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FUZZY COST OVERRUN ANALYSIS MODEL FOR CONSTRUCTION PROJECT

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ABSTRACT

Now a day's many factors which affect the productivity in construction project. Due to this delay factors time and cost overrun in a project. In this research helps to identify the most important factors that affect the productivity and form a modelling using fuzzy logic. The data's were collected through questionnaire survey from engineers, contractors and clients worked within the various construction industries. The collected data's were analyzed using relative importance index (RII) and ranking the factors based on percentage of relative importance and also this paper presents an application of fuzzy logic for developing delay factors causes cost overrun model using Fuzzy toolbox of MATLAB Program software. The results can facilitate the construction industry to take measures the delay factors causes cost overrun in construction projects.

Keywords: fuzzy logic, productivity, modelling, relative importance.

1. INTRODUCTION

In every construction project the poor productivity from the construction worker's is the main cause of cost and time overrun in the construction industry. All over the world the literature identified that successful construction projects is based upon the completion of the project before the planned date and also completed within the estimated cost .Delays occur in every construction project and the magnitude of these delays varies considerably from project to project. In Some projects are only a few days and some of the projects are delayed over a year behind the schedule, So it is essential to define the actual causes of delays in order to minimize or avoid the delays in any construction projects[1].

A labour performance is affected by many factors and their performance is usually based on time, cost and quality of the work. Latest information on key factors that affect project performance in terms of project completed in time .over the last decade and construction labour efficiency has often been cited as poor. In construction time is the one of the major consideration throughout the project management life cycle and it is one of the most important parameters of a project and driving force of the project success [2] [3][4].Proper management of resources in construction project can saving in time and cost in the construction .The labour productivity definitions aspect, measurements, factors affecting in the construction industry and construction productivity is usually taken to mean labour productivity, that is unit of works placed or produced per man-hour[5].

Labour cost is the largest one in every construction the project cost. Productivity is generally affected by the working conditions of the project. Accurate estimation of productivity became the success of a construction company in today's competitive market. The major risk in the construction company is the productivity of labours in the construction projects [6] [7] .In Nigeria, the factors that affected the construction productivity is investigated that contribute the time overrun in construction project. The analysis Showed funding and payment, contractor and client factors are the major factors contributing to the delay of Projects [8]. They are many factors that cause delay in the construction projects and also investigate the cause and their effects of delay. The study on integrated approach and attempts to analyze the impact of specific causes on specific effects in Malaysian construction industry this study has also established an empirical relationship between each cause and effect [9].

In India Construction has accounted for around 40 per cent of the development investment during the past 50 years. Around 16 per cent of the nation's working population depends on construction for its livelihood. In this research the survey conducted for identify the factors that affect the productivity and delay the completion of the project within the time period. The factors affected in the construction industry were based upon the four major groups such as management/supervision, Equipments, Material and Labours. Now a day the construction industry faced major problem is the poor productivity .In this research the affected factors were collected from the various professionals and from various literatures [1] to [15].Based on the collected data from the professionals the data's are analysed through relative importance index and the modelling is created by fuzzy logic tool box using Mat lab software

2. Research methodology:

The most of the factors were identified through questionnaire survey from the professional working in the various construction industries. This survey was made through questioner distributed to different construction professionals. These professionals include engineers, contractors, and clients. Moreover, all of the professionals are selected based on their experience and special care should be taken for their educational qualification. The collected data were analyzed through relative importance index (RII) method. These analyses include ranking the different causes according to relative important indices. Finally a fuzzy model was developed based on the importance level.

- Personal information of the respondent
- Types of projects the respondent worked
- Identify the important delay factors in the construction project
- Factors affect in a construction project
- Make a model through (FIS) fuzzy inference system.

2.1 Questionnaire Design

The questionnaire design took into the consideration and the main objectives of the study with the aim to answer the research question. Special care also was done for phrasing the questions that is easily understood by the respondents. The respondents were required to rate the factor in the way they affect delay in construction projects using their own experiences on building sites. The questionnaire required the respondents to rank these on scale with the rating of'1'representing very little effect;"2"little effect;"3"average effect:"4"high effect:"5"very high effect according to the degree of importance of delay in construction project.

2.2. COLLECTED DATAS:

The data's are collected from various professionals such as engineers, contractors, and clients from working various construction industries.

