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Alignment Modifications for the Link Canal by Adopting Remote Sensing and Verified by using MCDM (TOPSIS) Method

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Abstract In our country every year some of the regions are facing with heavy rainfall and the other regions are facing with lack of rain. As a part heavy rainfall regions are suffered with floods and the huge amount of the water is run off into the sea. At the same time the less rain fall regions are suffered with droughts and famines. To avoid all such type of problems NWDA (National Water Development authority) kept a proposal of interlinking of rivers. While the rivers are linking with one another there is some disturbance will be occur for the environment i.e, reserve forests, hilly terrains and human habitats will be affected. To minimize the degradation we suggested some diversions for the proposed (PENNAR TO CAUVERY) link canal. These suggestions are made through the remote sensing and verified through a mathematical tool. In identifying the diversions for a canal there is a multiple diversions have to face. From the multiple diversions the best alternative path was identified by using of TOPSIS (technique for order preference by similarity to ideal solution) method which gives the strength to the remote sensing assessment. Here we made eleven suggestions for the alignment. Through these modifications 25 villages and 5 tribal villages are benefitted. 39 sq.km. Reserve forest is going to be protected. 58 sq.km. hilly terrain is also benefitted without getting damage.

Keywords River linking, study area, command area.

I. INTRODUCTION

India has large amount of water resources, but their distribution is uneven due to the temperature differences and geological settings. Uneven rainfall and sudden down pore has been a regular phenomenon since more than a decade in the country. As a result, some regions are affected by frequent droughts and at the same time other parts are reeling under floods. In the very near future, water will become a scarce resource due to increasing thrust of population and industrial growth. Therefore, water should be harnessed at macro and micro levels with most scientific and efficient manner. Long distance inter-basin transfer of water from surplus basins to water deficit basins had been mooted in our country in order to reduce the imbalance in the water availability between various regions by K.L. Rao, in the year 1975 [1]. The Erstwhile union minister of irrigation, Central Water Commission (CWC) proposed national perspective plan (NPP) proposal for water resource development and later the Centre established NWDA in 1982 to give concrete shape to NPP by conducting scientific studies on inter-linking of rivers. A National Perspective Plan was formulated in the year 1980 by the Union Ministry of Irrigation and the Central Water Commission identifying a number of inter-basin water transfer links in respect of both Himalayan Rivers and Peninsular Rivers of the country. The inter-linking system of Mahanadi – Godavari – Krishna – Pennar – Cauvery – Vaigai – Gundar is one of the four parts of the Peninsular Rivers Development Component of the NPP. Amongst the Peninsular Rivers, as per National Water Development Agency studies show, the Mahanadi and the Godavari have sizeable quantum of water surplus after meeting the existing and projected requirements within the basins. It is, therefore, proposed to divert the surplus waters of the Mahanadi and the Godavari rivers to the water-short Krishna, the Pennar, the Cauvery and the Vaighai basins located towards south peninsula. Many researchers discussed on harvesting excess water in a basin and its pros and corns at length (Reddy [2]; Biyani & Gupta [3]; Radhakrishna [4]; Sharma [5]; Jain, Vijay Kumar & Panigraphy[6]; PrakasaRao et al, [7], [8], [9]; Bhaskar et.al, [10]).

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II. STUDY AREA

The study area of the Pennar (Somasila)-Cauvery (Grand Anicut) link canal is
17215.68 km2 which corresponds to the link canal and the command area. It is covered in 53 SOI sheets of 1:50,000 scales. The canal is bounded between 10˚43'57"N - 14˚36'52"N latitude and 78˚44'2"E - 80˚18'12"E longitude. Figure 1 shows the link canal (Center line), study area buffer of 20 km on both sides and the proposed command area. The Pennar-Palar-Cauvery Link Project lies in Andhra Pradesh and Tamil Nadu states. The existing Somasila dam is located just downstream of the confluence of Cheyyeru River and Kallettivagu River with Pennar River. Grand Anicut is located on the border of Tiruchchirappalli and Thanjavur districts of Tamil Nadu.

