1.00	medium
51	medium	high	medium	high	1.00	medium

Figure 6: Rule Base for Man-made factor



#	IF F3	F4	F5	F6	THEN DoS	OUT2
50	medium	high	medium	medium	1.00	medium
51	medium	high	medium	high	1.00	medium
52	medium	high	high	low	1.00	medium
53	medium	high	high	medium	1.00	medium
54	medium	high	high	high	1.00	high
55	high	low	low	low	1.00	medium
56	high	low	low	medium	1.00	medium
57	high	low	low	high	1.00	medium
58	high	low	medium	low	1.00	medium
59	high	low	medium	medium	1.00	medium
60	high	low	medium	high	1.00	medium
61	high	low	high	low	1.00	medium
62	high	low	high	medium	1.00	medium
63	high	low	high	high	1.00	medium
64	high	medium	low	low	1.00	medium
65	high	medium	low	medium	1.00	medium
66	high	medium	low	high	1.00	medium
67	high	medium	medium	low	1.00	medium
68	high	medium	medium	medium	1.00	medium
69	high	medium	medium	high	1.00	medium
70	high	medium	high	low	1.00	medium
71	high	medium	high	medium	1.00	medium
72	high	medium	high	high	1.00	high
73	high	high	low	low	1.00	medium
74	high	high	low	medium	1.00	medium
75	high	high	low	high	1.00	medium

Figure 7: Rule Base for Man-made factor



Spreadsheet Rule Editor - RB4

#	IF F3	F4	F5	F6	THEN DoS	OUT2
67	high	medium	medium	low	1.00	medium
68	high	medium	medium	medium	1.00	medium
69	high	medium	medium	high	1.00	medium
70	high	medium	high	low	1.00	medium
71	high	medium	high	medium	1.00	medium
72	high	medium	high	high	1.00	high
73	high	high	low	low	1.00	medium
74	high	high	low	medium	1.00	medium
75	high	high	low	high	1.00	medium
76	high	high	medium	low	1.00	medium
77	high	high	medium	medium	1.00	medium
78	high	high	medium	high	1.00	high
79	high	high	high	low	1.00	medium
80	high	high	high	medium	1.00	high
81	high	high	high	high	1.00	high
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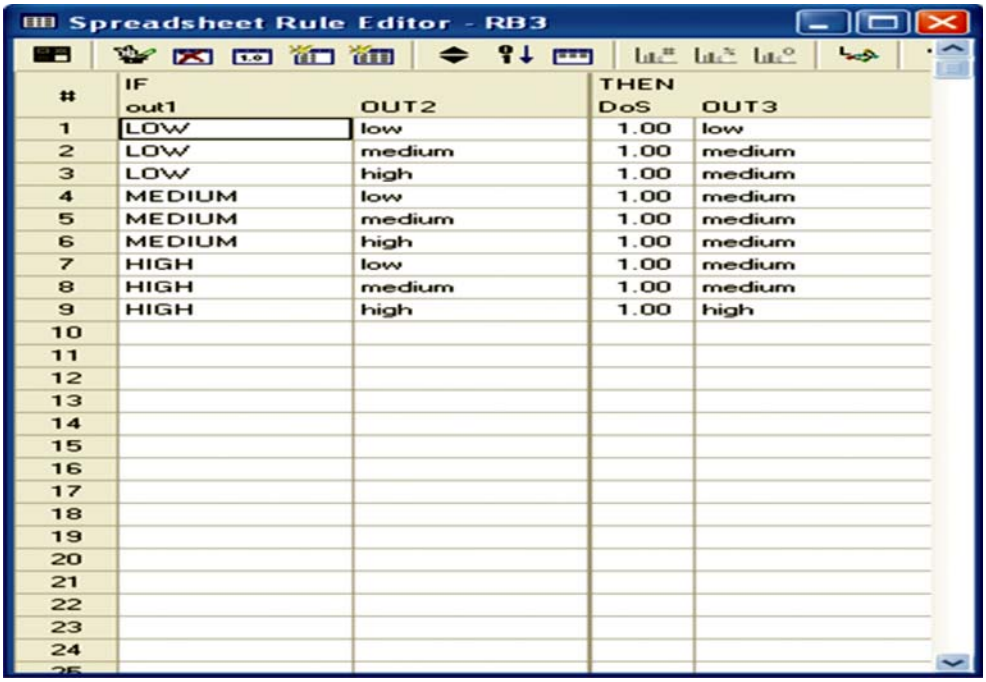
92						