TABLE 1: INDEX AND RANKINGS OF DELAY FACTORS

% of responses received	77.14%
% of valid responses received	70.28%
Professionals	
Engineers	60.16%
Contractors	25.20%
Clients	14.63%
Year of experience	**Numbers**
1-5	28
6-10	38
11-15	32
< 15	25

3. METHOD OF DATA ANALYSIS:

Data was collected using questionnaire survey. A 5-point likert scale was used to understand the perception of Practitioners as 1.very low effect, 2.low effect, 3.average effect, 4. High effect and 5.Veryhigh effect. Sambasivam and soon also used same approach to investigate the causes and effects of construction delay in Malaysian construction Industry. RII will be calculated with following expression [10].

Where;

$$RII = \frac{\sum_{i=1}^{i} W_i X_i}{AN} \quad \text{------------------------------ (1)}$$

RII = Relative importance index
w = weighting given to each factor by respondents and it ranges from 1 to 5
x = frequency of i^{th} response given for each cause
A = highest weight (i.e. 5 in this case)
N = total number of participants

The relative importance index for all the delay factors using equation (1).the index were ranked for engineers, contractors and clients. The group index is the average of relative importance index of the delay factors in each group.

TABLE 2: INDEX AND RANKINGS OF DELAY FACTORS

SI:NO	AFFECTED FACTORS IN THE CONSTRUCTION	OVERALL	
		RII	RANK
1.	Ineffective project planning and scheduling	81.61	**2**
2.	Financial difficulty	73.43	**9**
3.	Poor site management and supervision	81.82	**1**
4.	Frequent equipment breakdown	72.06	**10**
5.	Inadequate modern equipment	76.58	**5**
6.	Shortage of equipment	74.27	**8**
7.	delay in arrival of materials	79.97	**3**
8.	lag of material	77.23	**4**
9.	shortage of labours	75.83	**6**
10.	labour absenteeism	75.31	**7**

3.1 AGREEMENT ANALYSIS

The group index is the average of the delay factors in each group. The agreement between the rankings of any two parties was measured using the rank correlation coefficient. The rank correlation coefficient (p) is calculated as Follows (Mendenhall et al. 1993) and also these method is used by Sadi A. Assaf [11].

The spearman's rank correlation coefficient (r_s) was used to show the degree of agreement between the rankings of any two parties. The spearman's rank correlation is a non parametric test.non parametric test is also referred to as distribution free test. These test do not require the assumption of normality or the assumption of homogeneity of variance .the spearman rank correlation coefficient (r_s) was calculated as follows

$$r_s = 1 - \frac{6\sum d^2}{n(n^2-1)}$$

Where

d = the difference between the ranks given by any two respondent for an individual cause and

n=the number of cause. The rank correlation coefficients for the delay factors are 0.97, 0.97 and 0.99 for engineers, contractors and clients respectively.

3.2 Significance test

To determine whether the parties displayed significant agreement in their rankings the null hypothesis that null hypothesis that engineers and contractors, contractors and clients, clients and engineers do not agree ranking of the factors was tested using t-test at a 95% confidence level. The null hypothesis was rejected in all three cases. The alternate hypothesis that all the three parties generally agreed on the rank was accepted.

4. Modelling In Fuzzy Inference System

In this step, the fuzzy logic model is designed for predicting the factors that affects safety in construction and also the quality in Mamdani type inference using the fuzzy toolbox of MATLAB. There are five primary graphical user interface tools for building, editing, and observing in the fuzzy inference systems toolbox. The procedure to develop a model using Fuzzy Inference System (FIS) of MATLAB is shown in Fig 1.