A. . Weighted Normalized Decision Matrix

III. METHODOLOGY

A. Submission of the paper

The proposed river link maps of peninsular component are downloaded from NWDA department site http:// nwda.gov.in/nwda/proposals/feasibility in jpg format.

These link canal alignment maps are geo-rectified prior to demarcation of study area for each link. In GIS, a buffer zone is generated at a width of 10 km on either side of the canal alignment to demarcate effective study area covering 20 km corridor in addition to the command area proposed under each link forms the present study area. The shaded part of the figure in each link indicates the command area proposed. Prior to digitization, the SOI maps of 1:50,000 scales have been scanned and geo- referenced in poly conic projection system. Later the maps have been registered to real world co-ordinates using ERDAS IMAGINE 9.1 software. Total 85 topo-sheets are studied and prepared subset maps per the study area polygon to each link canal (Fig.1). Topo-sheet mosaics are prepared for each link canal and topographical features are discussed as under after overlay of link alignment and area polygon. LISS-III images of IRS-P6 satellite data are Geo-referenced utilizing SOI data base. The study includes topography, drainage, geology and geomorphology with remote sensing data update in detail for each area of the canals. Land use/land cover, rocky outcrops and forest cover changes are derived from LISS-III data.

The process of finding the best alternative in a set of feasible alternatives is called as decision-making. In this, the problems which are taken into account from several criteria are named as multi-criteria decision making (MCDM) problems. In other words, decision-making frequently happens in a fuzzy environment where the available information is uncertain. So, In such situation, one of the well known MCDM method is presented named as TOPSIS (technique for order preference by similarity to ideal solution). TOPSIS method was first presented by Hwang and Yoon [11] . Moreover, the negative ideal is the one of worst attribute value. Chen and Hwang [12], developed the concept of TOPSIS using fuzzy numbers and also reviewed on existing methods which resolve fuzzy MCDM problems.

B. Construction of Fuzzy decision Matrix

Suppose that $A_1, A_2, ..., A_n$ be the n alternatives and $C_1, C_2, ..., C_n$ be the m criteria. Each alternative is evaluated with respect to m criteria. Let $D = \left[\tilde{x}_{ij}\right]_{m\times n}$ be the decision matrix where $\tilde{x}_{ij}$ be the i^{th} ($i = 1, 2, ..., m$) alternative with respect to j^{th} criteria ($j = 1, 2, ..., n$). Also $\tilde{x}_{ij}$ be the linguistic trapezoidal fuzzy number which represents as $\tilde{x}_{ij} = \left(a_{ij}, b_{ij}, c_{ij}, d_{ij}\right)$

The following matrix represents the decision matrix of each alternative with respect to each criteria:

$$D = \begin{array}{c} \\ A_1 \\ A_2 \\ \dots \\ A_m \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \dots & C_n \end{array} \\ \begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{12} & \dots & \tilde{x}_{1n} \\ \tilde{x}_{21} & \tilde{x}_{22} & \dots & \tilde{x}_{2n} \\ \dots & \dots & \tilde{x}_{ij} & \dots \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \dots & \tilde{x}_{mn} \end{bmatrix} \end{array}$$

where A_i is the i^{th} alternative with respect to each criteria C_j (j^{th} criteria)

C. Normalized Decision Matrix

The Normalized fuzzy decision matrix can be represented as;

$$\tilde{Q} = \left[\tilde{r}_{ij}\right]_{m\times n}$$

where $\tilde{r}_{ij} = \left(\dfrac{a_{ij}}{d_j^+}, \dfrac{b_{ij}}{d_j^+}, \dfrac{c_{ij}}{d_j^+}, \dfrac{d_{ij}}{d_j^+}\right)$

here $d_j^+ = \max_i d_{ij}$

D. Weighted Normalized Decision Matrix

Considering the different significance of each criteria, the weighted normalized fuzzy decision matrix can be represented as;

$$\tilde{V} = \left[\tilde{v}_{ij}\right]_{m\times n} \quad i = 1, 2, ..., m \ ; \ j = 1, 2, ..., n.$$