Figure 8: Rule Base for Man-made factor



Spreadsheet Rule Editor - RB3

#	IF out1	OUT2	THEN DoS	OUT3
1	LOW	low	1.00	low
2	LOW	medium	1.00	medium
3	LOW	high	1.00	medium
4	MEDIUM	low	1.00	medium
5	MEDIUM	medium	1.00	medium
6	MEDIUM	high	1.00	medium
7	HIGH	low	1.00	medium
8	HIGH	medium	1.00	medium
9	HIGH	high	1.00	high
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Figure 9: Rule Base for Natural & Man-made factor

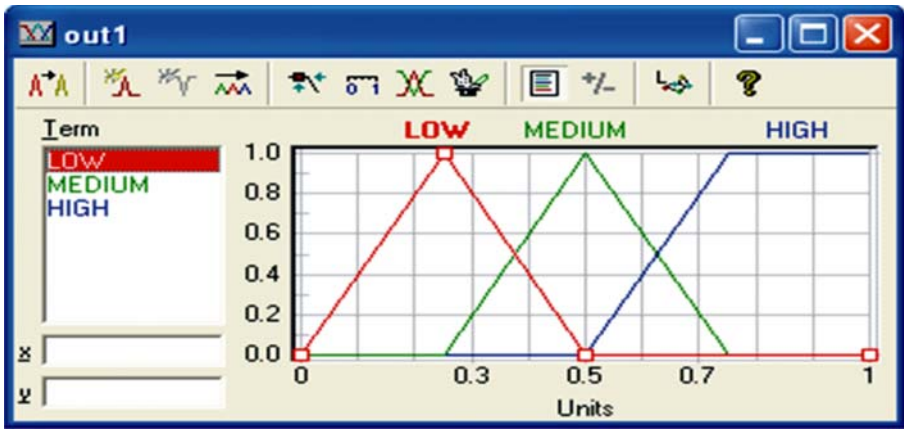

Figure 10: Output diagram of Natural factor

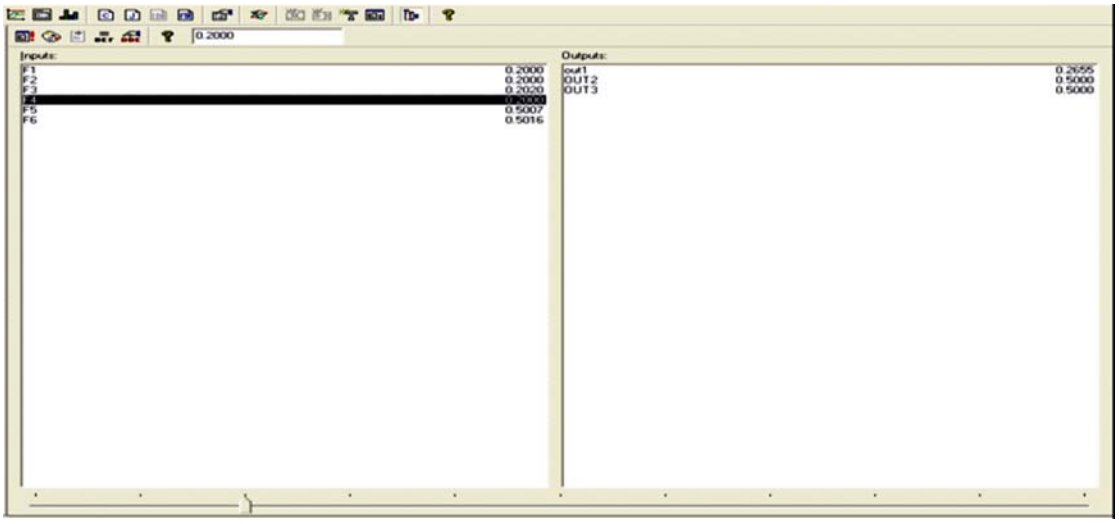

Figure 11: Output result: (Sequenced)

