Study on Mitigation Measures of Gumti Hydro Power Plant Using Analytic Hierarchy Process and Concordance Analysis Techniques

K. Majumdar, S. Datta

pen Science Index, Energy and Power Engineering Vol:8, No:12, 2014 publications.waset.org/999938.pdf

Abstract—Electricity is recognized as fundamental to industrialization and improving the quality of life of the people. Harnessing the immense untapped hydropower potential in Tripura region opens avenues for growth and provides an opportunity to improve the well-being of the people of the region, while making substantial contribution to the national economy. Gumti hydro power plant generates power to mitigate the crisis of power in Tripura, India. The first unit of hydro power plant (5MW) was commissioned in June 1976 & another two units of 5 MW was commissioned simultaneously. But out of 15MW capacity at present only 8MW-9MW power is produced from Gumti hydro power plant during rainy season. But during lean season the production reduces to 0.5MW due to shortage of water. Now, it is essential to implement some mitigation measures so that the further atrocities can be prevented and originality will be possible to restore. The decision making ability of the Analytic Hierarchy Process (AHP) and Concordance Analysis Techniques (CAT) are utilized to identify the better decision or solution to the present problem. Some related attributes are identified by the method of surveying within the experts and the available reports and literatures. Similar criteria are removed and ultimately seven relevant ones are identified. All the attributes are compared with each other and rated accordingly to their importance over the other with the help of Pair wise Comparison Matrix. In the present investigation different mitigation measures are identified and compared to find the best suitable alternative which can solve the present uncertainties involving the existence of the Gumti Hydro Power Plant.

Keywords—Concordance Analysis Techniques, Analytic Hierarchy Process, Hydro Power.

I. INTRODUCTION

HYDRO power plants convert potential energy of water into electrical energy. The basic principle of hydro power is that if water can be channelized from higher level to lower level than the resulting potential energy of water can be used to do work. Hydro power is a very clean source of energy and only uses the water, the water after generating electrical power, is available for other purposes like drinking water, irrigation etc. Traditionally it is cheap and clean source of electricity. Electricity plays an important role in the development of civilization of a country. The performance of all important sectors in the economy ranging from agriculture to commerce and industry as also the performance of social sectors like health depends largely on the availability, cost and quality of power. The development in power sector in Tripura despite geographical, economic and infrastructural hindrance has come a long way till now, but hydro power generation is not progressed properly.

Gumti is one of the larger rivers in Tripura, India which flow west ward and discharges into Bangladesh. Due to the construction of a dam for hydropower plant a large reservoir is created which is known as Gumti reservoir. This reservoir is at upper catchment of Gumti River. The storage capacity of reservoir is 23570 Hectare metre. The submerged area at F.R.L of 92.05m and M.W.L. of 95.25m was found to be respectively 46.34 and 74.86sqkm. With the help of this reservoir, Gumti Hydro Power plant generates power to mitigate the crisis of power in Tripura. Design capacity of this Hydro Power Plant was 15 MW. It has 3 unit(s). The first & 2nd units were commissioned in 1976 and the last in 1984. But out of 15MW capacity at present only 8MW-9MW power is produced from Gumti hydro power plant during rainy season. But during lean season the production reduces to 0.5MW. The present work wants to investigate the level of impact of climate change on availability of water in the Gumti reservoir through which hydro power is being generated using Artificial Neural Network under different climate change scenarios. Now, it is essential to implement some mitigation measures so that the further atrocities can be prevented and originality will be possible to restore. In this regard the present investigation utilized the advancement of the Analytic Hierarchy Process (AHP) and Concordance Analysis Techniques to identify the better alternative among the available options of mitigation.

II. LITERATURE REVIEW

The AHP and its use of pair wise comparisons have inspired the creation of many other decision-making methods. Besides its wide acceptance, it also created some considerable criticism; both for theoretical and for practical reasons. Since the early days it became apparent that there are some problems with the way pair wise comparisons are used and the way the AHP evaluates alternatives [1]. It is observed that the AHP may reverse the ranking of the alternatives when an alternative identical to one of the already existing alternatives is introduced [2]. In order to overcome this deficiency, Belton and Gear proposed that each column of the AHP decision matrix to be divided by the maximum entry of that column.

K. Majumdar is with the Tripura Institute of Technology Agartala, Department of Electrical Engineering, Tripura, PIN – 799009, India (phone: +91 381 2342 330; fax: +91 381 2342 332; e-mail: mana_pal@rediffmail.com).

S. Datta is with the Tripura Institute of Technology Narsingarh, Tripura, PIN – 799009, India as Principal (phone: +91 381 2342 330; fax: +91 381 2342 332; e-mail: sekhardatta@yahoo.co.in).

Thus, they introduced a variant of the original AHP, called the revised-AHP. Later, it is accepted the previous variant of the AHP and now it is called the Ideal Mode AHP [3]. Besides the revised-AHP, other authors also introduced other variants of the original AHP. However, the AHP (in the original or in the ideal mode) is the most widely accepted method and is considered by many as the most reliable Multi-criteria decision-making (MCDM) method.

The fact that rank reversal also occurs in the AHP when near copies are considered, has also been studied [4]. Few study provided some axioms and guidelines on how close a near copy can be to an original alternative without causing a rank reversal [5]-[7]. It is suggested that the decision maker has to eliminate alternatives from consideration that score within 10 percent of another alternative. This recommendation was later sharply criticized by Dyer [8].

III. SCOPE AND OBJECTIVE OF THIS STUDY

The objective of the present investigation is to predict selection of mitigation measures to sustain the plant feasibility by adopting the required cognitive decision making approaches. The advantages of capabilities of Analytical Hierarchy Process and Concordance Analysis Techniques are utilized in respectively predicting the impact of uncertainty and selection of suitable mitigation measure for environmental as well as socio-economical sustenance of the plant.

IV. METHODOLOGY

The decision making ability of the AHP and CAT are utilized to identify the better decision or solution to the present problem. In the present investigation different mitigation measures are identified and compared to find the best suitable alternative which can solve the present uncertainties involving the existence of the Gumti Hydro Power Plant. Some related criteria are identified by the method of surveying within the experts and the available reports and literatures. Similar criteria are removed and ultimately seven relevant ones are identified. All the criteria are compared with each other and rated accordingly to their importance over the other with the help of a scale of comparison known as Pair wise Comparison Matrix as given below.

- 1 Objectives i and j are of equal importance
- 3 Objectives i is weakly more important than j
- 5 Objectives i is strongly more important than j
- 7 Objectives i is very strongly more important than j

9 Objectives i is absolutely more important than j 2,4,6,8 Intermediate values

The values are normalized by dividing the rating by the sum of the columns. Then average of each row is taken as the weightage of those particular criteria.

Steps of Decision Making with the help of AHP

- Determination of Decision Objective
- Collection of Criteria
- Selection of Relevant and Uncommon Criteria

- Rating of Criteria with the help of Pair wise Scale of Importance
- Normalization of Each Rating
- Average of Each Row as the Weightage of the Criteria represented by that row.