Where

$$\tilde{v}_{ij} = \tilde{r}_{ij} \times \tilde{w}_j$$

and $\tilde{w}_j = \left(w_{j1}, w_{j2}, w_{j3}, w_{j4}\right)$, $j = 1, 2, ..., n.$ is the fuzzy weight of each criterion.

E. Determine Fuzzy positive and Negative Ideal solutions

According to the weighted normalized fuzzy decision matrix, normalized positive trapezoidal fuzzy number can be approximate by the elements $\tilde{v}_{ij}$. Then, the FPIS (Fuzzy Positive Ideal Solution) A^+ FNIS (Fuzzy Negative Ideal Solution) A^- can be *defined as;*

$$A^+ = \left(\tilde{v}_1^+, \tilde{v}_2^+, ..., \tilde{v}_n^+\right)$$

$$A^- = \left(\tilde{v}_1^-, \tilde{v}_2^-, ..., \tilde{v}_n^-\right)$$

where

$$\tilde{v}_j^+ = \max_i \left\{v_{ij4}\right\}$$

and $\tilde{v}_j^- = \min_i \{v_{ij1}\}, i = 1,2,...,m \; ; j = 1,2,...,n$. In the index, v_{ij1} and v_{ij4} are the first and fourth numbers in the trapezoidal fuzzy number, respectively

F: Distance of each alternative from Fuzzy positive and negative Ideal solutions

Let $\tilde{A} = (a_1, b_1, c_1, d_1)$ and $\tilde{B} = (a_2, b_2, c_2, d_2)$ be trapezoidal fuzzy numbers then the traditional distance between them is;

$$d_v(\tilde{A}, \tilde{B}) = \sqrt{\frac{1}{6}\left[(a_1 - b_1)^2 + 2(a_2 - b_2)^2 + 2(a_3 - b_3)^2 + (a_4 - b_4)^2\right]}$$

Now, the distance of each alternative from A^+ and A^- can be calculated as;

$$d_i^+ = \sum_{j=1}^{n} d_v(\tilde{v}_{ij}, \tilde{v}_j^+), i = 1,2...,m,$$

$$d_i^- = \sum_{j=1}^{n} d_v(\tilde{v}_{ij}, \tilde{v}_j^-), i = 1,2...,m$$

where $d_v(\tilde{v}_{ij}, \tilde{v}_j^+)$ and $d_v(\tilde{v}_{ij}, \tilde{v}_j^-)$ is the distance between the trapezoidal fuzzy numbers

G: Calculate the closeness coefficient of each Alternative

The closeness coefficient of each alternative is denoted by cc_i and is defined as;

$$cc_i = \frac{d_i^-}{d_i^- + d_i^+}$$

H :Best Alternative

According to the coefficient cc_i value, the larger closeness coefficient has a higher level ranking order. So the best alternative has the maximum closeness coefficient cc_i.

IV. ENVIRONMENT IMPACT

An attempt is made to evaluate positive and negative impacts on infrastructure, settlements, land use / land cover, soils, forest and landforms in the study area due to the construction of the link canal. Quantifications are arrived at in each sphere by integrating data sets in GIS environment.

In addition to the above study, water logging areas and seepage zones are demarcated by integrating the thematic maps soils, slope and lineaments.

The link canal stretches between Somasila and Cauvery spanning a length of 483 km. running across the districts of Nellore and Chittoor in Andhra Pradesh and through Chengal pattu, North Arcot, South Arcot, Tiruchuralpalle and Thanjavur districts in Tamil Nadu. The location of the command area proposed is in Chengal Pattu and South Arcot districts. 53 SOI maps at a scale of 1: 50,000 and a total area of17,215 sq.km. is covered under the study area.

