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EVALUATING PARETO FRONT WITH TOPSIS AND FUZZY TOPSIS FOR LITERACY RATES IN ODISHA

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Abstract: -
In engineering design and manufacturing, conflicting disciplines and technologies are always involved in the design process. Decision making is the process of finding the best option among the feasible alternatives. Multi Criteria Decision Making (MCDM) methods can help decision makes to effectively deal with such situation and make wise design decision to produce an optimized design. There are varieties of existing MCDM methods, thus the selection of the most appropriate method is critical since the use of inappropriate methods often causes misleading decision process. The MCDM methods are based on aggregating function representing closeness to ideal, TOPSIS is one of the most efficient methods. And also it can be fuzzified which gives rise to a new method called Fuzzy TOPSIS. Fuzzy TOPSIS is a new method for MCDM and very easy to understand and it is originated in the compromise programming method. Here we have adapted the Fuzzy TOPSIS method and we have arranged the multiple numbers of criteria using Knapsack algorithm and created a Pareto Front with the help of non-dominated sorting method. Then we have ranked all the alternatives with classical Fuzzy TOPSIS method. In this paper the literacy rate of Odisha (a state of India) has been analyzed by using normal TOPSIS and fuzzy TOPSIS methods and the comparative results are given. The data sets considered in this paper are the real time data given by National Census (20002013).

Index Terms: - *MCDM, TOPSIS, Fuzzy TOPSIS, FPIS, FNIS, VIKOR, Odisha,*

INTRODUCTION

The world around us is difficult to see in one dimensional way in order to judge what we see. We always compare and rank objects of our choice with respect to various criteria of choice, such as countries in regard to their environmental qualities, or several estimators with respect to their mean squared errors. One of the methods to compare, rank and order several alternatives is based on the notion of "Multiple Criteria Decision Making (MCDM)". MCDM has recently been recognized as an efficient statistical method to combine component indices arising from many sources into a single overall meaningful index therefore ranking and comparing are feasible. A typical MCDM problem involves a number of alternatives to be assessed and a number of criteria or indicators to assess the alternatives. Each alternative has a value for each indicator and based on these values the alternatives can be assessed and ranked. Moreover, multiple criteria decision making research has developed rapidly and has become a main area of research for dealing with complex decision problems which require the consideration of multiple objectives or criteria. Multiple criteria Decision Making (MCDM) is a body of techniques used for meaningful integration of component indices to an overall index in order to decide on the ranking of a number of locations from the best to worst. This is based on the premises that in the absence of a natural ideal location, a best alternative would be the one which has the shortest distance from the hypothetical ideal location and at the same time farthest distance from the hypothetical antiideal (negative ideal) location Technique for order preference by similarity to an ideal solution (TOPSIS), known as a classical MADM method, has been developed by Hwang and Yoon for solving the MADM problem. Although there are several other methods like AHP, GRA, Entropy method etc.
But we can say TOPSIS is a robust method. Then an extend approach of TOPSIS came into consideration to develop a methodology for solving multi-attribute decision making problems in fuzzy environments. Considering the fuzziness in the decision data, linguistic variables are used to assess the weight of each criterion and the rating of each alternative with respect to each criterion. The decision matrix is converted into a fuzzy decision matrix and constructs a weighted normalized fuzzy decision matrix once the decision makers' fuzzy ratings have been pooled. The lower bound value of alternatives has been designed to obtain the distance value of the corresponding alternatives for detecting the fuzzy positive ideal solution (FPIS) and the fuzzy negative ideal solution (FNIS). Then fuzzy similarity degree of each alternative is calculated from FPIS and FNIS, respectively. Finally, a closeness coefficient is defined for each alternative to determine the rankings of all alternatives. The higher value of closeness coefficient indicates that an alternative is closer to FPIS and farther from FNIS simultaneously. This method became more efficient than any other method as it uses fuzzy data not crisp data for calculation. In this paper we are trying to evaluate the Pareto front with TOPSIS and Fuzzy TOPSIS for literacy rate in Odisha (a state of India).

The rest of the paper discuss about background work in section 2, related work in section 3, problem statement in section 4, work objective in section 5, scope of the work in section 6, preliminaries in section 7, Pareto fuzzy model and data set in section 8, Simulated results in section 9, comparison results in section 10, and section 11 describes the conclusion and future works.

1. Background Work

Many papers have proposed analytical models as aids in conflict management situations. Decision making may be considered as a complex and dynamic process including one managerial level and one engineering level (Duckstein and Opricovic, 1980). The managerial level defines the goals, and chooses the final"optimal"alternative. The multi-criteria nature of decisions is emphasized at this managerial level, at which public officials called "decision makers" have the power to accept or reject the solution proposed by the engineering level. These decision makers, who provide the preference structure, are"off line"from the optimization procedure done at the engineering level. Very often, the preference structure is based on political rather than only technical criteria. In such cases, a system analyst can aid the decision making process by making a comprehensive analysis and by listing the important properties of no inferior and/or compromise solutions

(Yu, 1973). The engineering level of the MCDM process defines alternatives and points out the consequences of choosing any one of them from the standpoint of various criteria. This level also performs the multi-criteria ranking of alternatives. There are a variety of multiple criteria techniques to aid selection in conditions of multiple criteria. The acronym TOPSIS stands for technique for preference by similarity to the ideal solution.

