Decision making using Analytical hierarchy process in Ambika river basin

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Abstract - The multi-criteria programming made through the use of the analytic hierarchy process is a technique for decision making in complex environments in which many variables or criteria are considered in the prioritization and selection of alternatives or projects.

Index Terms – Analytical hierarchy process, Multi criteria decision making (MCDA)

1. Introduction

AHP was developed in the 1970s by Thomas L. Saaty and has since been extensively studied, and is currently used in decision making for complex scenarios. The application of AHP begins with a problem being decomposed into a hierarchy of criteria so as to be more easily analyzed and compared in an independent manner (Exhibit 2). After this logical hierarchy is constructed, the decision makers can systematically assess the alternatives by making pair-wise comparisons for each of the chosen criteria. This comparison may use concrete data from the alternatives or human judgments as a way to input subjacent information (Saaty, 2008).

2. Step to conduct AHP

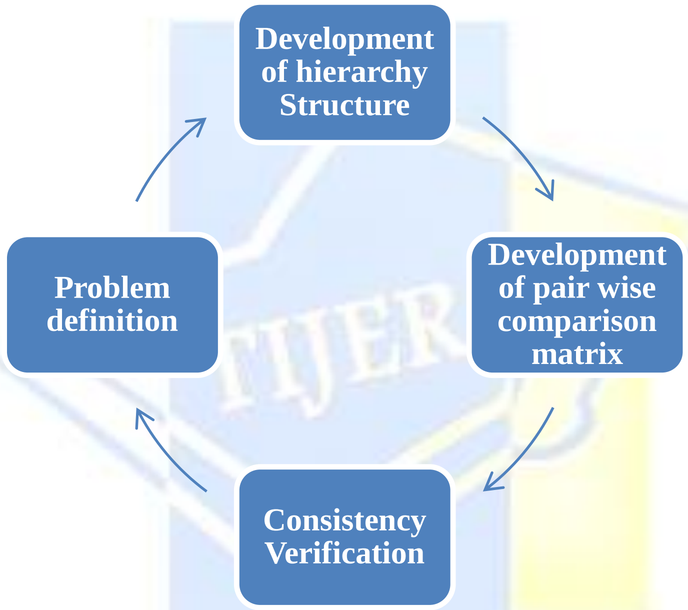

Figure 1 General Methodology of the AHP technique

Step 1: Problem definition
For the flood hazard assessment seven parameters are used in the ArcGis. Aim of the modifying the weights is to give the best and effective weights based on the study area which may improve the accuracy.

Step 2: Development of hierarchy Structure
Many factors effect on the flood hazard assessment, which is shown in Figure. After developing the hierarchy structure questionnaire responses are analyses using the table 1 Saaty's scale

The Comparison Scale (SAATY scale)
The comparison between two elements using AHP can be done in different ways, the relative importance scale between two alternatives as suggested by Saaty (SAATY, 2005) is the most widely used. Attributing values that vary from 1 to 9, the scale determines the relative importance of an alternative when compared with another alternative, as we can see in Table 1.

Table 1 Saaty's Scale of Relative Importance (Saaty, 2005)

Scale	Numerical rating	reciprocal
Extremely preferred	9	1/9
Very strong to extremely	8	1/8
Very strongly preferred	7	1/7
Strongly to very strongly	6	1/6
Strongly preferred	5	1/5
Moderately to strongly	4	1/4
Moderately preferred	3	1/3
Equally to moderately	2	1/2
Equally preferred	1	1

Step 3: Development of pair wise comparison matrix

Development of pair wise comparison matrix is very important step of the AHP technique. A pair wise comparison matrix of size n × n is constructed. For each level of the hierarchy, the pair-wise comparison generates a matrix of relative rankings. The number of matrices needed, depends on the number of elements at each level. The arithmetic means of all 50 responses in the form of pair wise comparisons are calculated and compiled into a single matrix, which is described in Table 2 and Table 3 includes the calculation procedure for the pair wise comparison matrix.

Table 2 Arithmetic mean values from the responses

	Slope	**Elevation**	**Rainfall**	**Soil**	**Distance from River**	**Drainage Density**	**Land use Land cover**
Slope	**1.00**	3.784160998	3.9340023	1.0936054	2.967891156	2.914829932	1.163356009
Elevation	**0.26**	**1.00**	2.9799546	1.1586848	1.257142857	2.496054422	0.820589569
Rainfall	**0.25**	**0.34**	**1.00**	2.1495798	1.110929705	1.953197279	0.886621315
Soil	**0.91**	**0.86**	**0.47**	**1.00**	1.215639832	1.401451247	1.038367347
Distance from River	**0.34**	**0.80**	**0.90**	**0.82**	**1.00**	2.566984127	1.016716553
Drainage Density	**0.34**	**0.40**	**0.51**	**0.71**	**0.39**	**1.00**	1.196190476
Landuse Landcover	**0.86**	**1.22**	**1.13**	**0.96**	**0.98**	**0.84**	**1.00**