Concordance Analysis Techniques (CAT) is one of the multi-criteria assessment tools in which alternative plans are ranked by a series of pair wise comparisons across a set of objectives in a rank-ordering technique [9]. In the current study, the Attributes are *IDFC*, *IDVC*, *SEB*, *EB*, *SHE*, *TH*, *EH* and objectives are five mitigation measures. The analysis is based on the project effects matrix, which contains a vector of scores for each alternative on each of the chosen objective measures. Two different indices are calculated from the project effects matrix: A concordance index calculates the degree to which one alternative plan is preferred to another for a given weighting structure on the objectives. Dominance indices are developed from the concordance scores, and are used to establish the relative preference of each alternative with respect to the given weighting scheme.

V.RESULT AND DISCUSSION

The criteria for identification of the optimal mitigation measure among the available options are selected as follows:

A. Infrastructure Development Fixed Cost (IDFC)

This criterion depicts the amount of fixed cost that will be incurred for development of infrastructures if a certain mitigation measure is decided to be adopted.

B. Infrastructure Development Variable Cost (IDVC)

This criterion depicts the amount of variable cost that will be incurred for development of infrastructures if a certain mitigation measure is decided to be adopted.

C. Socio-Economic Benefits (SEB)

This criterion shows the Socio-Economic benefits that may be created when a certain mitigation measure is decided to be implemented. The domain of Socio-Economic benefits may include increase in income of the local people, creation of various opportunities to earn additional income etc.

D. Environmental Benefits (EB)

Environmental benefits will include the up gradation and conservation of the natural landscape and resources of the region.

E. Probability of Socio-Economic Hazards (SEH)

This criterion will represent the hazards or uncertainty or negative impact that may be aggravated due to the implementation of a certain mitigation measure.

F. Probability of Environmental Hazards (EH)

This criterion will show the degradation of natural resources and landscaped due to the introduction of certain mitigation alternatives.

G. Probability of Technical Hazards (TH)

The mitigation measure to be adopted must be technically feasible and should not compromise the existing technical supremacies. These criteria will depict the technical hazards or compromises that may be required to be adopted for the implementation of certain mitigation option.