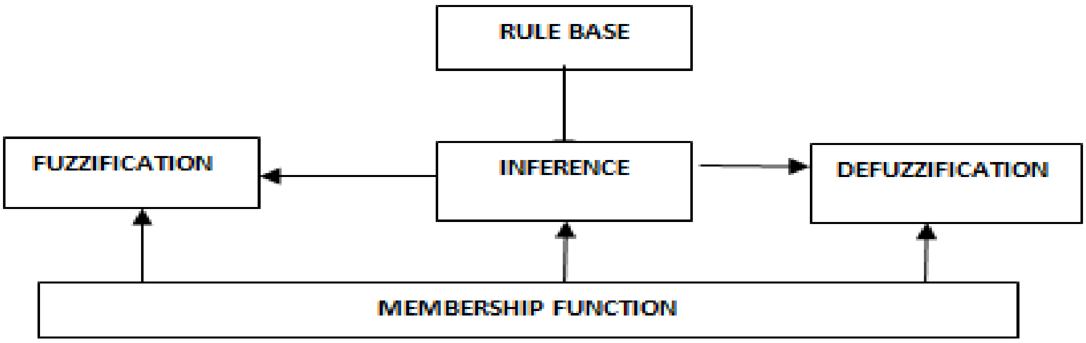

FIG: 1 FUZZY LOGIC SYSTEM

5. Defining input and output variables

The identified delay factors in a construction project are considered as input variable for the assessment model and the output variable is taken as the probability for the factors affect “cost overrun” in a construction project.

5.1 Defining membership functions for variables

The membership function represents the fuzziness degree of linguistic variables. Membership functions give a numerical meaning for each label. There are different shapes of membership functions, viz, triangular, trapezoidal, Gaussian, bell-shaped, piecewise-linear etc. Triangular and trapezoidal fuzzy membership functions are used in this study as they are widely used. A triangular fuzzy number x (see Fig.2) with membership function is defined by A trapezoidal fuzzy number x (see Fig.3) with membership function μA(x) specified by four parameters

$$\mu_A(x) = \begin{cases} \dfrac{x-a}{b-a} & \text{if } a \le x \le b \\ \dfrac{x-c}{b-c} & \text{if } b \le x \le c \\ 0 & \text{otherwise} \end{cases}$$

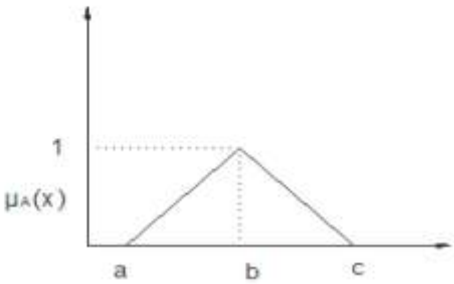

Fig:2 Triangular fuzzy number

A trapezoidal fuzzy number x (see Fig.3) with membership function μA(x) specified by four parameters {a, b1, b2, c} having a lower limit a, an upper limit c, a lower support limit b1, and an upper support limit b2, where, a < b1 < b2 < c, can be defined by

$$\mu_A(x)=\begin{cases}\dfrac{x-a}{b_1-a} & if \quad a\le x\le b_1\\ 1 & if \quad b_1\le x\le b_2\\ \dfrac{x-c}{b_2-c} & if \quad b_2\le x\le c\\ 0 & otherwise\end{cases}$$

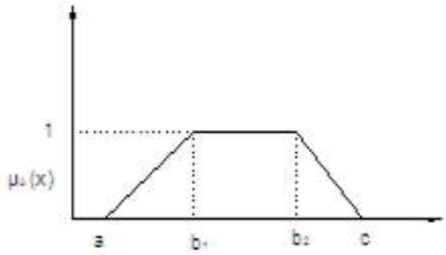

Fig:3 Trapezoidal fuzzy number

5.2 Defining Rules

Rules, which connect input variables to output variables, are defined in order to perform inference. Each rule is a logical inference and depends on the state of input and output variables. With the help of fuzzy rules values can be incorporated between the conventional evaluation of the precise logic 1 and 0. It also include logical operations such as “and”, “or”, “not” and “if-then”. „IF ... THEN ...“ forms are used in the present study to relate inputs to output variables in terms of linguistic variables.