TOPSIS was initially presented by Hwang and Yoon , Lai et al., and Yoon and Hwang. TOPSIS is attractive in that limited subjective input is needed from decision makers. The only subjective input needed is weights. In the past few years, numerous attempts have been carried out to apply fuzzy set theory to multiple criteria evaluation methods. First convert a fuzzy MADM problem into a crisp one via centered defuzzification and then solve the non fuzzy MADM problem using the TOPSIS approach. Chen and Tzen transform a fuzzy multiple criteria decision making (MCDM) problem into a non fuzzy MADM using fuzzy integral. Instead of using distance, they employ a grey relation grade to define the relative closeness of each alternative. Chu also changes a fuzzy MADM problem into a crisp one and solves the problem using the TOPSIS approach. Differing from the others, he first derives the membership functions of all the weighted ratings in a weighted normalization decision matrix using interval arithmetic off fuzzy numbers and then de-fuzzifies them into crisp values using the ranking method of mean of removals. Chen and Hwang extends the TOPSIS approach to fuzzy group decision making situations by defining a crisp Euclidean distance between any two fuzzy numbers. Hsu and Chen discuss an aggregation of fuzzy opinions under group decision making. Li proposes a simple and efficient fuzzy model to deal with multi-judges/MADM problems in a fuzzy environment. hence we have studied

- The concept of MCDM, Multi-criteria Group Decision Making (MCGDM),several MCDM methods for compromising solutions. The algorithm and its advantages and disadvantages of it.
- The concept of Multi Objective Optimization (MOO) method and the basic knowledge about Pareto front generation and other algorithms to generate Non Dominated sets.
- The TOPSIS method and the Fuzzy TOPSIS method.

3. Related Works

Many papers related to MCDM concept and methods, MCGDM, TOPSIS method and Fuzzy TOPSIS method are studied by the authors and finally the section related work has been summarized.

Chen-Tung Chen [6] extended the concept of TOPSIS to develop a methodology for solving multi-person multi-criteria decision-making problems in fuzzy environment. Considering the fuzziness in the decision data and group decision making process, linguistic variables are used to assess the weights of all criteria and the ratings of each alternative with respect to each criterion. Decision matrix can be converted into a fuzzy decision matrix and construct a weighted normalized fuzzy decision matrix once the decision makers' fuzzy ratings have been pooled. Ac-cording to the concept of TOPSIS, They defined the fuzzy positive ideal solution (FPIS) and the fuzzy negative ideal solution (FNIS). And then, a vertex method is proposed in this paper to calculate the distance between two triangular fuzzy ratings. Using the vertex method, distance of each alternative from FPIS and FNIS, can be calculated respectively. Finally, they calculated a closeness coefficient of each alternative is defined to determine the ranking order of all alternatives. The higher value of closeness coefficient indicates that an alternative is closer to FPIS and farther from FNIS simultaneously.

Jose Antonio Crispima and Jorge Pinho de Sousa developed a method for Partner selection problem in virtual enterprises (VE) .This can be viewed as a multi-criteria decision making problem that involves assessing trade-offs between conflicting tangible and intangible criteria. In general, this is a very complex problem due to the dynamic topology of the network, the large number of alternatives and the different types of criteria. In this paper they have proposed an exploratory process to help the decision-maker obtain knowledge about the network in order to identify the criteria and the companies that best suit the needs of each particular project. This process involves a multi-objective tabu search meta heuristic designed to find a good approximation of the Pareto front, and a fuzzy TOPSIS algorithm to rank the alternative VE configurations. In the exploratory phase they have applied clustering analysis to confine the search according to the decision-maker beliefs, and case base reasoning, an artificial intelligence approach, to totally or partially construct VEs by reusing past experiences. Preliminary computational results clearly demonstrate the potential of the approach for practical application.

MadhaviAmiri-Aref, Nikbakhsh Javadian, Mohammad Kazemi[9] presented a fuzzy multiple criteria decision making (FMCDM) problem with the TOPSIS based on the new concept of positive and negative ideal solution. Here decision making is a process which accuracy of data play major role to select the best alternative. They used a triangular fuzzy numbers (TFN) among decision making process are used to evaluate the weighted different alternatives versus various criteria and a fuzzy group weight is made by different experts. In this paper , additionally, a new fuzzy distance formula is applied to compute distance between each alternative and positive as well as negative ideal solution. The motivation related to define new FPIS and FNIS is to present a more reliable and easier way which guarantees that the preferred alternative is closer to the positive ideal solution and farther from the final negative ideal solution. As a result, a compromise satisfactory solution can be found, so the closeness coefficient value of each alternative for the positive ideal solution and negative ideal solution can also be considered, while maintaining the objectivity with regard to the criteria of ups and downs of alternatives. Therefore, according to the closeness coefficient values, They determined the ranking order of all alternatives and select the best one from among a set of feasible alternatives. Their method shows its practical advantages for comparing fuzzy utilities in fuzzy decision problems which is a valuable methodology for general managers and decision makers in practice.

Chen-Tung Chen, Ching-Torng Lin, Sue-Fn Huang[8] developed a fuzzy approach For the TOPSIS model for supplier selection problem. In this paper the importance weights of various criteria and the ratings of qualitative criteria are considered as linguistic variables.Because linguistic assessments merely approximate the subjective judgment of decision-makers, we can consider linear trapezoidal membership functions to be adequate for capturing the vagueness of these linguistic assessments. These linguistic variables can be expressed in positive trapezoidal fuzzy numbers. The importance weight of each criterion can be by either directly assigning or indirectly using pair wise comparison. It is suggested in this paper that the decision-makers use the linguistic variables to evaluate the importance of the criteria and the ratings of alternatives with respect to qualitative criteria.