IDFC IDFC NAME VALUES OF DEPENDATION VALUES OF DEPENDATION DFC X 0.778 0.556 0.556 0.522 0.444 DFC X.86 X 0.714 0.571 0.714 0.714 0.714 0.714 0.714 0.716 0.226 0.440 SEB 1.800 1.400 X 0.800 1.000 0.400 0.914 EB 2.250 1.750 1.250 X 1.250 X 0.400 0.914 FH 1.800 1.400 1.000 0.800 X 0.400 0.914 FH 4.500 3.500 2.500 2.500 X 0.250 X 2.500 TH 4.500 3.500 2.500 X 0.778 0.556 0.644 M1 N M M M M 0.778 0.556 0.644 M2 0.889 X 1.000 0.778 0.556 0.644			Tur	JODMALIZED DA	TABLE I	DIFFERENT AT	TDIDUTEC		
DPC Dec Dec Dec Dec Dec Dec Dec Dec DPC 1.286 X 0.778 0.556 0.444 0.556 0.222 0.444 DVC 1.280 1.400 X 0.800 1.000 0.400 0.914 EB 1.280 1.400 1.200 X 1.250 0.500 1.100 0.400 0.914 EB 1.800 1.400 1.000 0.800 X 1.000 0.400 0.914 TH 4.500 3.500 2.500 2.500 2.500 X 2.500 THE 1.800 1.400 1.000 0.800 X 2.500 X 2.500 DPC M ₁ A 1.125 0.875 0.625 0.750 M ₁ X 1.125 0.875 0.625 0.750 M ₂ 0.889 1.000 X 0.778 0.556 0.644 M ₄ 0.		IDEC	IDVC	SEB	FB	SEH	FH	ТН	Weightage (V
DVC 1.286 X 0.714 0.571 0.714 0.715 0.715 0.715 0.715 0.715 0.715 0.715 0.715 0.715 0.715 0.714 0.71	IDFC	X	0.778	0.556	0 444	0.556	0.556	0 222	0 444
Description 1.800 1.400 X 0.800 1.000 0.000 0.400 0.914 EB 2.250 1.750 1.250 X 1.250 1.250 0.500 1.175 SH 1.800 1.400 1.000 0.800 X 1.000 0.400 0.914 EH 1.800 1.400 1.000 0.800 1.000 X 0.400 0.914 EH 1.800 1.400 1.000 0.800 1.000 X 0.400 0.914 EH 1.800 1.400 1.000 0.700 2.500 2.500 X 0.500 THE NORMALIZED RATING VALUES OF DIFFERENT MITIGATION MEASURES WITH RESPECT TO IDVC Mi 0.889 1.600 1.800 1.400 X 1.320 Mi 0.889 1.000 0.778 0.556 0.644 Mi 1.430 1.800 1.400 X 1.320 DVC Mi Mi Ma Ma Ma 0.	IDVC	1 286	x	0.714	0.571	0.714	0.550	0.222	0.612
EB 2.250 1.750 1.250 X 1.250 1.250 0.500 SEH 1.800 1.400 1.000 0.800 X 1.000 0.900 0.914 TH 4.500 3.500 2.500 2.000 2.500 X 4.250 THE NORMALIZED RATING VALUES OF DIFFERENT MITIGATION MEASURES WITH RESPECT TO IDFC DFC Mi Mi Mi Mi Mi Mi Weighting Mi X 1.125 1.125 0.875 0.625 0.750 Mi X 1.125 1.125 0.875 0.625 0.750 Mi X 1.126 1.286 X 0.714 0.886 Mi 1.400 1.800 1.400 X 0.78 0.625 0.644 Mi Mi Mi Mi Mi Mi Mi 0.778 0.644 0.780 0.714 0.886 Mi 1.320 Mi Mi	SEB	1.800	1 400	X	0.800	1 000	1.000	0.400	0.012
Description Loco	FB	2 250	1 750	1 250	X	1 250	1 250	0 500	1 179
EH 1.800 1.400 1.000 0.800 1.000 X 0.400 0.914 TH 4.500 3.500 2.500 2.500 2.500 X 2.500 TABLE II THE NORMALIZED RATING VALUES OF DIFFRENT MITIGATION MEASURES WITH RESPECT TO IDFC IDFC M M_1 M_1 M_1 M_1 N Veighta M1 X 1.125 1.125 0.875 0.625 0.750 M2 0.889 X 1.000 0.778 0.556 0.644 M3 0.889 1.000 X 0.778 0.556 0.644 M4 1.143 1.286 1.280 1.400 X 0.320 JUVC Mi M2 M3 M4 M4 M4 M4 0.320 2.400 M3 0.222 0.444 X 0.778 0.444 0.378 M4 0.286 0.571 1.286 X 0.571 0.543 M4	SEH	1.800	1 400	1,000	0.800	X	1.000	0.400	0.914
ITH 4.500 3.500 2.500 2.500 2.500 X 2.500 TABLE II THE NORMALIZED RATING VALUES OF DIFFERENT MITIGATION MEASURES WITH RESPECT TO IDFC IDFC M1 M2 M4 M4 M4 Weighta M1 X 1.125 0.875 0.625 0.750 M2 0.889 X 1.000 0.778 0.556 0.644 M3 0.889 1.000 X 0.778 0.556 0.644 M4 1.143 1.286 1.286 X 0.714 0.886 M5 1.600 1.800 1.800 1.400 X 1.320 THE NORMALIZED RATING VALUES OF DIFFERENT MITIGATION MEASURES WITH RESPECT TO IDVC IDVC Mi Ma Ms Ma Ms 0.400 X 1.320 M1 X 2.000 4.500 3.500 2.000 2.400 1.400 1.000 M3 0.222 0.444 X 0.7778 0.444	EH	1.800	1 400	1.000	0.800	1 000	1.000 X	0.400	0.914
TABLE II THE NORMALIZED RATING VALUES OF DIFFREENT MITIGATION MEASURES WITH RESPECT TO IDFC IDFC M ₁ M ₂ M ₈ M ₄ M ₆ Weightag Mi X 1.125 0.875 0.625 0.750 M2 0.889 X 1.000 0.778 0.556 0.644 Mi 0.889 X 1.000 X 0.778 0.556 0.644 Mi 1.43 1.286 1.226 X 0.714 0.886 M3 1.600 1.800 1.800 1.400 X 1.320 TABLE III THE NORMALIZED RATING VALUES OF DIFFRENT MITIGATION MEASURES WITH RESPECT TO IDVC Mi X 2.000 4.500 3.500 2.000 2.400 M4 0.222 0.444 X 0.778 0.444 0.378 M4 0.286 0.571 1.286 X 0.571 0.543 M5 0.500 1.000 2.750 X 1.100	TH	4.500	3.500	2.500	2.000	2.500	2.500	X	2.500
THE NORMALIZED RATING VALUES OF DIFFERENT MITIGATION MEASURES WITH RESPECT TO IDFC IDFC M1 M2 M3 M4 M6 Weighta M1 X 1.125 1.125 0.875 0.625 0.750 M2 0.889 X 1.000 0.778 0.556 0.644 M3 0.889 1.000 X 0.778 0.556 0.644 M4 1.143 1.286 1.286 X 0.714 0.886 M5 1.600 1.800 1.400 X 1.320 TABLE III THE NORMALIZED RATING VALUES OF DIFFERENT MITICATION MEASURES WITH RESPECT TO IDVC IDVC M1 M2 0.414 X 0.770 0.443 M3 0.222 0.444 X 0.771 0.543 0.571 0.543 M4 0.226 0.571 1.286 X 0.571 0.543 M5 0.500 1.000 2.250 1.750 X 1.100 <					TABLE II				
IDFC M1 M2 M3 M4 M6 Weightag M1 X 1.125 1.125 0.875 0.625 0.750 M2 0.889 X 1.000 0.778 0.556 0.644 M1 0.1890 1.286 1.286 X 0.7714 0.886 M4 1.143 1.286 1.286 X 0.7714 0.886 M5 1.600 1.800 1.800 1.400 X 1.320 THE NORMALIZED RATING VALUES OF DIFFERENT MITIGATION MEASURES WITH RESPECT TO IDVC IDVC M1 M2 M4 M3 Weightag M1 X 2.000 4.500 3.500 2.000 2.400 M4 0.286 0.571 1.286 X 0.571 0.543 M4 0.286 0.571 1.286 X 0.571 0.543 M5 0.500 1.000 2.250 1.750 X 1.100 SEB <		THE NOR	MALIZED RATI	NG VALUES OF D	DIFFERENT MITIC	GATION MEASU	RES WITH RES	SPECT TO IDFC	