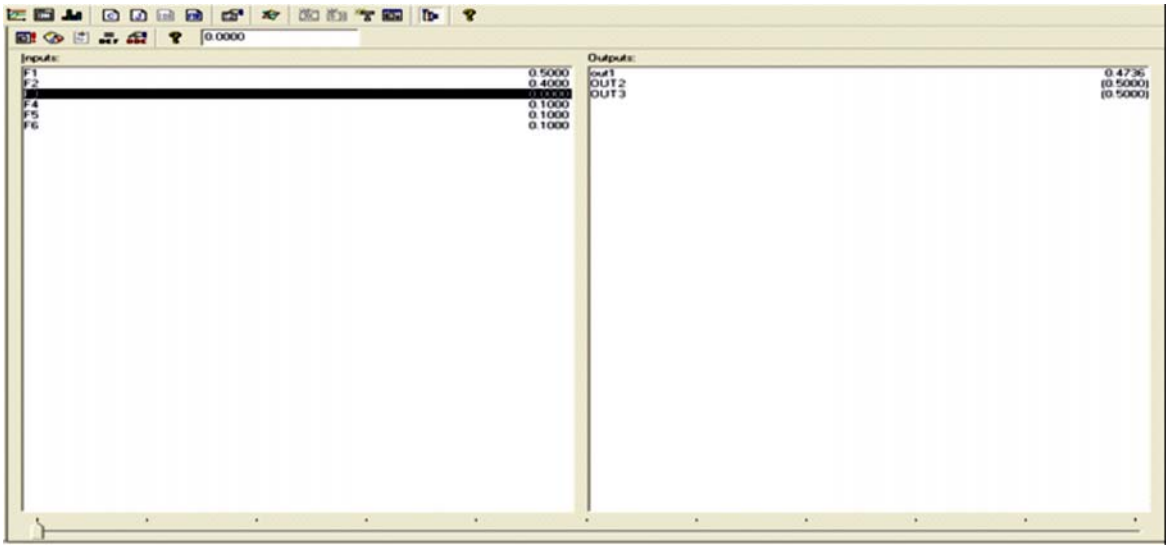

Figure 12: Output result: (Prioritized)

7. RESULT

When the impact of Elnino and global warming is found comparatively low the output (out 1) is also low, for example refer fig(10) The above factors a) Elnino , b) global warming have the equal range of mean ie 0.2 and as well low is it's Mnemonic.

Whereas manmade disaster like illegal construction, unplanned infrastructure, land maphiya, and environmental pollution are having their means 0.2020, 0.2000, 0.5004 and 0.5060 respectively hence its mean (weighted average) is measured at out 2 as 0.5 which is extremely high. Similarly the out 3 (ie, cumulative outputs of out 1and out 2) is also high.

A theoretical claim has been arrived that the destructive impact of natural disaster can be passified through nullifying the manmade disaster and it also requires some additional surface engineering geographically for weakening the factors F3, F4, F5, and F6. Furthermore the time being flood management of a particular region can also be planned through the mean value arrived by the above illustrated of method of fuzzy logical controller model. During the runtime a well defined preventive measure/action can also be arrived through this statistical approach, the decision making can be obtained/ arrived by just examing the mean value in advance of few days.

And the factor mean value rule based method need not be identical for different flood affecting areas .It is also found as nonvolatile over a period of time.

8. CONCLUSION

As per the study through this research article, Natural disaster have been discussed and identified when they occur, what could be its quantum, where they affect and what was the manmade mistakes/policies and destructive constructions. Thus depending upon the scale of destructive causes experienced so for, A rule based fuzzy logic control model has been implemented and their successive results have been tabulated from figure 1to 12 Here all the above discussed factors right from monsoon, summer, winter seasons, Elnino, climate change, flood, cyclone, tsunamis, droughts etc, named F1 and F2.

On other side factors for manmade disaster like illegal construction, unplanned infrastructure, land maphiya, and environmental pollution etc named us F3, F4, F5, F6.

For all the probabilistic and determinations and other logical interrupts (like draining reservoir, lake, dam and their quantity of cumulative discharge over a period of time of a rainy season) have also been taken into our calculation and their results have been arrived as DoS (cumulative cause/logical output) and the final output (out 3) is textual result of the flood analysis. This result of predictive model measure analysis can give us the severity of the flood monitoring, This can also alert us little advance in time because we could finetune the mean average of sub factors of natural disasters/causes and also factors from manmade disasters/cause. Thus the discussed method is identified as one of the successful methods of fuzzy logical control models of flood assessment.

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