Table 3 Sum of respective parameter in the columns

	Slope	Elevation	Rainfall	Soil	Distance from River	Drainage Density	Land use Land cover
Slope	**1.00**	3.784160998	3.9340023	1.0936054	2.967891156	2.914829932	1.163356009
Elevation	**0.26**	**1.00**	2.9799546	1.1586848	1.257142857	2.496054422	0.820589569
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Landuse Landcover	**0.86**	**1.22**	**1.13**	**0.96**	**0.98**	**0.84**	**1.00**
Sum	3.97	8.40	10.92	7.90	8.92	13.17	7.12

Table 4 Relative normalized matrix

	Slope	Elevation	Rainfall	Soil	Distance from River	Drainage Density	Land use Land cover
Slope	0.2517	0.4506	0.3603	0.1384	0.3325	0.2213	0.1634
Elevation	0.0665	0.1191	0.2729	0.1466	0.1409	0.1895	0.1152
Rainfall	0.0640	0.0400	0.0916	0.2721	0.1245	0.1483	0.1245
Soil	0.2302	0.1028	0.0426	0.1266	0.1362	0.1064	0.1458
Distance from River	0.0848	0.0947	0.0824	0.1041	0.1120	0.1949	0.1428
Drainage Density	0.0864	0.0477	0.0469	0.0903	0.0436	0.0759	0.1680
Landuse Landcover	0.2164	0.1451	0.1033	0.1219	0.1102	0.0635	0.1404

Table 5 Finding out criterion weights

	Slope	Elevation	Rainfall	Soil	Distance from River	Drainage Density	Land use Land cover	**Criteria weights**
Slope	0.2517	0.4506	0.3603	0.1384	0.3325	0.2213	0.1634	0.2740
Elevation	0.0665	0.1191	0.2729	0.1466	0.1409	0.1895	0.1152	0.1501
Rainfall	0.0640	0.0400	0.0916	0.2721	0.1245	0.1483	0.1245	0.1236
Soil	0.2302	0.1028	0.0426	0.1266	0.1362	0.1064	0.1458	0.1272
Distance from River	0.0848	0.0947	0.0824	0.1041	0.1120	0.1949	0.1428	0.1165
Drainage Density	0.0864	0.0477	0.0469	0.0903	0.0436	0.0759	0.1680	0.0798
Land use Land cover	0.2164	0.1451	0.1033	0.1219	0.1102	0.0635	0.1404	0.1287

Step 4: Consistency Verification

Some degree of inconsistency may emerge due to personal or subjective judgments. For the performance checking consistency is a main step. It suggests that given weights are applicable or not. Consistency is determined by the consistency ratio (CR). For a given order of the matrix, the Consistency Ratio (CR) is the ratio of the Consistency Index (CI) to the Randomness Index (RI). Table 6 and 7 includes the general calculation steps for the consistency checking.

After calculating the values of table 7, weighted sum is found out using the example shown below and it is included in table 8. Weighted sum value is the sum of all column values in respective rows.

For slope,

0.274+0.568+0.486+0.139+0.345+0.232+0.149 = 2.193

Similar Calculation for all the parameters.

Table 6 Weight Sum value

	Slope	Elevation	Rainfall	Soil	Distance from River	Drainage Density	Land use Land cover	**Weighted sum value**
Slope	0.27404357	0.568053796	0.4860677	0.1391325	0.345902423	0.232694671	0.1497055	2.195600135
Elevation	0.07125133	0.150113538	0.3681898	0.1474122	0.146517759	0.199263277	0.105596886	1.188344759
Rainfall	0.06851089	0.051038603	0.1235555	0.2734775	0.129476877	0.155926284	0.114094126	0.916079784
Soil	0.24937965	0.129097643	0.0580711	0.1272237	0.141680655	0.111879679	0.133621438	0.950953849
Distance from River	0.09317481	0.12009083	0.1112	0.1043234	0.116548217	0.204925688	0.130835323	0.881098262
Drainage Density	0.09317481	0.060045415	0.0630133	0.0903288	0.045453805	0.079831303	0.153930776	0.585778247
Landuse Landcover	0.23567747	0.183138516	0.1396177	0.1221348	0.114217253	0.067058295	0.128684168	0.990528174

Ratio is found out from the weighted sum value and the criteria weights in respective rows which is mentioned in table 4.