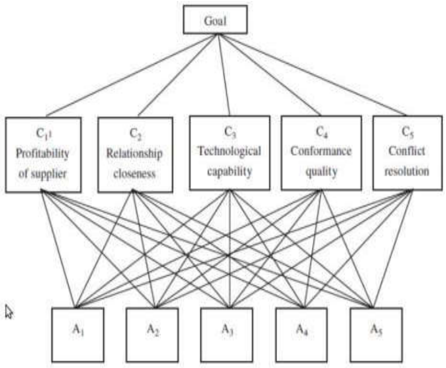

Figure 1:- Supply Chain Management Flow Chart.

Serafim Opricovic, Gwo-Hshiung Tzeng [1] developed a comparative approch of TOPSIS and VIKO (VlseKriterijumska Optimizacija I Kompromisno Resenje; in Serbian) in Serbian)) R.Ranking by VIKOR may be performed with different values of criteria weights, analyzing the impact of criteria weights on proposed compromise solution. The VIKOR method determines the weight stability intervals. The compromise solution obtained with initial weights will be replaced if the value of a weight is not within the stability interval. The analysis of weight stability intervals for a single criterion is performed for all criterion functions, with the same given initial values of weights. In this way, the preference stability of an obtained compromise solution may be analyzed using the VIKOR program. VIKOR is a helpful tool in multi-criteria decision making, particularly in a situation where the decision maker is not able, or does not know to express his/her preference at the beginning of system design. The obtained compromise solution could be accepted by the decision makers because it provides a maximum group utility of the majority, and a minimum of the individual regret (represented by min R) of the opponent. The compromise solutions could be the basis for negotiations, involving the decision makers preference by criteria weights.

These two MCDM methods use different kinds of normalization to eliminate the units of criterion functions: the VIKOR method uses linear normalization, and the TOPSIS method uses vector normalization. The highest ranked alternative by VIKOR is the closest to the ideal solution. However, the highest ranked alternative by TOPSIS is the best in terms of the ranking index, which does not mean that it is always the closest to the ideal solution. In addition to ranking, the VIKOR method proposed a compromise solution with an advantage rate. They used a mountain climber example which chooses his important stuffs by ranking method. Balwinder Sodhi and Prabhakar T.V. [7] gave a simplified description of Fuzzy TOPSIS is presented. They have adapted the TOPSIS description from existing Fuzzy theory literature and distilled the bare minimum concepts required for understanding and applying TOPSIS. An example has been worked out to illustrate the application of TOPSIS for a multi-criteria group decision making scenario. They developed a 3 decision maker 2 alternative and 4 criteria model for ranking method.

4. Problem Statement

The problem statement of this paper is “Evaluating Pareto Front with TOPSIS and Fuzzy TOPSIS for Literacy Rates in Odisha”

- In a multi criteria decision making problem there are several criteria if the number of criteria could be minimized then the calculation could be easier and effective.
- Hence we introduce a method to form a Pareto front to minimize the number of several conflicting criteria so both the methods Pareto TOPSIS and Fuzzy TOPSIS method could work in a better way
- First we should minimize the number of criteria and then we rank several alternatives to show the best one chosen out of them and also the worst one.

5. Objective of the work In this work we present a MCDM based modified method to choose from several conflicting criteria using MOO method to generate Pareto front of a non dominated sorting and then fuzzy TOPSIS method is applied on chosen criteria to form a ranking of the alternatives. Here we are using district wise several literacy percentages of Odisha to show which the most literate district is. We are using the National Census data for calculation.

- Well-organized MCDM method for choosing the best alternative
- Less computational complexity
- Minimized the number of criteria
- Efficient and clear ranking of the alternatives

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6. Scope of the work

The fuzzy TOPSIS method is one the most flexible. According to the closeness coefficient, we can determine not only the ranking order but also the assessment status of all possible alternatives. In this method which we propose, we not only order the alternatives but also we determine the important criteria by using non dominated sorting for Pareto front. Significantly, this method provides more objective information for literacy of several districts of Odisha and evaluation of the whole Education Department of our state. The systematic framework for realistic data in a fuzzy environment presented here can be easily extended to the analysis of other management decision problems.

7. Preliminaries

MCDM can be applied for complex decisions when a lot of criteria are involved. There is a variety of MCDM methods developed as well as case studies of their application presented.

7.1. Steps of MCDM

a) Establishing system evaluation criteria that relate system capabilities to goals;
b) Developing alternative systems for attaining the goals (generating alternatives);
c) Evaluating alternatives in terms of criteria (the values of the criterion functions);
d) Applying a normative multi-criteria analysis method;
e) Accepting one alternative as ”optimal” (preferred);
f) If the final solution is not accepted, gather new information and go into the next iteration of multi-criteria optimization;

7.2 Description of steps

Here steps (a) and (e) are performed at the upper level, where decision makers have the central role, and the other steps are mostly engineering tasks. For step (d), a decision maker should express his/her preferences in terms of the relative importance of criteria, and one approach is to introduce criteria weights. These weights do not have a clear economic significance, but their use provides the opportunity to model the actual aspects of decision making (the preference structure). It is considered “importance weights” which represent the relative importance of criteria. Another approach is to introduce weights in a simple aggregating function (weighted sum), where weights reflect both criterion importance and measurement scale (”tradeoffs” weights). Since criteria usually are expressed in different units (no commensurable) it is difficult to determine the values of such weights. There are applications with “objective weights” determined from a performance matrix, and these have no relationship with preference of the decision maker.
In the engineering level, the main efforts are in generating and evaluating the alternatives (steps (b) and (c)); and these efforts are different for individual projects, since projects vary in the types of needs they meet or the problems they solve. The physical, environmental, and social settings in which planning takes place also differ from one location to another. Alternatives can be generated and their feasibility can be tested by mathematical models, physical models, and/or by experiments on the existing system or other similar systems. Constraints are seen as high-priority objectives, which must be satisfied in the process of generating alternatives. Generating alternatives can be a very complex process, since there is no general procedure or model, and no mathematical procedure could replace human creativity in generating and evaluating alternatives. However, after generating and evaluating the alternatives, a creative decision making method could be applied to rank alternatives and to propose a solution to the decision maker.