Alignment modification:

The canal passes through hilly terrains, reserve forest, crop lands as well as human habitats, causing greater damage to the mentioned above and to the environment equally. Inorder to overcome this problem, diversions at certain places have been suggested so that, damage to human habitats and reserve forest is reduced to the minimum.

Table-1.0

Path-1	(25,26.8,29.48,34)
Path-2	(24,25.4,26.68,27.2)
Path-3	(26,27.5,29.1,32)

The Normalized fuzzy decision matrix can be represented as;

$$\tilde{Q} = [\tilde{r}_{ij}]_{m \times n}$$

$$\left(\frac{25}{34}, \frac{26.8}{34}, \frac{29.48}{34}, \frac{34}{34}\right) = (0.73, 0.78, 0.86, 1)$$

$$\left(\frac{24}{34}, \frac{25.4}{34}, \frac{26.68}{34}, \frac{27.2}{34}\right) = (0.70, 0.74, 0.78, 0.80)$$

$$\left(\frac{26}{34}, \frac{27.5}{34}, \frac{29.1}{34}, \frac{32}{34}\right) = (0.76, 0.80, 0.85, 0.94)$$

Weighted Normalized Decision Matrix(7,9,9,9)

$$(0.73, 0.78, 0.86, 1) \times (7,9,9,9) = (5.14, 7.09, 7.80, 9)$$

$$(0.70, 0.74, 0.78, 0.80) \times (7,9,9,9) = (4.94, 6.72, 7.06, 7.2)$$

$$(0.76, 0.80, 0.85, 0.94) \times (7,9,9,9) = (5.35, 7.27, 7.70, 8.47)$$

$$A^+ = \{(9,9,9,9)\}$$ and

$$A^- = \{(4.94, 4.94, 4.94, 4.94)\}$$

Distance of each Alternative Fuzzy positive and negative Ideal solutions

nce o **Table-1.1(A)**

Path-1	$d(\tilde{A}_1, A^+)$	1.5321
Path-2	$d(\tilde{A}_2, A^+)$	2.233
Path-3	$d(\tilde{A}_3, A^+)$	1.92

Table-1.1(B)

Path-1	$d(\tilde{A}_1, A^-)$	2.3836
Path-2	$d(\tilde{A}_2, A^-)$	1.782
Path-3	$d(\tilde{A}_3, A^-)$	2.450

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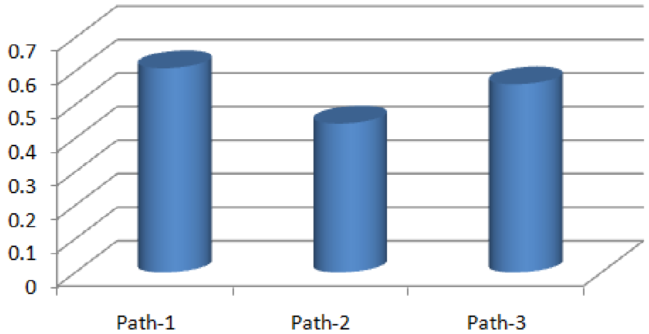
Table-1.1(C)

	D+	D-	$cc_i = \frac{d_i^-}{d_i^+ + d_i^-}$
Path-1	1.5321	2.3836	0.60872
Path-2	2.233	1.782	0.44383
Path-3	1.92	2.450	0.56064

The largest closeness coefficient refeers the best alternative path. Hence path -1 is best alternative path.



Since the original alignment is cutting across a hilly terrain in Dakkali mandal, a change in the direction of the original alignment is suggested from Alturupadu mandal and this diversion meets the original alignment at Palemkota in Venkatagiri mandal. The original length of the canal at this point is7.38km.,the right diversion is 8.97km. and the left diversion is 8.8km.wherein the right diversion only will exist since the left diversion and the original alignment are passing through a hilly terrain.