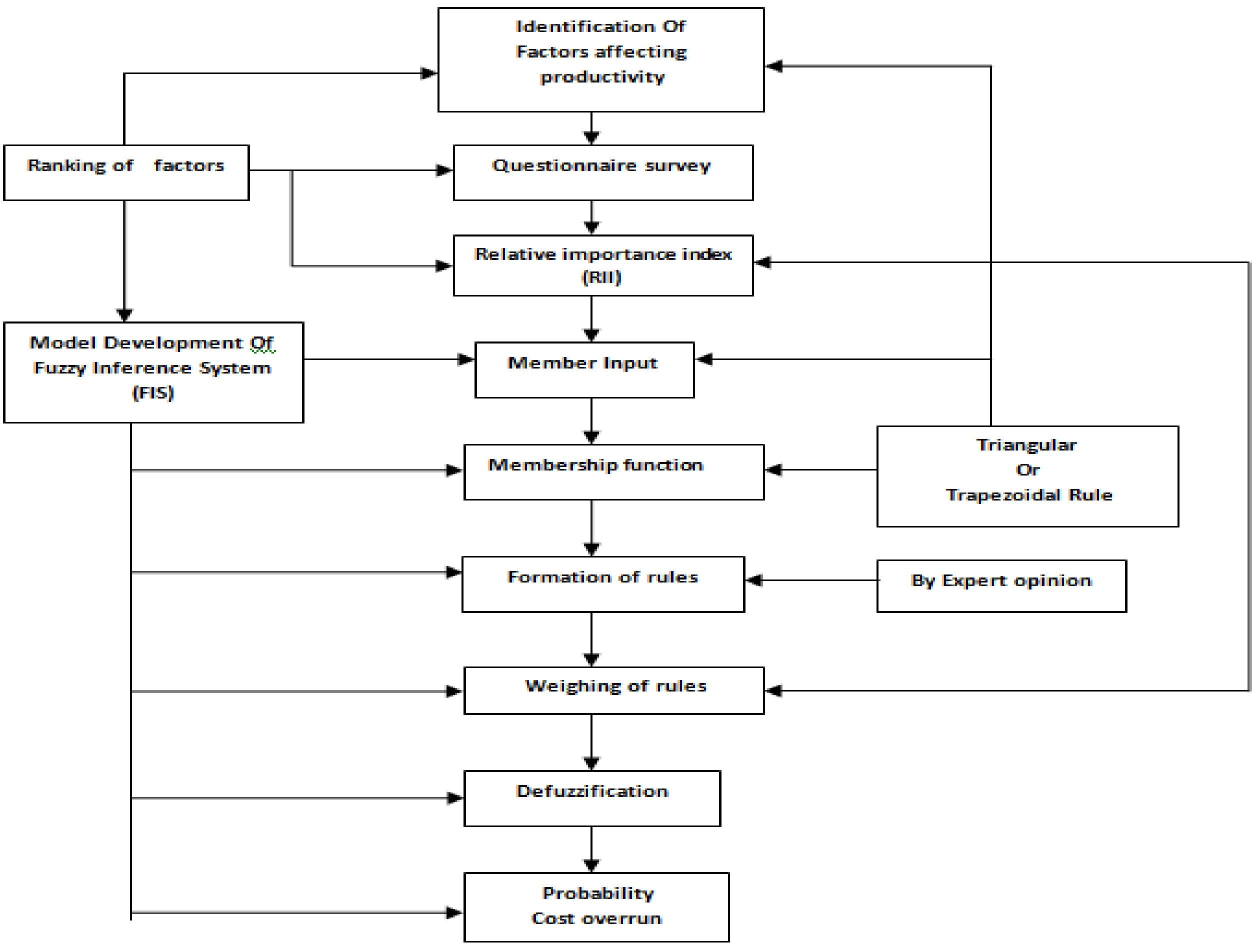

Fig:4 Flow diagrams for the development of cost assessment model in fuzzy inference system

The number of rules depends on the number of inputs and outputs, and the required performance of the system. Mamdani type fuzzy inference method is used for the present study for their wide application in the construction industry. Assigning the weights to the fuzzy rules. The relative importance indices for the cost overrun factors which are calculated in Table 4 are assigned as fuzzy rules weight.

6. Defuzzification

Defuzzification is the process in which outcomes of control models in the form of fuzzy numbers can be converted to precise output numbers. Therefore, in this stage, fuzzy outcomes of fuzzy control model, including effects of all input variables of problem, and considering integrated effects of them by accessing various cost overrun phenomenon by fuzzy rules, are undergone fuzzy removing process and probability of cost overrun is determined as an exact number in the interval of zero to one. The complete procedure is shown in the form of flow chart as shown in **Fig 4.**

7. Analysis steps for the model development

To develop the model, following steps are performed on fuzzy logic tool box of MATLAB.