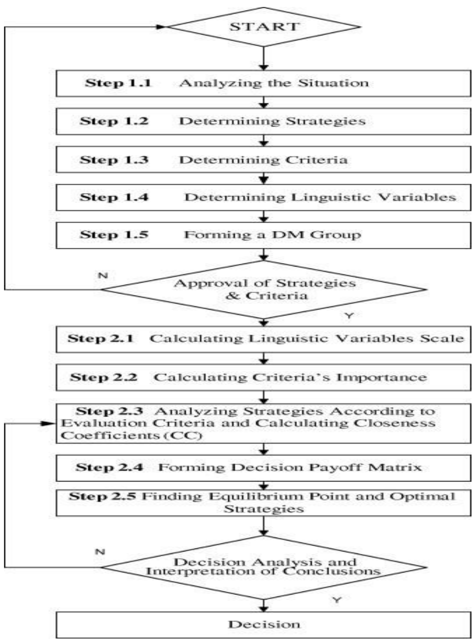

Figure 2:- Flow chart of decision making method showing all the steps

Multi-criteria optimization is the process of determining the best feasible solution according to the established criteria (representing different effects). Practical problems are often characterized by several no commensurable and conflicting (competing) criteria, and there may be no solution satisfying all criteria simultaneously. Thus, the solution is a set of non-inferior solutions, or a compromise solution according to the decision makers preferences [3].

7.3 Topsis

TOPSIS is a useful technique in dealing with multi- attribute or multi-criteria decision making (MADM/MCDM) problems in the real world. It helps decision maker(s) (DMs) organize the problems to be solved, and carry out analysis, comparisons and rankings of the alternatives. Accordingly, the selection of a suitable alternative(s) will be made. However, many decision making problems within organizations will be a collaborative effort. The basic idea of TOPSIS is rather straightforward. It originates from the concept a displaced ideal point from which the compromise solution has the shortest distance. Hwang and Yoon further propose that the ranking of alternatives will be based on the shortest distance from the (positive) ideal solution (PIS) and the farthest from the negative ideal solution (NIS) or nadir. TOPSIS simultaneously considers the distances to both PIS and NIS, and a preference order is ranked according to their relative closeness, and a combination of these two distance measures. According to Kim et. all and our observations, four TOPSIS advantages are

a) A sound logic that represents the rationale of human choice
b) A scalar value that accounts for both the best and worst alternatives simultaneously
c) A simple computation process that can be easily programmed into a spread sheet
d) The performance measures of all alternatives on attributes can be visualized on a polyhedron, at least for any two dimensions.

7.4 Topsis method

a) Obtain performance data for n alternatives over k criteria. Raw measurements are usually normalized, converting raw measures into standardized measures x_{ij} and s_{ij} by some methods sown in fig 2
b) Develop a set of importance weights wk, for each of the criteria. The basis for these weights can be anything, but, usually, is ad hoc reflective of relative importance. Scale is not an issue if standardizing was accomplished in Step a.
c) Identify the ideal alternative (extreme performance on each criterion) s+
d) Identify the nadir alternative (reverse extreme performance on each criterion) s−.
e) Develop a distance measure over each criterion to both ideal (D^+) and nadir (D^-).
f) For each alternative, determine a ratio R equal to the distance to the nadir divided by the sum of the distance to the nadir and the distance to the ideal

$$R = \frac{D^-}{D^- + D^+} \qquad \text{(eq. I)}$$

7.5. Fuzzy numbers and linguistic variables

The representation of multiplication operation on two or more fuzzy numbers is a useful tool for decision makers in the fuzzy multiple criteria decision-making environment for ranking all the candidate alternatives and selecting the best one [2]. Now some basic definitions of fuzzy sets, fuzzy numbers and linguistic variables are reviewed from Buckley and Kaufmann and Gupta are given below.

Definition 1: A fuzzy set a in a universe of discourse X is characterized by a membership function $\mu_{\tilde{a}}$(x), which associates with each element x in X, a real number in the interval [0, 1]. The function value $\mu_{\tilde{a}}$(x)is termed as grade membership of a in x.

Definition *2:*A fuzzy number is a fuzzy subset of the universe of discourse X that is both convex and normal. Fig. 4 shows a fuzzy number ~a in the universe of discourse X that conforms to this definition.

We use triangular fuzzy numbers [8]. A triangular fuzzy number ~a can be defined by a triplet a1; a2; a3. Its conceptual schema and mathematical form are shown by fig.3

$$\mu_{\tilde{a}}(x) = \begin{cases} 0, & x \le a_1, \\ \frac{x-a_1}{a_2-a_1}, & a_1 < x \le a_2, \\ \frac{a_3-x}{a_3-a_2}, & a_2 < x \le a_3, \\ 0, & x > a_3. \end{cases}$$

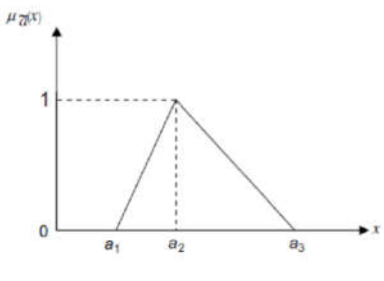

Figure 3:- A Triangular Fuzzy number and its definition

Definition 3:
A Trapezoidal fuzzy number is a fuzzy subset of the universe of discourse X that is both convex and normal. Fig. 5 shows a fuzzy number ~n in the universe of discourse X that conforms to this definition the membership function $\mu_{\tilde{a}}$(x) is defined in figure 4.