Table 7 Ratio Calculation

	slope	**elevation**	**rainfall**	**soil**	**Distance from Main River**	**Drainage Density**	**LULC**	**WEIGHTED SUM VALUE(1)**	**CRITERIA WEIGHTS (2)**	**RATIO (1/2)**
Slope	0.27404357	0.568053796	0.4860677	0.1391325	0.345902423	0.232694671	0.1497055	2.195600135	0.2740	8.011865
Elevation	0.07125133	0.150113538	0.3681898	0.1474122	0.146517759	0.199263277	0.105596886	1.188344759	0.1501	7.916306
Rainfall	0.06851089	0.051038603	0.1235555	0.2734775	0.129476877	0.155926284	0.114094126	0.916079784	0.1236	7.414318
Soil	0.24937965	0.129097643	0.0580711	0.1272237	0.141680655	0.111879679	0.133621438	0.950953849	0.1272	7.47466
Distance from main River	0.09317481	0.12009083	0.1112	0.1043234	0.116548217	0.204925688	0.130835323	0.881098262	0.1165	7.559946
Drainage Density	0.09317481	0.060045415	0.0630133	0.0903288	0.045453805	0.079831303	0.153930776	0.585778247	0.0798	7.337701
LULC	0.23567747	0.183138516	0.1396177	0.1221348	0.114217253	0.067058295	0.128684168	0.990528174	0.1287	7.697359

After calculating the ratio computation of eigen value λmax is find out. Now, to Calculate. λmax,

$\lambda max = \frac{8.012+7.916+7.413+7.475+7.560+7.337+7.697}{7} = 7.630$

Step 4(a): Consistency Index Calculation

Consistency Index is finding out using the values of the λmax and the size of the matrix.

Consistency Index (CI)= $\frac{\lambda\ \mathrm{max} - \mathrm{n}}{n-1}$

Here λmax = 7.630, n= number of criteria=7 So, CI=0.105

Step 4(b): Consistency Ratio Calculation

Consistency Ratio (CR) = $\frac{\text{Consistency Index (CI)}}{\text{Randomness Index (RI)}}$

RI values calculated from the table 11 of Random consistency value which is given by the Saaty 1980.

From the equation CR = 0.105 / 1.35 = 0.0777 < 0.10

From the AHP methodology Consistency Ratio < 0.10 so no need to change the weights or the weights are appropriate for the study. After completing all the methodology steps of the AHP weights of the all parameters mentioned in the table 11.

3. Result

Put all weights in flood hazard map and creating final flood hazard map of Ambika river.

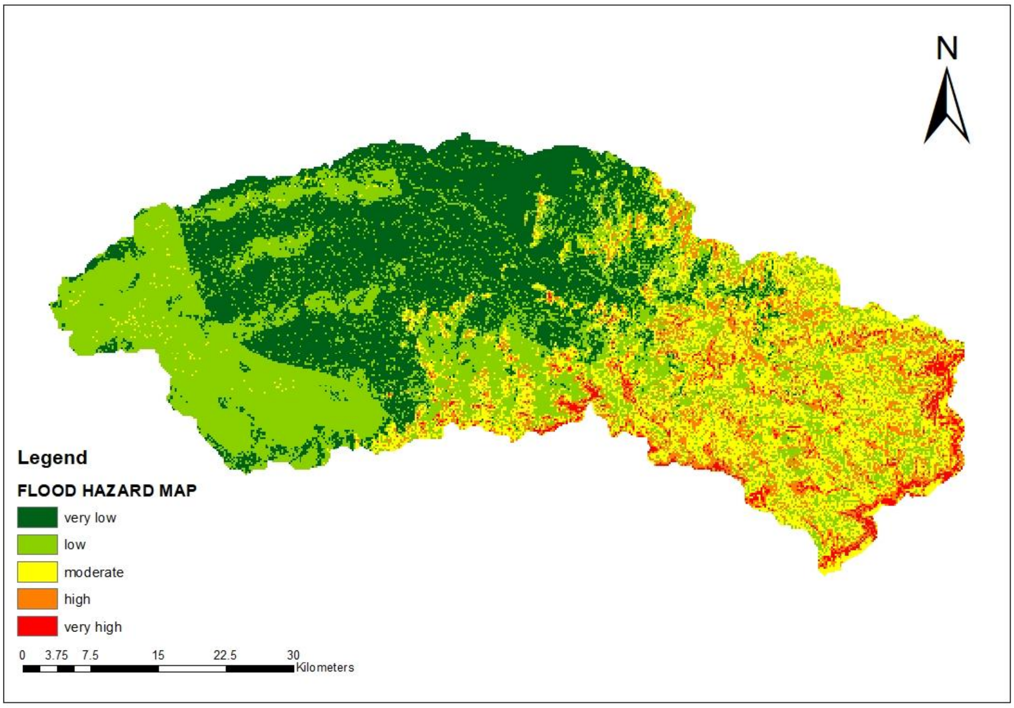

Figure 2 flood hazard map

4. Conclusion

The study is focused on the gis technique and explain the importance of this technology. From the above study we have to find different parameter weights of our study area and creating flood hazard map using ArcMap 10.8 software.

5. References

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