Table-1.2

Decision Matrix	Normalized Decision Matrix	Weighted Normalized Decision matrix	D+	D-	cci
(5.5,7.3,8.97,10.5)	(0.5,0.66,0.81,0.95)	(3.5,5.97,7.33,8.5)	2.23	3.4	0.6071
(5.3,6.4,7.38,8)	(0.48,0.58,0.67,0.72)	(3.37,5.23,6.03,6.54)	3.37	2.32	0.407733
(7.2,8,8.8,11)	(0.65,0.72,0.8,1)	(4.58,6.54,7.2,9)	2.3	3.1	0.592734

Form the above table the closeness coefficient of the path-1 is 0.6071. There fore Path-1 is the best alternative path on the fuzzy project network. And it also supports the diversions proposed previously. Another diversion to the original alignment is suggested beyond Devarakona which fuses with the original alignment again after Kuntakalva. The actual length of the original alignment is 9.3km.whereas the right diversion has a length of 10.3km.and the left diversion stretches to a length of 10.1km.As the left diversion and the actual path are passing through a hilly terrain, the right diversion is suggested.

Table-1.3

Decision Matrix	Normalized Decision Matrix	Weighted Normalized Decision matrix	D+	D-	CCI
(7.8,9.5,10.3,12)	(0.53,0.65,0.71,0.82)	(3.76,5.89,6.39,7.44)	1.52	2.70	0.639
(7.1,8.7,9.3,10)	(0.48,0.6,0.64,0.68)	(3.42,5.4,5.77,6.20)	2.52	3.07	0.549195
(8.2,9,10.1 ,14.5)	(0.56,0.62,0.69,1)	(3.95,5.58,6.26,9)	1.42	2.12	0.5988

Form the above table the closeness coefficient of the path-1 is 0.639. There fore Path-1 is the best alternative path on the fuzzy project network which supports the diversions proposed earlier. The original alignment once again intersects Velikonda hill and the protected forest near Krishnapuram, because of which a much larger digression is advocated for from Uppukonda, close to Gollapalle village in Srikalahasti mandal and moves across a 140 km long contour and links up with the original alignment near Vikrutamala village in Yerpedu mandal. At this point the original path length is 23.72km.the right and left diversions are 28.31km. and 28.1km. respectively. Although the right diversion since lengthy, it is suggested to save the resereve forest from being degraded in the original path.

Table-1.4

Decision Matrix	Normalized Decision Matrix	Weighted Normalized Decision matrix	D+	D-	cci
(25.5,26.7,28.31,30)	(0.79,0.83,0.88,0.93)	(5.57,7.50,7.96,8.43)	1.51	2.84	0.6534
(22,22.8,23.72,25.2)	(0.68,0.71,0.74,0.78)	(4.8,6.41,6.67,7.08)	2.54	1.65	0.393795
(25.8,27.2,28.1,32)	(0.80,0.85,0.87,1)	(5.64,7.65,7.90,9)	2.06	3.2	0.608365

Form the above table the closeness coefficient of the path-1 is 0.6534. There fore Path-1 is the best alternative path on the fuzzy project network which supports the modifications to the alignment. The original alignment navigates through the reserve forest of Narayanavanam of the same mandal and thus an alteration in the original alignment is put forward from Suddakaka village and becomes fused with the original alignment in proximity of Ramakrishnapuram to circumvent the forest area. Whereas the lengths are 12.54km.,15.36km. and 15.1km.respectively for the original and the right and left alignments. Here the right side diversion is prefrable to decrease the degradiation of forest.