$$\mu_{\tilde{n}}(x) = \begin{cases} 0, & x < n_1, \\ \frac{x-n_1}{n_2-n_1}, & n_1 \leqslant x \leqslant n_2, \\ 1, & n_2 \leqslant x \leqslant n_3, \\ \frac{x-n_4}{n_3-n_4}, & n_3 \leqslant x \leqslant n_4, \\ 0, & x > n_4. \end{cases}$$

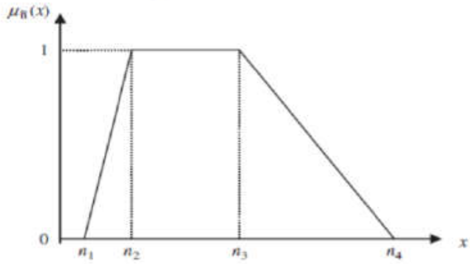

Figure 4:- A Trapezoidal Fuzzy number

7.5.2 Fuzzy Topsis Methods
In summation, an algorithm of the fuzzy decision-making method for dealing with the supplier selection is given as follows.

- **Step 1:** Form a committee of decisionmakers, and then identify the evaluation criteria.
- **Step 2:** Choose the appropriate linguistic variables for the importance weight of the criteria and the linguistic ratings for alternatives.
- **Step 3:** Aggregate the weight of criteria to get the aggregated fuzzy weight criterion C_j, and pool the decision-makers ratings to get the aggregated fuzzy rating of supplier A_i under criterion C_j.
- **Step 4:** Construct the fuzzy-decision matrix and the normalized fuzzy-decision matrix.
- **Step 5:** Construct weighted normalized fuzzy decision matrix.
- **Step 6:** Determine FPIS and FNIS.
- **Step 7:** Calculate the distance of each supplier from FPIS and FNIS, respectively.
- **Step 8:** Calculate the closeness coefficient of each supplier.
- **Step 9:** According to the coefficient, we can understand assessment status of each alternative and determine the ranking order of all alternatives.

8. Pareto Fuzzy Model and the Data Set. Here the working model of the paper is discussed and several criteria are summarized. A criteria can be defined by 2 values one is benefit and weight. Then Pareto graph is generated by Non Dominated Sorting method using approach one (naive and slow).for forming the non-dominated set. The steps of Non Dominated Sorting are written as follows:

- Step 1: Set all the non-Dominated sets by approach 1 P_j, (j = 1; 2; ::) as empty sets. Sets domination level counter j = 1.
- Step2: Use any one of the approaches 1 to 3 to find the non-dominated set P' of population P
- Step 3: Update $P_j = P'$ and P= P/P'
- Step 4: If $P \neq \emptyset$ increment j by one and go to step 2.and declare all non-dominated sets P_i, for i= 1,2…j.

Then we generate a graph showing the non-dominated set which is chosen criteria. Then the chosen criteria will participate in MCDM approach, after that the ordering is done. Proposed model is given below in figure 5.

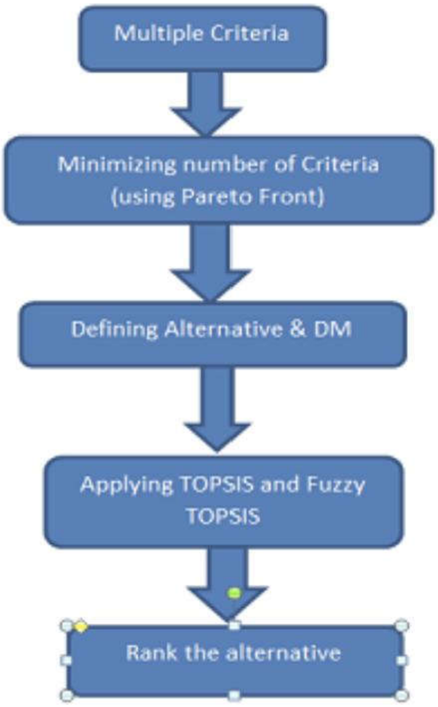

Figure 5:-Flow Graph of the Proposed Model.

8.1 Data Set

Here we have used the dataset of district wise several literacy percentages of Odisha [11]. This percentage rates are given by National Census (2000-2013). Odisha has 4.7percentage of India's landmass (8th largest state), 3.47percentage of the India population (11th largest),more than 480 km coast line(eastern coast) nearly about area of 155,707 square kilometers and total population about 4.19 (crores).

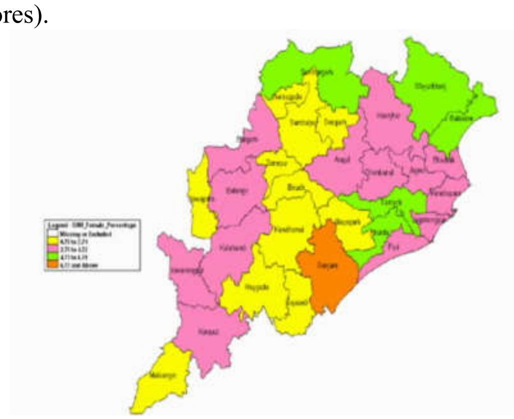

Figure 6:- Literacy distribution of Odisha.