M1 X 1.125 1.125 0.875 0.625 0.750 M2 0.889 X 1.000 0.778 0.556 0.644 M3 0.889 1.000 X 0.778 0.556 0.644 M4 1.143 1.286 1.286 X 0.714 0.886 M5 1.600 1.800 1.400 X 1.320 THE NORMALIZED RATING VALUES OF DIFFERENT MITIGATION MEASURES WITH RESPECT TO IDVC IDVC Mi M4 M5 Weightan M1 X 2.000 4.500 3.500 2.000 2.400 M5 0.2222 0.444 X 0.778 0.444 0.378 M4 0.2222 0.444 X 0.779 X 1.100 TABLE IV THE NORMALIZED RATING VALUES OF DIFFERENT MITIGATION MEASURES WITH RESPECT TO SEB SEB M1 M2 M3 A4 M5 0.875 M2 1.143 X 1.143<	IDFC	М	[1	M_2	M ₃	M ₄		M ₅	Weightage
M2 0.889 X 1.000 0.778 0.556 0.644 M3 0.889 1.000 X 0.778 0.556 0.644 M4 1.143 1.286 1.286 X 0.714 0.886 M5 1.600 1.800 1.400 X 1.320 TABLE III THE NORMALIZED RATING VALUES OF DIFFERENT MITIGATION MEASURES WITH RESPECT TO IDVC IDVC M1 M2 M3 M4 M5 Weightan M1 X 2.000 4.500 3.500 2.000 2.400 M3 0.222 0.444 X 0.778 0.444 0.378 M4 0.286 0.571 1.286 X 0.571 0.543 M4 0.286 0.571 1.286 X 0.570 0.725 SEB M4 M5 0.875 1.000 1.000 0.750 0.725 M5 1.000 0.875 X 1.000 0.750 0.725 <tr< td=""><td>M_1</td><td>Х</td><td>C C C C C C C C C C C C C C C C C C C</td><td>1.125</td><td>1.125</td><td>0.87</td><td>5</td><td colspan="2">0.625</td></tr<>	M_1	Х	C C C C C C C C C C C C C C C C C C C	1.125	1.125	0.87	5	0.625	
M3 0.889 1.000 X 0.778 0.556 0.644 M4 1.143 1.286 1.286 X 0.714 0.886 M5 1.600 1.800 1.800 1.400 X 1.320 TABLE III THE NORMALIZED RATING VALUES OF DIFFERENT MITIGATION MEASURES WITH RESPECT TO IDVC IDVC M1 M2 M3 M4 M5 Weightag M1 X 2.000 4.500 3.500 2.000 2.400 M5 0.550 X 2.250 1.750 1.000 1.000 M3 0.222 0.444 X 0.778 0.444 0.378 M4 0.286 0.571 1.286 X 0.571 0.543 M5 0.500 1.000 2.750 1.000 0.750 0.725 M4 0.286 0.571 1.286 X 0.571 0.543 M4 M2 M3 1.413 1.413 0.857 0.877	M_2	0.8	89	Х	1.000	0.77	8	0.556	0.644
M ₁ 1.143 1.286 1.286 X 0.714 0.886 M ₅ 1.600 1.800 1.800 1.400 X 1.320 TABLE III THE NORMALIZED RATING VALUES OF DIFFERENT MITIGATION MEASURES WITH RESPECT TO IDVC M ₁ M M ₄ M ₈ Weightag M ₁ X 2.000 4.500 3.500 2.000 2.400 M ₂ 0.500 X 2.250 1.750 1.000 1.000 M ₃ 0.222 0.444 X 0.778 0.444 0.378 M ₄ 0.286 0.571 1.286 X 0.571 0.543 M ₄ 0.286 0.571 1.286 X 0.571 0.543 M ₅ 0.500 1.000 2.250 1.750 X 1.100 THE NORMALIZED RATING VALUES OF DIFFERENT MITIGATION MEASURES WITH RESPECT TO SEB SEB M ₁ M ₂ M ₃ M ₄ M ₅ 0.667 M ₁ X 0.000 <td>M_3</td> <td>0.8</td> <td>89</td> <td>1.000</td> <td>Х</td> <td>0.77</td> <td colspan="2">78 0.556</td> <td>0.644</td>	M_3	0.8	89	1.000	Х	0.77	78 0.556		0.644
M5 1.600 1.800 1.400 X 1.320 THE NORMALIZED RATING VALUES OF DIFFERENT MITIGATION MEASURES WITH RESPECT TO IDVC IDVC M1 M2 M3 M4 M5 Weightan M1 X 2.000 4.500 3.500 2.000 2.400 M5 0.500 X 2.250 1.750 1.000 1.000 M3 0.222 0.444 X 0.778 0.444 0.378 M4 0.286 0.571 1.286 X 0.571 0.543 M5 0.500 1.000 2.250 1.750 X 1.100 THE NORMALIZED RATING VALUES OF DIFFERENT MITIGATION MEASURES WITH RESPECT TO SEB SEB M1 M2 M4 M4 M5 Weightan M1 X 0.875 1.000 1.000 0.750 0.752 M4 1.000 0.875 X 1.000 0.500 0.503 M4 1.000 0.875 1.	M_4	1.1	43	1.286	1.286	Х		0.714	0.886
TABLE III THE NORMALIZED RATING VALUES OF DIFFERENT MITIGATION MEASURES WITH RESPECT TO IDVC IDVC M ₁ M ₂ M ₅ M ₄ M ₅ Weightage M ₁ X 2.000 4.500 3.500 2.000 2.400 M ₂ 0.500 X 2.250 1.750 1.000 1.000 M ₃ 0.222 0.444 X 0.778 0.444 0.378 M ₄ 0.286 0.571 1.286 X 0.571 0.543 M ₅ 0.500 1.000 2.250 1.750 X 1.100 THE NORMALIZED RATING VALUES OF DIFFERENT MITIGATION MEASURES WITH RESPECT TO SEB SEB M ₁ M ₂ M ₄ M ₄ M ₅ 0.877 M ₁ X 0.875 1.000 1.000 0.750 0.725 M ₂ 1.143 X 1.143 1.143 0.487 0.887 M ₁ X 0.875 1.000 X 0.050 0.725	M ₅	1.6	00	1.800	1.800	1.40	0	Х	1.320
IDVC M1 M2 M3 M4 M5 Weighta Weighta M3 M1 X 2.000 4.500 3.500 2.000 2.400 M2 0.500 X 2.250 1.750 1.000 1.100 M3 0.222 0.444 X 0.778 0.444 0.378 M4 0.286 0.571 1.286 X 0.571 0.543 M3 0.500 1.000 2.250 1.750 X 1.100 TABLE IV THE NORMALIZED RATING VALUES OF DIFFRENT MITIGATION MEASURES WITH RESPECT TO SEB SEB M1 M2 M3 M4 M5 Weighta M4 1.000 0.750 0.725 M2 1.143 X 1.143 1.143 0.857 0.857 M4 1.000 0.875 1.000 X 0.750 0.725 M4 1.000 0.875 1.000 X 0.750 0.725 M5 1.333 1.167 1.333 <td></td> <td>THE NOR</td> <td>MAI IZED RATI</td> <td>ng Values of D</td> <td>TABLE III</td> <td>ATION MEASUR</td> <td>ES WITH RES</td> <td>PECT TO IDVC</td> <td></td>		THE NOR	MAI IZED RATI	ng Values of D	TABLE III	ATION MEASUR	ES WITH RES	PECT TO IDVC	
Mi Ni Mi Mi Mi Mi Mi X 2.000 4.500 3.500 2.000 2.400 M2 0.500 X 2.250 1.750 1.000 1.100 Mi 0.222 0.444 X 0.778 0.444 0.378 M4 0.286 0.571 1.286 X 0.571 0.543 M5 0.500 1.000 2.250 1.750 X 1.100 THE NORMALIZED RATING VALUES OF DIFFERENT MITIGATION MEASURES WITH RESPECT TO SEB SEB M1 M2 M3 M4 M4 S Weightan M1 X 0.875 1.000 1.000 0.750 0.725 M3 1.000 0.875 1.000 X 0.750 0.725 M4 1.000 0.875 1.000 X 0.750 0.725 M5 1.333 1.167 1.333 1.333 X 1.033	IDVC	M		Ma	M ₂	M		Me	Weightage
M1 A L000 4.000 L000 L00	M	X		2 000	4 500	3.50	0	2 000	2 400
Ng 0.300 X 2.200 1.700 1.000 1.000 1.000 Mi 0.222 0.444 X 0.778 0.444 0.378 Mi 0.286 0.571 1.286 X 0.571 0.543 Ms 0.500 1.000 2.250 1.750 X 1.100 TABLE IV THE NORMALIZED RATING VALUES OF DIFFERENT MITIGATION MEASURES WITH RESPECT TO SEB SEB Mi Mg Mg Mg Weightag Mi X 0.875 1.000 1.000 0.750 0.725 Mg 1.143 1.143 1.143 0.857 0.857 Mg 1.000 0.875 X 1.000 0.750 0.725 Mg 1.333 1.167 1.333 1.333 X 1.033 TABLE V THE NORMALIZED RATING VALUES OF DIFFERENT MITIGATION MEASURES WITH RESPECT TO EB EB Mi Mg Mg Mg Mg Mg M	M	0.5	00	2.000 V	4.500	1.75	0	2.000	2.400