(i) Construct a ten input, one output system in the FIS editor. The identified delay factors” are entered as input members and output member respectively. These are shown in the Fig.5

(ii) Membership functions associated with all of the input and output variables are defined in membership function editor. All the parameter related to their membership function of each variable is given in the Table 3. An example of membership function of costoverrun factors is shown in Fig.6.

(iii) In order to perform fuzzy inference, rules which connect input variables to output variables are defined. For the present model 50 rules are constructed in the form of IF-THEN. Five of them are given below.

Rule1: if the probability of Poor site management and supervision is very low the cost overrun is very low

Rule2: if the probability of Poor site management and supervision is low the cost overrun is low

Rule3: if the probability of Poor site management and supervision is medium the cost overrun is medium

Rule4: if the probability of Poor site management and supervision is high the s cost overrun is high

Rule5: if the probability of Poor site management and supervision is very high the cost overrun is very high

(iv)The relative importance indices (RII‟s) of delay factors are assigned as weightage to the fuzzy rules to develop the assessment model to estimate the probability of cost overrun in construction. Since the RII‟s of the delay factors have different values, the fuzzy rules weights will differ accordingly. So that eachif- then rule will have different weights, showing relative importance of fuzzy rules. These are presented in Table 4

(v) The rule viewer displays a roadmap of the whole fuzzy inference process. The rule viewer shows how the shape of the certain membership function influences the overall result. The Fig.7 shows the rule view of the system.

(vi)Finally, the input-output mappings are obtained by choosing view menu and under it view surface. Fig.8 Ineffective project planning and scheduling and Poor site management and supervision with respect to cost overrun in construction. Similarly, variation of delay factors for different combination of input variables can be obtained. Fig.9 .These types of three- dimensional graphical views can be analyzed by the owner and contractor easily and quickly.

8. CONCLUSIONS

A systematic procedure is presented for developing the cost overrun assessment model in fuzzy environment using Fuzzy toolbox of MATLAB Program Software. The procedure consists of identification of factors that affect the productivity and assesses their rank according to relative importance index. Using these relative importance indexes, model has been developed in fuzzy inference system (FIS).Different graphs are plotted to show the variation of different combination of costoverrun factors .These graphs are useful for construction industry to understand the effect of delay factors in the project .

Table: 2 Linguistic variables used in model and their membership function

Variables	Range	MFs	No of MFs	Name of the parameters
Factors affecting productivity				
Ineffective project planning and scheduling	[0 -1]	trimf	5	1.Very Low 2.Low 3.Medium 4.High 5.Very High
Financial difficulty	[0 -1]	trimf	5	1.Very Low 2.Low 3.Medium 4.High 5.Very High
Poor site management and supervision	[0 -1]	trimf	5	1.Very Low 2.Low 3.Medium 4.High 5.Very High
Frequent equipment breakdown	[0 -1]	trimf	5	1.Very Low 2.Low 3.Medium 4.High 5.Very High
Inadequate modern equipment	[0 -1]	trimf	5	1.Very Low 2.Low 3.Medium 4.High 5.Very High
Shortage of equipment	[0 -1]	trimf	5	1.Very Low 2.Low 3.Medium 4.High 5.Very High
delay in arrival of materials	[0 -1]	trimf	5	1.Very Low 2.Low 3.Medium 4.High 5.Very High
lag of material	[0 -1]	trimf	5	1.Very Low 2.Low 3.Medium 4.High 5.Very High

shortage of labours	[0 -1]	trimf	5	1.Very Low 2.Low 3.Medium 4.High 5.Very High
labour absenteeism	[0 -1]	trimf	5	1.Very Low 2.Low 3.Medium 4.High 5.Very High
Output				
cost overrun	[0 -1]	trimf	5	1.Very Low 2.Low 3.Medium 4.High 5.Very High

Table: 3 Sample fuzzy rules for the of cost overrun assessment model and rules weight

Si.No	Rules	Rule weight (Average RII)
1	If the probability of Ineffective project planning and scheduling is very low the cost overrun is very low	81.61
2	If the probability of Financial difficulty is very low the safety is very low	73.43
3	If the probability of Poor site management and supervision is very low the cost overrun is very low	81.82
4	If the probability of Frequent equipment breakdown is very low the cost overrun is very low	72.06
5	If the probability of Inadequate modern equipment is very low the cost overrun is very low	76.58
6	If the probability of Shortage of equipment is very low the cost overrun is very low	74.27
7	If the probability of delay in arrival of materials is very low the cost overrun is very low	79.97
8	If the probability of lag of material is very low the cost overrun is very low	77.23
9	If the probability of shortage of labours is very low the cost overrun is very low	75.83
10	If the probability of labour absenteeism is very low the cost overrun is very low	75.31