But still we are not in good stage in literacy. As Education is one of the most essential part of our life and literacy reacts the development of one state. So considering the Literacy rates of Odisha we can show the best district in case of educational development and the worst one.

Sl No.	Name of the District/State	Literacy Rate (Rural)			Literacy Rate (Urban)			Literacy Rate (All classes)			Gender Disparity Index		
		Person	Male	Female	Person	Male	Female	Person	Male	Female	Rural	Urban	Total
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Angul	66.1	79.7	52.0	85.1	91.4	77.5	68.8	81.4	55.4	0.5590	0.4906	0.5483
2	Balasore	69.5	81.2	57.4	78.8	85.8	71.2	70.6	81.7	58.9	0.5048	0.3870	0.4932
3	Baragarh	62.7	76.5	48.6	79.2	87.7	70.1	64.0	77.4	50.3	0.5367	0.4845	0.5304
4	Bhadrak	74.3	85.4	63.0	70.4	78.9	61.4	73.9	84.7	62.9	0.5342	0.3708	0.5132
5	Bolangir	52.7	69.5	35.8	78.0	87.1	68.2	55.7	71.7	39.5	0.6125	0.4977	0.5881
6	Boudh	56.5	75.3	37.4	82.0	92.9	70.5	57.7	76.2	39.0	0.7085	0.7366	0.7000
7	Cuttack	73.6	84.3	62.5	84.7	89.7	78.9	76.7	85.8	66.9	0.5060	0.3658	0.4763
8	Deogarh	59.1	72.4	45.6	76.3	84.1	67.7	60.4	73.3	47.2	0.4959	0.4035	0.4883
9	Dhenkanal	68.0	79.5	56.1	84.1	90.8	76.7	69.4	80.6	57.9	0.4823	0.4776	0.4795
10	Gajapati	37.6	51.4	24.5	71.1	81.2	61.1	41.3	54.7	28.4	0.5126	0.4389	0.4832
11	Ganjam	56.5	72.2	41.3	79.7	88.2	70.6	60.8	75.2	46.4	0.5679	0.4956	0.5442
12	Jagatsinghpur	78.7	88.6	68.8	82.2	88.1	74.5	79.1	88.6	69.3	0.5477	0.4053	0.5352
13	Jajpur	71.0	81.6	60.1	81.7	88.4	74.3	71.4	81.9	60.8	0.4676	0.4195	0.4654
14	Jharsuguda	66.7	79.5	53.6	77.5	86.6	67.4	70.7	82.2	58.5	0.5265	0.4945	0.5145
15	Kalahandi	43.5	60.7	26.5	74.4	84.6	63.4	45.9	62.7	29.3	0.6317	0.5000	0.6076
16	Kandhamal	50.1	67.8	32.8	85.4	93.6	76.6	52.7	69.8	35.9	0.6353	0.6508	0.6162
17	Kendrapara	76.5	87.0	66.3	82.6	89.6	75.3	76.8	87.1	66.8	0.5309	0.4488	0.5270
18	Keonjhar	56.9	70.2	43.6	73.7	82.8	63.6	59.2	72.0	46.2	0.4840	0.4394	0.4757
19	Khurda	74.1	85.0	63.0	86.7	91.4	80.9	79.6	87.9	70.4	0.5213	0.3968	0.4858
20	Koraput	27.3	39.2	15.6	74.9	83.4	65.9	35.7	47.2	24.3	0.5415	0.4143	0.4457
21	Malkangiri	27.9	37.4	18.4	65.3	74.9	55.0	30.5	40.1	20.9	0.4223	0.3890	0.4042
22	Mayurbhanj	49.5	63.8	35.0	82.6	89.1	75.2	51.9	65.8	37.8	0.5146	0.4332	0.4990
23	Nabarangpur	31.3	44.6	18.0	73.7	83.1	63.5	33.9	47.0	20.7	0.5645	0.4525	0.5326
24	Nayagarh	69.8	82.2	56.7	85.6	92.4	78.0	70.5	82.7	57.6	0.5473	0.5334	0.5445
25	Nuapada	40.3	57.6	23.8	70.5	81.6	59.0	42.0	58.5	25.8	0.6384	0.4891	0.6074
26	Puri	77.3	88.2	66.3	81.9	87.5	75.9	78.0	88.1	67.6	0.5786	0.3488	0.5498
27	Rayagada	29.9	42.1	18.3	72.2	81.8	62.4	36.2	48.2	24.6	0.5130	0.4329	0.4557
28	Sambalpur	62.8	75.9	49.5	79.1	86.9	70.6	67.3	79.0	55.2	0.5062	0.4410	0.4852
29	Sonepur	61.7	78.1	44.7	77.3	88.6	65.0	62.8	78.9	46.2	0.6461	0.6200	0.6405
30	Sundargarh	55.3	67.4	43.1	82.5	89.0	75.0	64.9	75.3	53.9	0.4370	0.4322	0.4175
	ORISSA	59.8	72.9	46.7	80.8	87.9	72.9	63.1	75.4	50.5	0.4885	0.4333	0.4764
	Co efficient of Variation	27.2	21.2	37.2	6.9	5.0	9.6	24.4	18.9	33.2			

Source: Census of India

Figure 7: Literacy distribution of Odisha Table 1, source: Census India

So we can clearly visualize we have 30 alternatives (districts of Odisha) and 11 criteria

- C1:overall population
- C2:literacy rate of child(age between 714)for each district
- C3 :literacy rate of young(age between 15 to 24)for each district
- C4:literacy rate of person(age above 25)for each district
- C5 :literacy rate
- C6: Male literacy rate for each district
- C7: Female literacy rate for each district
- C8:literacy rate of rural area
- C9:literacy rate of urban area
- C10:child growth
- C11: Over all literacy for each district

And the alternatives are the 30 districts of Odisha state

- Baragadh
- Jharsuguda
- Sambalpur
- Deogargh
- Sundergarh
- Keonjhar
- Mayurbhanj
- Baleswar
- Bhadrakh
- Kendrapada
- Jagatsinghpur
- Cuttack
- Jajpur
- Dhenkanal

- Angul
- Nayagadh
- Khordha
- Puri
- Ganjam
- Gajapati
- Kandhamal
- Boudh
- Sonpur
- Bolangir
- Nuapada
- Kalahandi
- Rayagada
- Nabarangpur
- Koraput
- Malkanagiri

Here we are considering 1 decision maker as National Census is based upon real data so Census is one and only decision maker.