Table-1.5

Decision Matrix	Normalized Decision Matrix	Weighted Normalized Decision matrix	D+	D-	cci
(12.5,14.2,15.36,17)	(0.68,0.77,0.83,0.92)	(4.78,6.98,7.55,8.36)	1.85247	2.3645	0.560711
(11,12,12.54,14)	(0.60,0.65,0.68,0.76)	(4.20,5.90,6.16,6.88)	1.7524	1.770249	0.502533
(14.3,15.2,15.1,18.3)	(0.78,0.83,0.84,1)	(5.46,7.47,7.62,9)	1.81012	2.14214	0.541772

By determining the closeness coefficient of paths using the TOPSIS method path-1 is prefarable because whose closeness coefficient is the largest that is 0.560711. This supports the right side of diversion of the canal alignment. Then the alignment crosses over a hilly terrain (400 m elevation) close to Krishnasamudram village of Nagari mandal. This can be sidestepped by an amendment in the direction of the alignment from Krishnasamudram to Pentakandigai in Chengalpattu Taluk. For this modification the original length is 12.7km., the left and right side diversions are 16.96km. and 16.7km. respectively. To avoid hilly terrain in the path left side diversion is proposed.

Table-1.6

Decision Matrix	Normalized Decision Matrix	Weighted Normalized Decision matrix	D+	D-	cci
(14.8,16.2,16.96,18.5)	(0.71,0.77,0.81,0.88)	(4.98,7.00,7.33,8.0)	1.1749	3.177	0.730
(11.6,12.1,12.7,13.8)	(0.55,0.58,0.61,0.66)	(3.90,5.23,5.49,5.97)	1.6864	2.4135	0.58867
(14.2,15.6,16.7,20.8)	(0.68,0.75,0.80,1)	(4.77,6.75,7.22,9)	2.2596	4.267	0.65378

As the closeness coefficient of the path-1 is 0.730 which is larger comparing with the other paths. It is suggested as the best alternative path and supports the left side diversion of the canal alignment.

Near this end point of the diversion, yet another modification could be carried out to detour 2 hillocks.

The lengths are 4.24km. (original),4.1km.(right) and 4.38km(left). Wherein the left diversion is suggested to avoid the cutting of two hillocks.

Table-1.7

Decision Matrix	Normalized Decision Matrix	Weighted Normalized Decision matrix	D+	D-	cci
(3.2,3.8,4.1,6.7)	(0.56,0.56,0.611,1)	(3.97,5.10,5.50,9)	2.611941	3.032173	0.537227
(3,3.7,4.24,4.6)	(0.44,0.55,0.63,0.68)	(3.13,4.97,5.69,6.17)	3.696518	4.437482	0.545547
(3.1,3.74,4.38,5.4)	(0.46,0.55,0.65,0.80)	(3.23,5.02,5.88,7.25)	3.8471	4.6174	0.545502

Though the closeness coefficient of the original path and the left diversion are almost equal the left diversion is preffered to save the hillocks as per the suggested modifications. A small diversion is suggested from the village of Nattam in Tiruthani Taluk bonds with the original alignment at Padmapuram And the lengths of the original path and the assumed diversions are 5.51km.,6.12km. and 6.39km. to avoid the hilly terrrain which exists in the original and right side diversions, the left side diversion is suggested.

Table-1.8

Decision Matrix	Normalized Decision Matrix	Weighted Normalized Decision matrix	D+	D-	cci
(4.5,5.5,6.12,9.9)	(0.45,0.55,0.61,1)	(3.18,5,5.56,9)	2	3.258485	0.619662
(4.2,4.8,5.51,5.8)	(0.42,0.48,0.55,0.58)	(2.96,4.36,5.00,5.27)	1.33165	1.76835	0.570435
(4.9,5.7,6.39,7.5)	(0.49,0.57,0.64,0.75)	(3.46,5.18,5.80,6.81)	1.478676	2.5547	0.63339

As the closeness coefficient of the path-3 is 0.63339 which is the largest, it is suggested as the best alternative path in support to the previous modifications suggested. As the original alignment cuts through the town of Arakkonam, a small alteration in the direction of the alignment from Kaimur village to Perumuchchi is advised. The lengths of the canal here are original 5.94km. right side diversion 6.98km. and the left diversion 7.17 km. inorder to save the town, the left side diversion is prefered as the original path and the right side diversion cut through the town.