NR 0.222 0.444 X 0.778 0.444 0.778 M4 0.286 0.571 1.286 X 0.571 0.543 M5 0.500 1.000 2.250 1.750 X 1.100 THE NORMALIZED RATING VALUES OF DIFFERENT MITIGATION MEASURES WITH RESPECT TO SEB SEB M1 M2 M3 M4 M4 M5 Weightag M1 X 0.875 1.000 1.000 0.750 0.725 M2 1.143 X 1.143 1.143 0.887 0.887 M3 1.000 0.875 X 1.000 0.750 0.725 M4 1.000 0.875 1.000 X 0.750 0.725 M4 1.000 0.875 1.000 X 0.750 0.725 M5 1.333 1.167 1.333 1.333 X 1.033 TABLE V TABLE V M1 M2 <td>1v1₂</td> <td>0.5</td> <td>22</td> <td>A 0.444</td> <td>2.230 V</td> <td>0.77</td> <td>0</td> <td>0.444</td> <td>0.278</td>	1v1 ₂	0.5	22	A 0.444	2.230 V	0.77	0	0.444	0.278
M4 0.280 0.371 1.260 X 0.371 0.343 M5 0.500 1.000 2.250 1.750 X 1.100 TABLE IV THE NORMALIZED RATING VALUES OF DIFFERENT MITIGATION MEASURES WITH RESPECT TO SEB SEB M1 M2 M3 M4 M5 Weightag M1 X 0.875 1.000 1.000 0.750 0.725 M2 1.143 X 1.143 0.857 0.857 M3 1.000 0.875 X 1.000 0.750 0.725 M4 1.000 0.875 X 1.000 0.750 0.725 M4 1.000 0.875 1.000 X 0.750 0.725 M4 1.000 0.875 1.000 X 0.750 0.725 M5 1.333 1.167 1.333 1.333 X 1.033 TABLE V TABLE V TABLE VI TAB	IVI3	0.2	22	0.444	A 1 296	0.77	0	0.444	0.578
M5 0.300 1.000 2.230 1.730 X 1.100 TABLE IV THE NORMALIZED RATING VALUES OF DIFFERENT MITIGATION MEASURES WITH RESPECT TO SEB SEB M1 M2 M3 M4 M5 Weightag M1 X 0.875 1.000 1.000 0.750 0.725 M2 1.143 X 1.143 1.143 0.857 0.857 M3 1.000 0.875 X 1.000 0.750 0.725 M4 1.000 0.875 X 1.000 0.750 0.725 M3 1.333 1.167 1.333 1.333 X 1.033 TABLE V THE NORMALIZED RATING VALUES OF DIFFERENT MITIGATION MEASURES WITH RESPECT TO EB EB M1 M2 M3 M4 M5 Weightag M1 X 1.000 0.667 0.500 0.500 0.533 M3 1.500 1.500 X 0.750 0.750 0.900 M4 M2	IVI4	0.2	80 00	1.000	1.280	A 1.75	0	0.371 V	0.545
SEB M1 M2 M3 M4 M5 Weightage M1 X 0.875 1.000 1.000 0.750 0.725 M2 1.143 X 1.143 1.143 0.857 0.857 M3 1.000 0.875 X 1.000 0.750 0.725 M4 1.000 0.875 X 1.000 0.750 0.725 M4 1.000 0.875 1.000 X 0.750 0.725 M5 1.333 1.167 1.333 1.333 X 1.033 TABLE V THE NORMALIZED RATING VALUES OF DIFFERENT MITIGATION MEASURES WITH RESPECT TO EB TABLE VI M1 X 1.000 0.667 0.500 0.500 0.533 M2 1.000 X 0.667 0.500 0.500 0.533 M3 1.500 X 0.750 0.750 0.900 M4 2.000 2.000 1.333		T N			TABLE IV		D		
MI M2 M3 M4 M5 Weightad M1 X 0.875 1.000 1.000 0.750 0.725 M2 1.143 X 1.143 0.857 0.857 M3 1.000 0.875 X 1.000 0.750 0.725 M4 1.000 0.875 X 1.000 X 0.750 0.725 M5 1.333 1.167 1.333 1.333 X 1.033 TABLE V TABLE V THE NORMALIZED RATING VALUES OF DIFFERENT MITIGATION MEASURES WITH RESPECT TO EB EB M1 M2 M3 M4 M5 Weightad M1 X 1.000 0.667 0.500 0.500 0.533 M2 1.000 X 0.667 0.500 0.500 0.533 M3 1.500 X 0.750 0.750 0.900 M4 2.000 2.000 1.333 X	SEB	THE NOF	RMALIZED RAT	ING VALUES OF I	DIFFERENT MITIO	GATION MEASU	RES WITH RE	SPECT TO SEB	Weightage
M1 A 0.375 1.000 1.000 0.750 0.725 M2 1.143 X 1.143 1.143 0.857 0.857 M3 1.000 0.875 X 1.000 0.750 0.725 M4 1.000 0.875 X 1.000 X 0.750 0.725 M5 1.333 1.167 1.333 1.333 X 1.033 TABLE V THE NORMALIZED RATING VALUES OF DIFFERENT MITIGATION MEASURES WITH RESPECT TO EB EB M1 M2 M3 M4 M5 Weightag M1 X 1.000 0.667 0.500 0.500 0.533 M2 1.000 X 0.667 0.500 0.500 0.533 M3 1.500 X 0.750 0.750 0.900 0.433 1.000 1.267 TABLE VI TABLE VI TABLE VI TABLE VI TABLE VI </td <td>M.</td> <td>v</td> <td>r r</td> <td>0.875</td> <td>1,000</td> <td>1 00</td> <td>0</td> <td>0.750</td> <td>0.725</td>	M.	v	r r	0.875	1,000	1 00	0	0.750	0.725
M2 1.14-3 1.14-3 1.14-3 0.637 0.637 M3 1.000 0.875 X 1.000 0.750 0.725 M4 1.000 0.875 1.000 X 0.750 0.725 M5 1.333 1.167 1.333 1.333 X 1.033 THE NORMALIZED RATING VALUES OF DIFFERENT MITIGATION MEASURES WITH RESPECT TO EB EB M1 M2 M3 M4 M4 M5 Weightag M1 X 1.000 0.667 0.500 0.500 0.533 M2 1.000 X 0.667 0.500 0.500 0.533 M3 1.500 1.500 X 0.750 0.750 0.900 M4 2.000 2.000 1.333 X 1.000 1.267 M5 2.000 2.000 1.333 X 1.000 1.267 M4 M2 M3 M4 M5 Weightag M1	M	11	12	0.875 V	1.000	1.00	2	0.750	0.723
M3 1.000 0.673 X 1.000 0.730 0.723 M4 1.000 0.875 1.000 X 0.750 0.725 M5 1.333 1.167 1.333 1.333 X 1.033 THE NORMALIZED RATING VALUES OF DIFFERENT MITIGATION MEASURES WITH RESPECT TO EB EB M1 M2 M3 M4 M5 Weightag M1 X 1.000 0.667 0.500 0.500 0.533 M2 1.000 X 0.667 0.500 0.500 0.533 M3 1.500 X 0.6750 0.750 0.750 0.900 M4 2.000 2.000 1.333 X 1.000 1.267 M5 2.000 2.000 1.333 X 1.000 X 1.267 M4 M2 M3 M4 M5 Weightag M1 M2 M3 M4 M5 Weightag M1 M2	M	1.1	45	A 0.975	1.145 V	1.14	·5 0	0.837	0.837
M4 1.000 0.875 1.000 X 0.750 0.725 M5 1.333 1.167 1.333 1.333 X 1.033 TABLE V THE NORMALIZED RATING VALUES OF DIFFERENT MITIGATION MEASURES WITH RESPECT TO EB EB M1 M2 M3 M4 M5 Weightag M1 X 1.000 0.667 0.500 0.500 0.533 M2 1.000 X 0.667 0.500 0.500 0.533 M3 1.500 1.500 X 0.750 0.750 0.900 M4 2.000 2.000 1.333 X 1.000 1.267 M5 2.000 2.000 1.333 1.000 X 1.267 TABLE VI THE NORMALIZED RATING VALUES OF DIFFERENT MITIGATION MEASURES WITH RESPECT TO SEH TABLE VI THE NORMALIZED RATING VALUES OF DIFFERENT MITIGATION MEASURES WITH RESPECT TO SEH SEH M1 M2 M3 M4 M5 Weightag M1 X 1.000	IVI3	1.0	00	0.875	A 1.000	1.00	0	0.750	0.725