9. Simulation Results

First we considered weight and value matrix for drawing the Pareto Graph weights = [6 5 4 3 8 5 2 6 9 7 1] values = [2 5 6 3 4 7 8 1 9 1 8] Then we simulated the graph for generating pareto front Then we applied the algorithm of Non Dominated sorting form hand calculation we have found the Pareto graph, In first iteration we selected criteria C11 and C7 and in second iteration we selected C3 and C6 similarly C2,C9,C4 in 3rd iteration ,C1 and C5 in 4th, C8 C10 in 5th. For Pareto front we have considered 1st and 2nd iteration. So now we have C3, C6, C7, and C11 for generation the Ordering. So now we have 4 criteria and 30 alternatives. Then we simulated TOPSIS and Fuzzy TOPSIS. Then the graph is plotted.

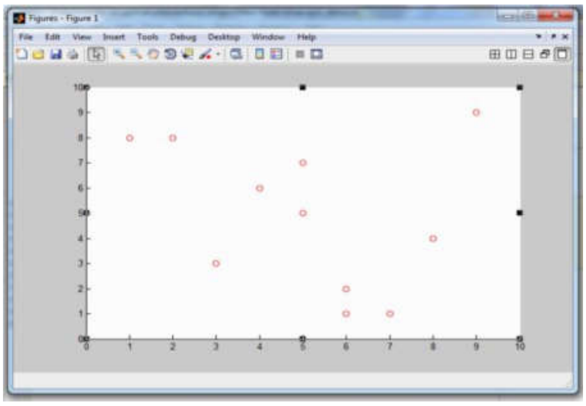

Figure 8:- Simulated Graph as per the Census data

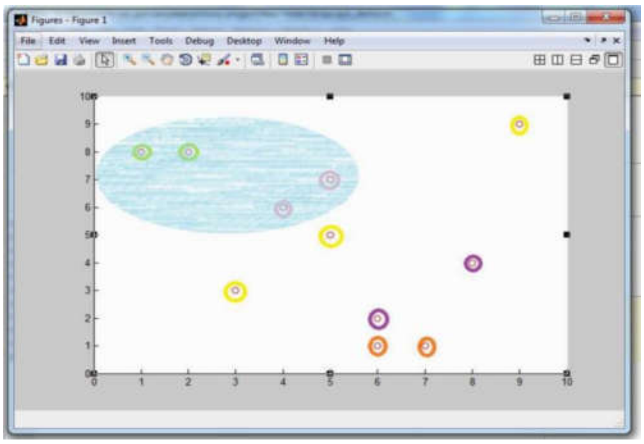

Figure 9:- Modified graph showing the selected criteria.

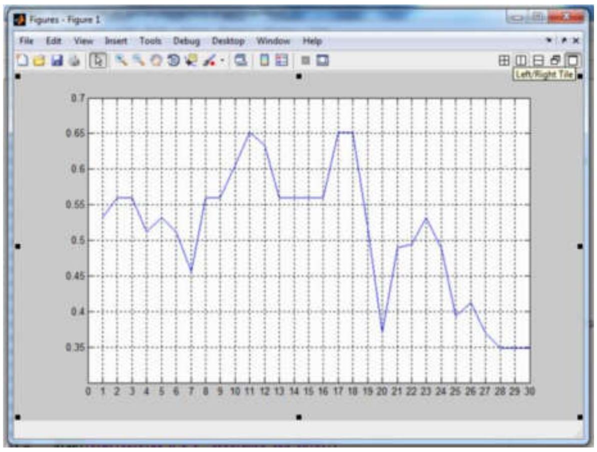

Figure 10:- Simulated Graph for TOPSIS

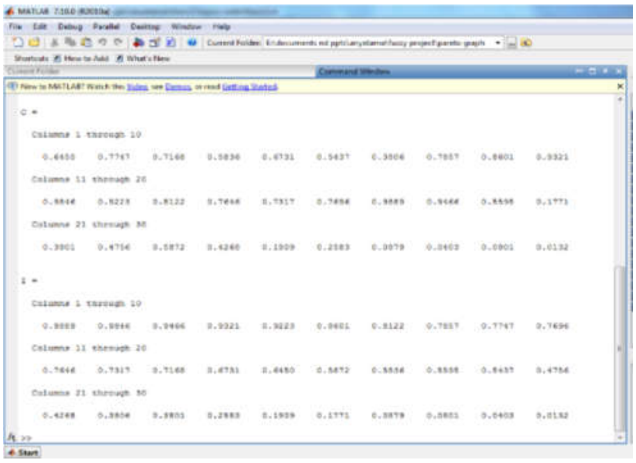

Figure 11:- Simulated Result for TOPSIS

10. Comparison of Result

Comparing both the Graphs and result we can say Fuzzy TOPSIS gives a generalized view of the ordering but TOPSIS gives more clear view of the result as the closeness values are more clear than that of Fuzzy TOPSIS. For Nabarangpur Koraput and Malkanagiri value it seems to have less different closeness value in Fuzzy TOPSIS. But in TOPSIS is more differentiated in these 3 values. But for a ly man view Fuzzy gives better knowledge. Simulated result for both the method is shown figure 10 and 11 and the comparative result is given in table 1.