Table-1.9

Decision Matrix	Normalized Decision Matrix	Weighted Normalized Decision matrix	D+	D-	cci
(4.8,5.4,6.98,9)	(0.53,0.6,0.77,1)	(3.73,5.4,6.98,9)	1.9854	3.9471	0.665335
(4.8,5.5,5.94,6.4)	(0.53,0.66,0.66,0.71)	(3.73,5.5,5.94,6.4)	1.31185	2.448148	0.651104
(6.4,6.4,7.17,8.3)	(0.71,0.711,0.79,0.92)	(4.97,6.4,7.17,8.3)	1.4571	3.5241	0.70748

As the closeness coefficient of the path-3 is larger it is suggested as the best alternative path which strengthens the proposals of modification. Near Sittur village, another small diversion is advocated so that 3 villages are bypassed and the original alignment is met at Pullalur village (Figure 7.1c). the lenghts of the canal alignment and suggested diversions are 3.55km., 3.9km, and 3.1km. respectively. The right diversion is suggested here to avoid the submerging of villages.

Table-1.10

Decision Matrix	Normalized Decision Matrix	Weighted Normalized Decision matrix	D+	D-	cci
(2.5,3.3,3.9,4.9)	(0.46,0.61,0.72,0.90)	(3.24,5.5,6.5,8.16)	2.6748	3.985427	0.598392
(2.8,3.2,3.55,3.9)	(0.51,0.59,0.65,0.72)	(3.62,5.33,5.91,6.5)	2.397737	3.572263	0.598369
(2.1,2.6,3.1,5.4)	(0.38,0.48,0.57,1)	(2.72,4.33,5.16,9)	2.296296	3.274485	0.587796

Form the above table the closeness coefficient of the path-1 is 0.598392.which is the largest. There fore Path-1 is the best alternative path on the fuzzy project network. And it also supports the diversions proposed previously.Similarly, another change in the alignment is suggested to evade 3 villages which are spanned by the original alignment between the villages' katteri and kalpakkam. In this modification the length of the original alignment is 5.57km. and proposed right and left diversions are 5.78km. and 5.6km. respectively. Wherein the right side diversion is proposed to save the villages from being submerged.

Table-1.11

Decision Matrix	Normalized Decision Matrix	Weighted Normalized Decision matrix	D+	D-	CCI
(4.1,4.9,5.78,6.4)	(0.60,0.72,0.85,0.94)	(4.22,6.48,7.65,8.47)	2.2647	2.9013	0.5614
(4.5,5,5.57,6.1)	(0.66,0.73,0.81,0.89)	(4.63,6.61,7.37,8.07)	2.0220	2.7779	0.42126
(4.7,5.1,5.6,6.8)	(0.69,0.79,0.88,1)	(4.83,7.14,7.94,9)	2.3088	3.3375	0.408902

Form the above table the closeness coefficient of the path-1 is 0.5614. There fore Path-1 is the best alternative path on the fuzzy project network. And it also supports the diversions proposed previously.

V. CONCLUSION:

Here we are suggested up to 11 alignment modifications to avoid degradiation of reserve forest, hilly terrains and human habitates without damaging the environmental and ecosystems. These suggestions are given by the remotesensing techniques and verified by adopting a mathematical approach which gives the strength to those suggestions. By modifying the alignment, it is noted that 21 villages are being saved. The modification effects save approximately 39 sq·km area of reserved forest which was to be lost before the alignment was modified. Hilly terrain of 58 sq·km area remains intact due to the modification and the burden of cutting and flattening of this terrain can be saved, which proves to be cost effective for that reason.

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