M5 I.333 I.107 I.333 I.333 X I.033 TABLE V THE NORMALIZED RATING VALUES OF DIFFERENT MITIGATION MEASURES WITH RESPECT TO EB EB M1 M2 M3 M4 M5 Weightag M1 X 1.000 0.667 0.500 0.500 0.533 M2 1.000 X 0.667 0.500 0.500 0.533 M3 1.500 1.500 X 0.750 0.750 0.900 M4 2.000 2.000 1.333 X 1.000 1.267 M5 2.000 2.000 1.333 1.000 X 1.267 TABLE VI THE NORMALIZED RATING VALUES OF DIFFERENT MITIGATION MEASURES WITH RESPECT TO SEH TABLE VI THE NORMALIZED RATING VALUES OF DIFFERENT MITIGATION MEASURES WITH RESPECT TO SEH SEH M1 M2 M3 M4 M5 Weightag M1 X 1.000 2.000 1.000 1.000 1.000 1.000 M1 <th< td=""><td>NI4</td><td>1.0</td><td>22</td><td>0.875</td><td>1.000</td><td>A 1.22</td><td>2</td><td>0.750</td><td>0.725</td></th<>	NI4	1.0	22	0.875	1.000	A 1.22	2	0.750	0.725
THE NORMALIZED RATING VALUES OF DIFFERENT MITIGATION MEASURES WITH RESPECT TO EB EB M1 M2 M3 M4 M5 Weightag M1 X 1.000 0.667 0.500 0.500 0.533 M2 1.000 X 0.667 0.500 0.500 0.533 M3 1.500 X 0.667 0.500 0.750 0.900 M4 2.000 1.500 X 0.750 0.750 0.900 M4 2.000 2.000 1.333 X 1.000 1.267 M5 2.000 2.000 1.333 1.000 X 1.267 TABLE VI THE NORMALIZED RATING VALUES OF DIFFERENT MITIGATION MEASURES WITH RESPECT TO SEH SEH M1 M2 M3 M4 M5 Weightag M1 X 1.000 2.000 1.000 1.000 0.000 M2 M1 M2 M3 M4 M5 Weightag M1 X <	M ₅	1.3	33	1.107	1.555	1.33	3	Λ	1.055
EB M1 M2 M3 M4 M5 Weightage M1 X 1.000 0.667 0.500 0.500 0.533 M2 1.000 X 0.667 0.500 0.500 0.533 M3 1.500 1.500 X 0.750 0.750 0.900 M4 2.000 2.000 1.333 X 1.000 1.267 M5 2.000 2.000 1.333 1.000 X 1.267 M5 2.000 2.000 1.333 1.000 X 1.267 TABLE VI THE NORMALIZED RATING VALUES OF DIFFERENT MITIGATION MEASURES WITH RESPECT TO SEH SEH M1 M2 M3 M4 M5 Weightage M1 X 1.000 2.000 1.000 1.000 1.000 1.000 M2 1.000 X 2.000 1.000 1.000 1.000 1.000 M3 0.500 0.500 X 0.500 0		THE NO	RMALIZED RAT	TING VALUES OF	DIFFERENT MIT	IGATION MEASU	IRES WITH RE	ESPECT TO EB	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	EB	М	1	M_2	M ₃	M_4		M ₅	Weightage
M2 1.000 X 0.667 0.500 0.500 0.533 M3 1.500 1.500 X 0.750 0.750 0.900 M4 2.000 2.000 1.333 X 1.000 1.267 M5 2.000 2.000 1.333 1.000 X 1.267 TABLE VI THE NORMALIZED RATING VALUES OF DIFFERENT MITIGATION MEASURES WITH RESPECT TO SEH SEH M1 M2 M3 M4 M5 Weightag M1 X 1.000 2.000 1.000 1.000 1.000 1.000 M2 1.000 2.000 X 0.500 0.500 0.400 M4 M1 X 2.000 1.000 1.000 1.000 M3 0.500 0.500 X 0.500 0.500 0.4000 M4 1.000 1.000 2.000 X 1.000 1.000 M4 1.000 1.000 2.000 X 1.000 <	M_1	Х		1.000	0.667	0.50	0	0.500	0.533
M3 1.500 1.500 X 0.750 0.750 0.900 M4 2.000 2.000 1.333 X 1.000 1.267 M5 2.000 2.000 1.333 1.000 X 1.267 TABLE VI THE NORMALIZED RATING VALUES OF DIFFERENT MITIGATION MEASURES WITH RESPECT TO SEH SEH M1 M2 M3 M4 M5 Weightag M1 X 1.000 2.000 1.000 1.000 1.000 1.000 M3 0.500 0.500 X 0.500 0.500 0.400 0.4000 M4 1.000 1.000 2.000 1.000 1.000 1.000 1.000 M3 0.500 0.500 X 0.500 0.500 0.4000 M4 1.000 1.000 2.000 X 1.000 1.000	M_2	1.0	00	Х	0.667	0.50	0	0.500	0.533
M4 2.000 2.000 1.333 X 1.000 1.267 M5 2.000 2.000 1.333 1.000 X 1.267 TABLE VI THE NORMALIZED RATING VALUES OF DIFFERENT MITIGATION MEASURES WITH RESPECT TO SEH SEH M1 M2 M3 M4 M5 Weightag M1 X 1.000 2.000 1.000 1.000 1.000 M3 0.500 0.500 X 0.500 0.500 0.400 M4 1.000 1.000 2.000 1.000 1.000 1.000 M3 0.500 0.500 X 0.500 0.500 0.400 M4 1.000 1.000 2.000 X 1.000 1.000	M_3	1.5	00	1.500	Х	0.75	0	0.750	0.900
M5 2.000 2.000 1.333 1.000 X 1.267 TABLE VI THE NORMALIZED RATING VALUES OF DIFFERENT MITIGATION MEASURES WITH RESPECT TO SEH SEH M1 M2 M3 M4 M5 Weightage M1 X 1.000 2.000 1.000 1.000 1.000 M2 1.000 X 2.000 1.000 1.000 1.000 M3 0.500 0.500 X 0.500 0.500 0.400 M4 1.000 1.000 2.000 X 1.000 1.000 M4 0.500 0.500 X 1.000 1.000 1.000	M_4	2.0	00	2.000	1.333	Х		1.000	1.267
TABLE VI THE NORMALIZED RATING VALUES OF DIFFERENT MITIGATION MEASURES WITH RESPECT TO SEH SEH M1 M2 M3 M4 M5 Weightage M1 X 1.000 2.000 1.000 1.000 1.000 M2 1.000 X 2.000 1.000 1.000 1.000 M3 0.500 0.500 X 0.500 0.400 M4 1.000 1.000 2.000 X 1.000 1.000	M ₅	2.0	00	2.000	1.333	1.00	0	Х	1.267
SEH M1 M2 M3 M4 M5 Weightag M1 X 1.000 2.000 1.000 1.000 1.000 M2 1.000 X 2.000 1.000 1.000 1.000 M3 0.500 0.500 X 0.500 0.400 M4 1.000 1.000 2.000 X 1.000 1.000		THE NOR	2MALIZED RAT	ING VALUES OF I	TABLE VI	GATION MEASU	RES WITH RE	SPECT TO SEH	
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	SEH	M		M ₂	M ₂	M.		Me	Weightage
M1 A 1.000 2.000 1.000 1.000 1.000 M2 1.000 X 2.000 1.000 1.000 1.000 M3 0.500 0.500 X 0.500 0.500 0.400 M4 1.000 1.000 2.000 X 1.000 1.000	M	v	-1	1,000	2 000	1 00	0	1 000	1 000
M2 1.000 A 2.000 1.000 1.000 1.000 M3 0.500 0.500 X 0.500 0.500 0.400 M4 1.000 1.000 2.000 X 1.000 1.000	M.	10	<u>.</u> 00	X	2.000	1.00	0	1,000	1.000
M3 0.500 X 0.500 0.400 M4 1.000 1.000 2.000 X 1.000 1.000	M	1.0	00	0.500	2.000 V	1.00	0	0.500	0.400
M 1000 1000 2000 1000 X 1000	IV13 M	1.0	00	1 000	2 000	0.50		1 000	1 000
	1 V1 4	1.0	00	1.000	2.000	A 1.00	0	1.000	1.000