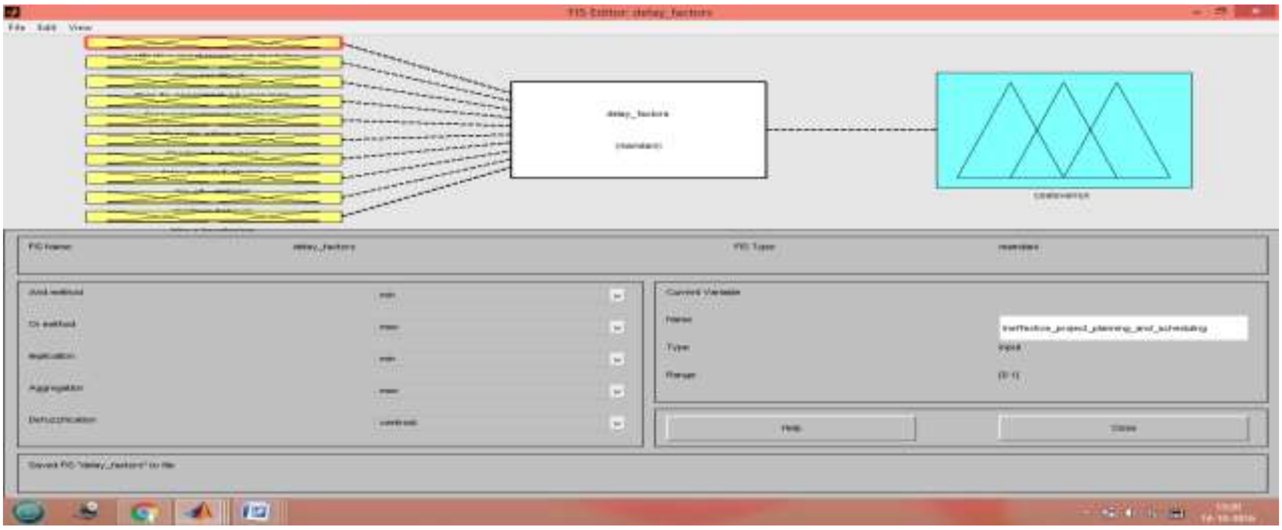

Fig: 5 Input and output members for cost overrun assessment model

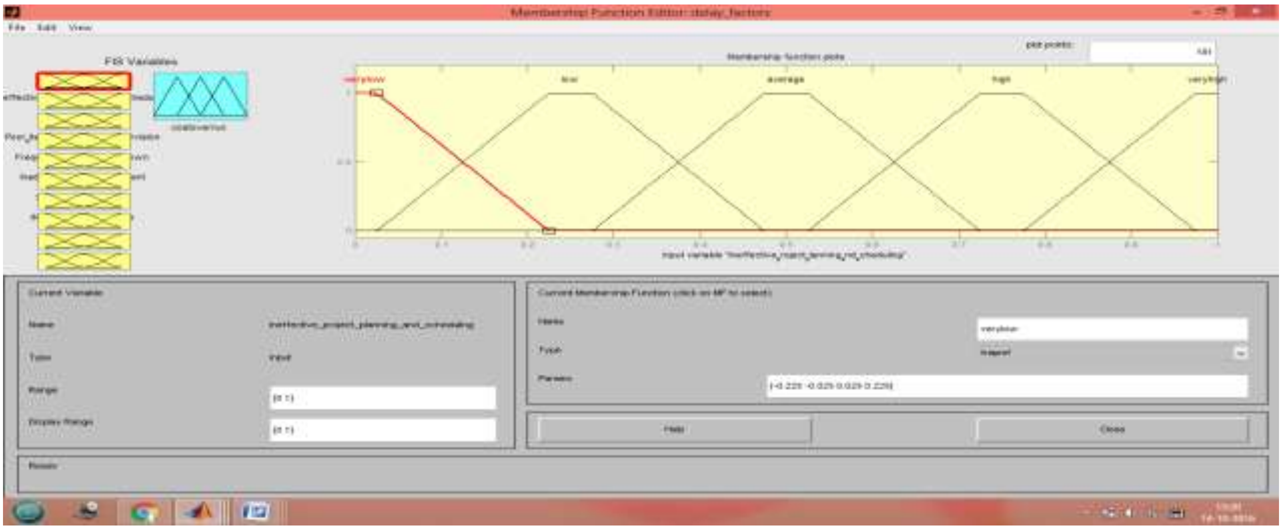

Fig: 6 Membership function for the cost overrun model