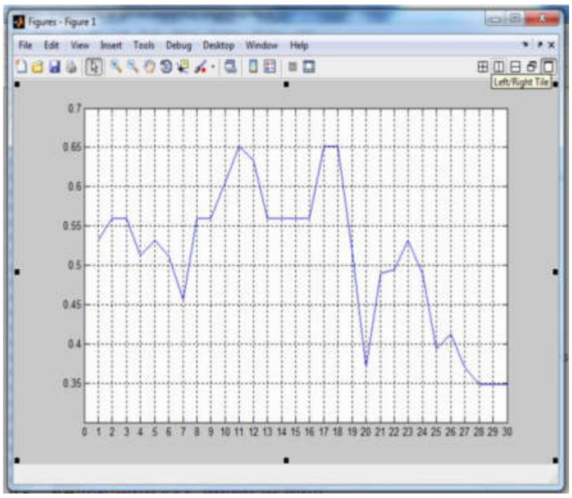

Figure 12:- Simulated graph for Fuzzy TOPSIS

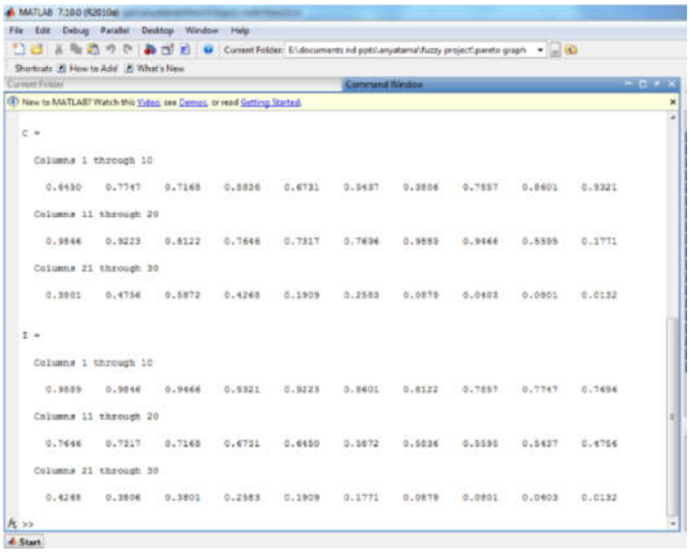

Figure 13:- Simulated Results for Fuzzy TOPSIS

Serial Number	Normal TOPSIS	Proposed Model with TOPSIS	Fuzzy TOPSIS
1	0.6486	0.6450	0.5319
2	0.6671	0.7747	0.5945
3	0.6486	0.7618	0.5494
4	0.5269	0.5836	0.5118
5	0.6486	0.6731	0.5139
6	0.4645	0.5437	0.5118
7	0.3335	0.3806	0.4570
8	0.7076	0.7857	0.5494
9	0.8418	0.8601	0.5494
10	0.8418	0.9321	0.5904
11	0.8498	0.9846	0.6354
12	0.8418	0.9223	0.6205
13	0.8418	0.8122	0.5494
14	0.6671	0.7647	0.5494
15	0.6555	0.7317	0.5494
16	0.6671	0.7696	0.5494
17	0.9535	0.9889	0.6354
18	0.8498	0.9466	0.5170
19	0.5269	0.5595	0.3852
20	0.1572	0.1771	0.4891
21	0.3338	0.3801	0.4960
22	0.4189	0.4756	0.5319
23	0.5269	0.5872	0.4891
24	0.3469	0.4260	0.3973
25	0.1572	0.1909	0.4159
26	0.2565	0.2583	0.3852
27	0.1634	0.1525	0.3756
28	0.0298	0.0403	0.3646
29	0.0465	0.0801	0.3646
30	0.0131	0.0132	0.3646

Table 1:- Result comparison

11. Conclusion and Future Work

Multi-criteria decision method is based on reliable indicators to determine the most feasible alternative. In dealing with practical problem, it is very important to select indicators and to determine the corresponding index weight. It integrates multiple indicators or various columns of a data matrix into a single meaningful result. MCDM method in continuous version is to compare the estimators from distributions in order to obtain the best one. TOPSIS is one of the most efficient method in MCDM and in addition with fuzzy it woks effectively as well as simples it. As fuzzy adds flexibility and eradicates crispness of data so it gives plenty of space to decision makers to give ratings for alternatives. As we know TOPSIS and Fuzzy TOPSIS are two robust, efficient and flexible algorithms for ordering the alternatives we applied some concept of MOO that is Pareto front generation. The Proposed model works for the Censor data set of literacy of Odisha and found in both the cases District Khurdha is the best alternative in case of literacy and Malkanagiri is the worst performed district. As the Female literacy of Khurdha district is approximately high and also the over all literacy is high. Here we can summarize that TOPSIS is efficient and if it is fuzzified then it gives good understanding of the problem. We have calculated the Pareto front in a generalized way with the help of Non Dominated sorting technique by hand calculation. There are so many algorithm which can form the Pareto front in a optimized way for a MOO problem as we know we can only form the Pareto graph after optimization. Study and application for some of the evolutionary algorithm to this method can be make it more efficient and also robust to form the Pareto front which can be left for future study.

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