World Academy of Science, Engineering and Technology International Journal of Energy and Power Engineering Vol:8, No:12, 2014

	1.000	1.500	1.	1.000	1.500		1.0	Х	M_1	
	1.000	1.500	1.	1.000	1.500		Х	1.000	M_2	
	0.600	1.000	1.	0.667	Х		0.6	0.667	M_3	
	1.000	1.500	1.	Х	1.500		1.0	1.000	M_4	
	0.600	Х		0.667	1.000		0.6	0.667	M ₅	
			D	f	BLE VIII	TA		Tree Monte		
	Weightage	M ₅	TTH RESPEC	MA	M ₂	LUES OF DIFFEI	LIZED RATING V	THE NORMA M1	ТН	
	0.840	1.200	1.	1.200	1.200		0.6	X	M ₁	
	1.533	2.000	2.	2.000	2.000		Х	1.667	M_2	
	0.667	1.000	1.	1.000	Х		0.5	0.833	M_3	
	0.667	1.000	1.	Х	1.000		0.5	0.833	M_4	
	0.667	Х		1.000	1.000		0.5	0.833	M ₅	
	TR RANK	FASURES AND THE	TION MEASI	тне Мітідат	BLE IX NW) of Each of	T <i>A</i> d Weightage	G THE NORMALI	X FOR DECIDIN	Της Μάτρι	
		TH	TI	EH	SEH	EB	SEB	IDV(IDFC	
RANK	NW	2.5	2.:	0.914	0.914	1.179	0.914	0.612	0.444	Wa
2	1.003	0.840	0.8	1.000	1.000	0.533	0.725	2.400	0.750	M ₁
1	1.148	1.533	1.5	1.000	1.000	0.533	0.857	1.100	0.644	M ₂
5	0.689	0.667	0.6	0.600	0.400	0.900	0.725	0.378	0.644	M3
4	0.911	0.667	0.6	1.000	1.000	1.267	0.725	0.543	0.886	M_4
3	0.975	0.667	0.6	0.600	1.000	1.267	1.033	1.100	1.320	M ₅
		URES M5	ON MEASURE	O MITIGATION M4	S WITH RESPECT T M3	ENT ATTRIBUTI M2	ATING OF DIFFE M1	THE I		
		70		75	80	70	65	IDFC		
		10 Moderate Moderate Less Less		15	40	70	60	IDVC		
				Moderate	good	V.high	High	SEB		
				V.less	less	V.good	good	EB		
				High V Less	High	Moderate	Moderate	SER		
				V.Less Moderate	Less	W High	High	ЕП ТЦ		
		Less	; L	Widderate	Widderate	v.nigli	nigii	п		
				IBUTES	BLE XI DIFFERENT ATTR	T <i>A</i> Weightages c	Тн		_	
		F) TH (G)	EH (F)	IBUTES SHE (E)	BLE XI 5 Different Attr 3 (C) EB (D)	TA VEIGHTAGES C VC (B) SE	TH IDFC (A)	Attributes	-	
		F) TH (G) 45	EH (F) 40	IBUTES SHE (E) 35	BLE XI F DIFFERENT ATTR B (C) EB (D) D0 90	TA VEIGHTAGES C VC (B) SE 50 I	TH IDFC (A) 1 70	Attributes weightages	-	
		F) TH (G) 45	EH (F) 40	IBUTES SHE (E) 35	BLE XI F DIFFERENT ATTR 3 (C) EB (D) 00 90 BLE XII	TA VEIGHTAGES C VC (B) SE 50 I TA	TH IDFC (A) 1 70	Attributes weightages	_ 	
Rank	Total	F) TH (G) 45 ND THEIR RANK M5	EH (F) 40 SURES AND 7	IBUTES SHE (E) 35 GATION MEAS	BLE XI DIFFERENT ATTR (C) EB (D) 00 90 BLE XII ACH OF THE MITIC M4	TA VEIGHTAGES C VC (B) SE 50 1 TA EIGHTAGE OF 1 M3	TH IDFC (A) 1 70 R DECIDING THE M2	Attributes weightages HE MATRIX FO	- - - - - - - - - - - - - - - - - 	
Rank 2 nd	<u>Total</u> 0 1085	F) TH (G) 45 ND THEIR RANK M5 +D+E+F+G=360	EH (F) 40 SURES AND 7 B+C+D+	IBUTES SHE (E) 35 GATION MEAS	BLE XI DIFFERENT ATTR G (C) EB (D) DO 90 BLE XII ACH OF THE MITIC M4 B+C+D+F+C	TA VEIGHTAGES C VC (B) SE 50 TA EIGHTAGE OF 1 M3 D+F+G=325	TH IDFC (A) 1 70 R DECIDING THE M2 (+F=75 B+4	Attributes weightages HE MATRIX FO		/11
Rank 2 nd 1 st	<u>Total</u> 1085 30 1510	F) TH (G) 45 ND THEIR RANK M5 +D+E+F+G=360 C+D+E+F+G=4:	EH (F) 40 sures and 7 B+C+D+ A+B+C+D	IBUTES SHE (E) 35 GATION MEAS G=325 G=325	BLE XI DIFFERENT ATTR (C) EB (D) 00 90 BLE XII ACH OF THE MITTR M4 B+C+D+F+C B+C+D+F+C	TA VEIGHTAGES C VC (B) SE 50 T TA EIGHTAGE OF T M3 D+F+G=325 D+F+G=325	TH IDFC (A) 1 70 R DECIDING THE M2 C+F=75 B+4 X B+4	Attributes weightages HE MATRIX FO I +G=430		41 42
Rank 2 nd 1 st 3 rd	Total 0 1085 30 1510 9 980	F) TH (G) 45 ND THEIR RANK M5 +D+E+F+G=360 C+D+E+F+G=42 +C+E+F+G=340	EH (F) 40 SURES AND 7 B+C+D+ A+B+C+D A+B+C+D	IBUTES SHE (E) 35 GATION MEAS G=325 G=325 F+G=430	BLE XI © DIFFERENT ATTR (C) EB (D) 00 90 BLE XII <u>ACH OF THE MITTR</u> M4 B+C+D+F+C B+C+D+F+(A+B+C+D+E+)	TA VEIGHTAGES C VC (B) SE 50 TA EIGHTAGE OF T M3 D+F+G=325 D+F+G=325 X	TH IDFC (A) 1 70 R DECIDING THE M2 X+F=75 B+4 X B+4 +E=105	Attributes weightages HE MATRIX FO H +G=430	 	41 42 43
Rank 2 nd 1 st 3 rd 4 th	Total 1085 30 1510 980 590	F) TH (G) 45 ND THEIR RANK M5 +D+E+F+G=360 C+D+E+F+G=42 +C+E+F+G=340 B+C+E+G=300	EH (F) 40 sures and 7 B+C+D+ A+B+C+D A+B+C+ A+B+C+ A+B+C	IBUTES SHE (E) 35 GATION MEAS G=325 G=325 F+G=430	BLE XI © DIFFERENT ATTR B (C) EB (D) 00 90 BLE XII ACH OF THE MITTR M4 B+C+D+F+C B+C+D+F+C A+B+C+D+E+1 X	TA VEIGHTAGES C VC (B) SE 50 TA EIGHTAGE OF M3 D+F+G=325 D+F+G=325 X E+G=80	TH IDFC (A) 1 70 R DECIDING THE M2 X+F=75 B+4 X B+4 +E=105 +E=105	Attributes weightages HE MATRIX FO I +G=430 ; A	T M1 X A+B+C+D+E+F A+E=10. A+E=10.	A1 A2 A3 A4