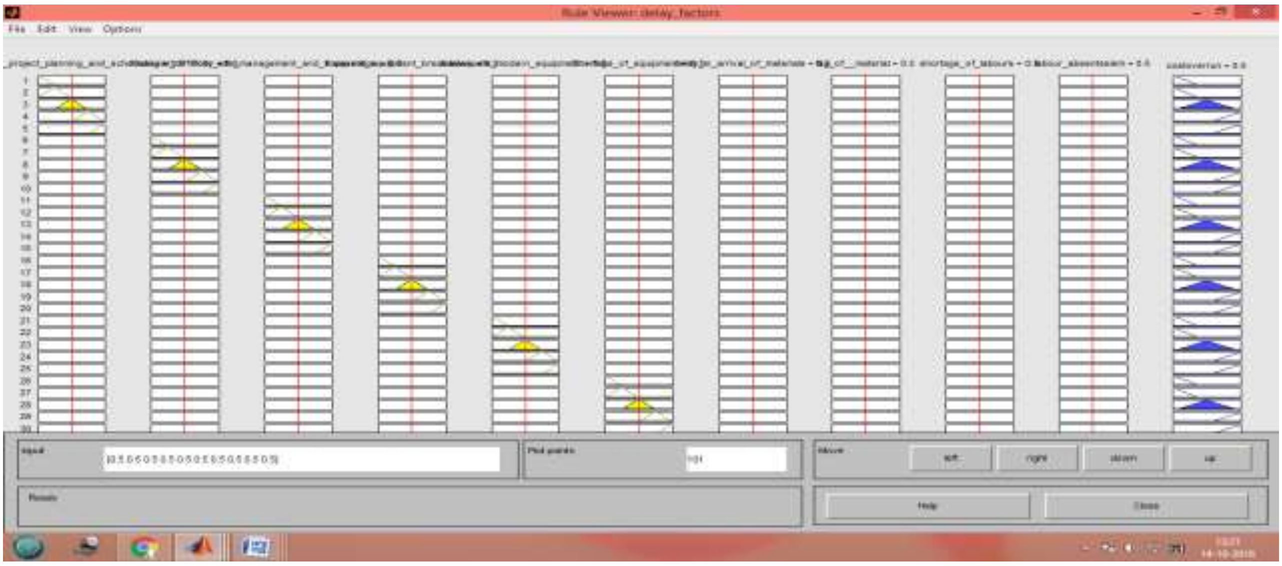

Fig: 7 Defuzzification process for the cost overrun assessment model

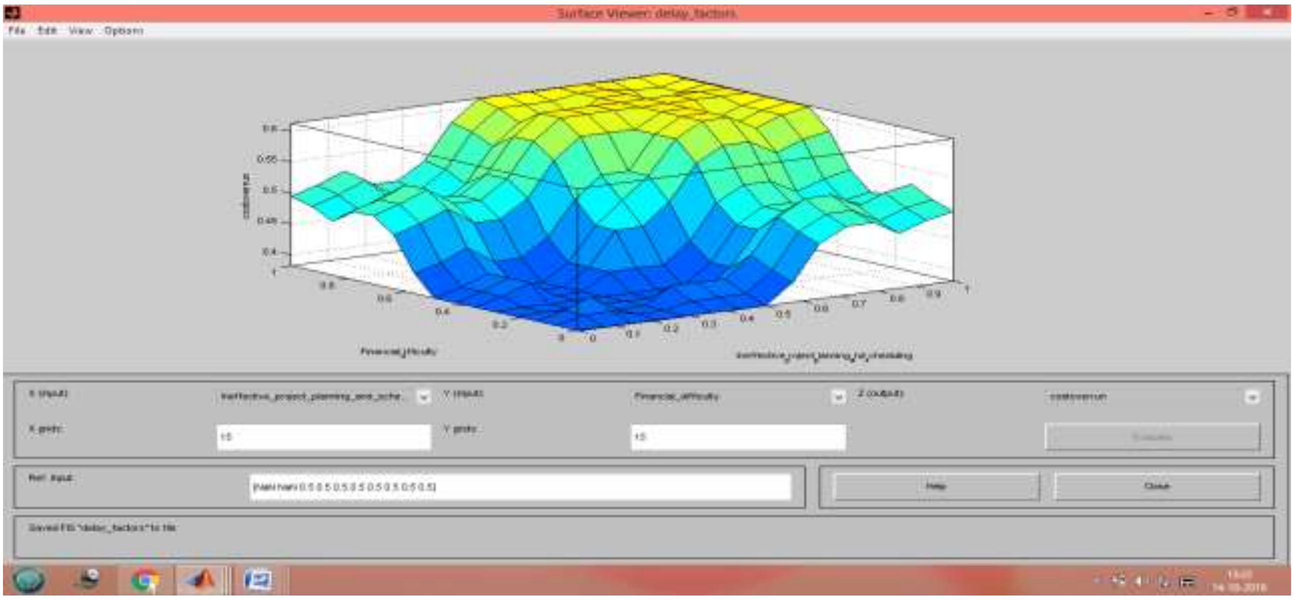

Fig: 8 Variation of ineffective planning and financial difficulty with respect to cost overrun

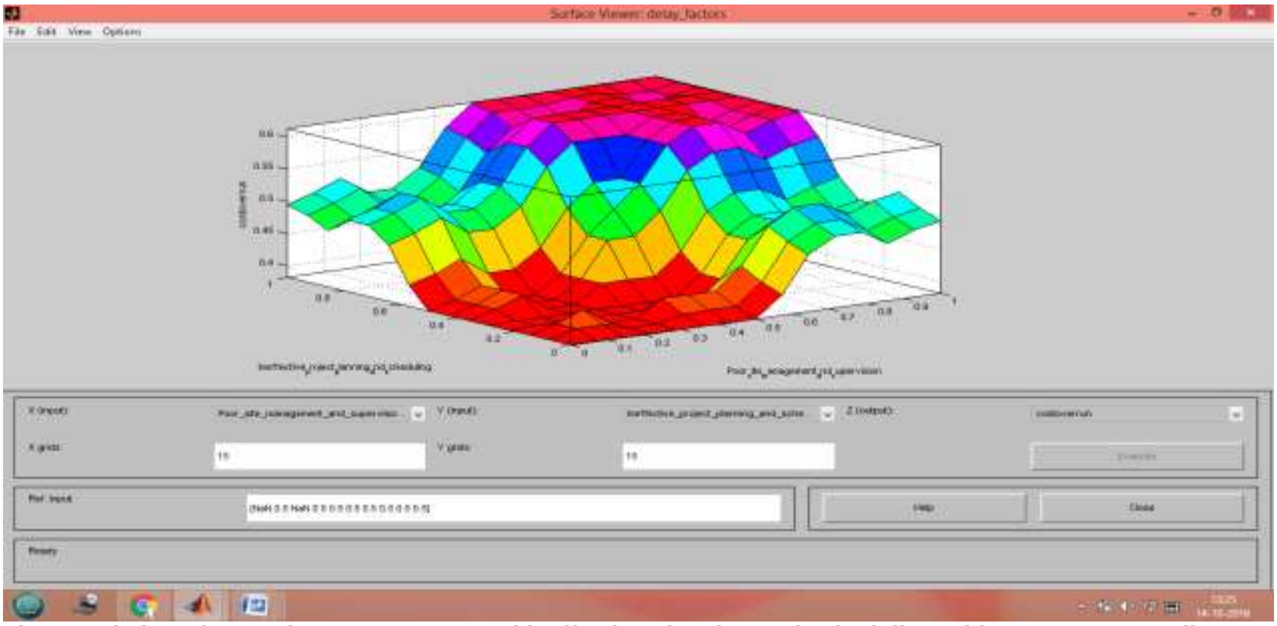

Fig: 9 Variation of Poor site management and ineffective planning and scheduling With Respect To Quality

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