TABLE VII The Normalized rating Values of Different Mitigation Measures with Respect to EH

 M_3

 M_4

Weightage

 M_5

 M_2

 M_1

After surveying throughout the literatures and consulting with the experts it is found that the following mitigation measures can be adopted to prevent the present degradation:

 Desiltation of the River Bed (M1) which confluents to form the Dumboor Lake. This measure will ensure steady flow of water from the rivers. This will also satisfy the increasing demand for water from the local inhabitants. The level of work involved to de-silt these two rivers is enormous and expensive. But adoption of such measures will ensure steady supply of water from the upstream.

Desiltation of the Reservoir (M2) to increase depth of the same which in turn will also increase the storage capacity of the reservoir. This measure is economical but if the supply of water from the rivers decreases along with the

EH

rainfall then the benefit from such activity will be uncertain.

- Installation of Micro Hydro Power Plant (M3) may be installed near by the existing plant to meet up the water availability during lean season.
- Implementation of Variable Head Turbines (M4) instead of the fixed head turbines which are in use now. This change will ensure plant capacity even at the time of water scarcity. The installation of such turbines is expensive but will ensure maximum utilization of the available resources.
- Installation of Surge tank (M5) which will hold the excess water and release the same when there will be scarcity in the resource. The implementation of a surge tank will ensure a steady flow of water within the penstocks to maintain the required kinetic energy for generation of power from the power plant. The cost of such installations is lesser than de-siltation activities but efficiency and capability of the same to satisfy the demand is doubtful.







Fig. 2 Weightage of each of the Mitigation Measures as per Concordance Analysis Techniques

A. As per Analytic Hierarchy Process

Table I shows the Pair wise Ratings assigned to each of the attributes identified based on the literature survey and consultation with the experts. Tables II-VIII show the ratings of the different mitigation measures compared with each other with respect to each attributes considered for the study.

Ultimately the overall result from the decision making procedure is given in Table IX. From the decision it is observed that Mitigation measure No. 2 and No. 1 are the better alternatives for improvement of Gumti hydro power plant. All the mitigation measures can be considered rank wise viz. M2, M1, M5, M4, M3 (Fig. 1) and these measures can restore the hydro power plant to its original capacity.

B. As per Concordance Analysis Techniques

Table XI shows the Ratings of attributes with respect to mitigation measures based on the literature survey and consultation with the experts. The weights for different attributes put by a group of experts are also computed using another rating scale and these are showing in Table XII.

Ultimately the overall result from the decision making procedure is given in Table XII. From the decision it is observed that Mitigation measure No.2 and No.1 are the better alternatives for improvement of Gumti hydro power plant. All the mitigation measures can be considered rank wise viz. M2, M1, M3, M4, M5 (Fig. 2) and these measures can restore the hydro power plant to its original capacity.

VI. CONCLUSION

The present investigation tried to analyze the different mitigation measures and compared to find the best suitable alternative which can solve the present uncertainties involving the existence of the Gumti Hydro Power Plant. Out of 15MW capacity of Gumti hydro power plant, at present only 8MW-9MW power is produced during rainy season. But during lean season the production reduces to 0.5MW due to shortage of water. So, it will be essential to implement some mitigation measures so that the further atrocities can be prevented and originality will be possible to restore. In this regard the present investigation utilizes the advancement of the AHP & CAT to identify the better alternative among the 5(five) available options of mitigation. Some related attributes are identified by the method of surveying within the experts and the available reports and literatures. Similar criteria are removed and ultimately 7 (seven) relevant ones are identified. All the attributes are compared with each other and rated accordingly to their importance over the other with the help of Pair wise Comparison Matrix. From the Analytic Hierarchy Process (AHP) and Concordance Analysis Techniques (CAT) it is observed that Mitigation measure No.2 and No.1 are the better alternatives for improvement of Gumti hydro power plant. All the mitigation measures can be considered rank wise viz. M2, M1, M5, M4, M3 as per Analytic Hierarchy Process and viz. M2, M1, M3, M4, M5 as per Concordance Analysis Techniques. That is rank of M3, M4, M5 are not similar for Analytic Hierarchy Process and Concordance Analysis Techniques. But the rank of M1 and M2 are same in both the analysis. So from the decision it is clear that rank wise Mitigation measure No.2 and No.1 are the better alternatives for improvement of Gumti hydro power plant and these measures can restore the hydro power plant to its original capacity.

REFERENCES

- Mohd., M., Mohd., A., and Mohd., I.A.H, "Basic design aspects of micro hydro power plant and its development in Malaysia", National power & energy conference Proceedings, Kualampur, Malaysia, pp220-223, 2004.
- [2] Belton, V. and Gear, T., "On a Short-coming of Saaty's Method of Analytic Hierarchies", Omega, pp. 228-230. 1983.
- [3] Saaty, T.L., "Fundamentals of Decision Making and Priority Theory with the AHP", RWS Publications, Pittsburgh, PA, U.S.A, 1994.
- [4] Dyer, J.S., and Wendell, R.E., "A Critique of the Analytic Hierarchy Process", Working Paper, 84/85, Department of Management, The University of Texas at Austin, Austin, TX, pp. 4-24, 1985.
- [5] Saaty, T.L., "Axiomatic Foundations of the Analytic Hierarchy Process", Management Science, Vol. 32, pp. 841-855, 1983.
- [6] Saaty, T.L., "A Scaling Method for Priorities in Hierarchical Structures", Journal of Mathematical Psychology, Vol. 15, pp. 57-68, 1977.
- [7] Saaty, T.L., "The Analytic Hierarchy Process", McGraw-Hill International, New York, NY, U.S.A., 1980.
- [8] Dyer, J.S., "Remarks on the Analytic Hierarchy Process", Management Science, Vol. 36, pp. 249-258. 1990.
- [9] Sharma, A., "Validation of the monsoonal river inflow forecasting model-A case study" Journal of applied Hydrology, Vol. xv, pp.1-12, 2002.

Ms. Kaberi Majumdar is an Assistant professor of Electrical Engineering Department in Tripura Institute of Technology Narsingarh (TIT), India. She receives B.E. (Electrical) from Tripura Engineering College, India in 1995 and M.Tech from Tripura University Agartala, India in 2007. Prsently, she is pursuing Ph.D in Jadavpur University. She was born in Agartala, India in October 17, 1973. Her research interest covers Hydro Power Plant.

Dr. Sekhar Datta is a Professor of Mechanical Engineering Department. He is also the Principal of Tripura Institute of Technology Narsingarh (TIT), India. He receives B.E. (Civil) from Tripura Engineering College, India and M.Tech and PhD from Jadavpur University, India. He was born in Agartala, India.