

AN ANALYTIC HIERARCHY PROCESS MODEL TO PRIORITIZE THE ELECTORAL PARTIES

¹Sakshi Aggarwal

¹MTech Software Engineering

¹School of Computing Science and Engineering

¹Galgotias University, Greater Noida, India

Abstract: Elections are the cardinal part of any democratic country. During elections, many journalists as well as the advisers start discussion about each political party in different aspects. Some evaluate their performance by emphasizing over areas like criminal offense, law and order while some focuses over economic condition, literacy rate, etc. But the conclusion of their debate is somehow not fruitful for the voters. From the perspective of the voters, which electoral party supposed to come into power has remain a matter of concern. Therefore, we try to build a framework using AHP tool for bridging the gap between expert's advice and voter's uncertainties. This paper aims to highlight the fundamentals of AHP model and how we can utilize its significance in political background.

Index Terms -Politics and Decision-Making; Analytic Hierarchy Process.

I. INTRODUCTION

1.1 Politics and Decision-Making

Decision-making theory in the area of politics is somehow not manageable easily. It seems the citizens giving the country for 5 consecutive years to the hands of one reliable party to govern the nation effectively. Their expectations raises with the excellent performance of the government in the power but the expectations are let down when they are not willing to deal with the issues or accept the reality. That is why voters are always conscious in making precise judgements when it comes to assess the political parties on the basis of multiple criteria.

The paper is intended to propose a model based on Analytic Hierarchy Process (AHP) [1] for handling the conflicts among the perspective of voters and expert's judgements. The following section underlines the fundamentals and relevance of AHP in making complex decisions.

1.2 Analytic Hierarchy Process (AHP)

AHP is considered as analogous to decision-making theory. It is a popular tool because,

- Open-source package [2].
- Probability theory is the core part.
- Steps of computation are easy to understand.
- Results are summarized and visualized in the tabular format.

The AHP algorithm [1] is mainly summarized into 6 following steps:-

- 1) Decompose the problem statement into goal, criteria, sub-criteria and alternatives.
- 2) Prepare the preference matrix of criteria and sub-criteria.
- 3) Assign the scores to alternatives for each defined criterion.
- 4) Compute the weights for all the criteria as well as alternatives.
- 5) Evaluate the global priority.
- 6) Prioritize the alternatives according to their evaluated priorities.

We identify the relevance of AHP in the political application. The AHP model in this research is described with the case study of UP Assembly Elections in 2012. The structure is relied on several parameters such as GSDP, Agriculture, Industry, Crime and Literacy Rate. Also there are sub-criteria with respect to Crime such as Riots, Kidnapping and Abduction, Rape and Murder. Similarly for Literacy Rate, there are two sub-criteria i.e. Male Literacy Rate and Female Literacy Rate. During Uttar Pradesh 2012 assembly elections, the two emerging state parties were Bahujan Samaj Party (BSP) and Samajwadi Party (SP). There was a fierce competition

between those two parties. Therefore, we have taken the SP and BSP as alternatives in the framework. The successive sections of the paper offer the implementation of proposed AHP model in the political background.

II. DATASET AND METHODOLOGY

2.1 Political Statistics

The statistics is primarily intended to analyze the performance of both the state parties under the defined parameters when they hold the state legacy. We retrieved the political data from the web repository available in bar graphs and histograms. The statistics are interpreted and then transformed into the following table:-

Table 1 Political Statistics

Year →	STATE PARTIES	
	2003-04 to 2006-07	2007-08 to 2011-12
Alternatives →	Samajwadi Party (SP)	Bahujan Samaj Party (BSP)
Criteria ↓		
GSDP	4.9	5.4
Agriculture	0.8	2.8
Industry	9.7	3.1
CRIME:		
(a) Riots	77	115
(b) Kidnapping and Abduction	66	158
(c) Rape	27	46
(d) Murder	125	121
LITERACY RATE:		
(a) Male Literacy Rate(%)	68.8	79.24
(b) Female Literacy Rate(%)	42.22	59.26

2.2 Methodology

The paper covers the steps of algorithm proposed by Thomas L. Saaty. The renowned theoretician developed the Analytic Hierarchy Process (AHP) framework for the decision-making process and making judgements precisely. The following section provides the working of our AHP model [3] which includes major steps-

Step 1 Interpretation of dataset

The above table (Table 1) of political statistics is transformed into the required dataset format. In this case, AHP algorithm works on YAML format. YAML format is one of the *Markup Language* used for files configuration and data storage [7]. Its Python-style indentation makes it flexible to indicate nesting for lists and maps.

Step 2 Implementation of AHP model on the dataset

Since the AHP model begins with analyzing the problem and presenting the multilevel view of the problem statement, the figure given below provides a complete picture about how the problem is being decomposed into several levels:-

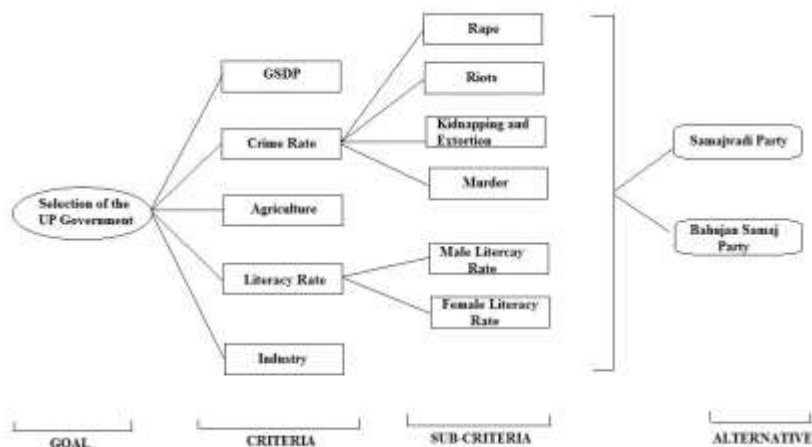


Fig 1 Multilevel Representation [4]

Step 3 Pairwise comparison matrix of criteria and sub-criteria

Suppose $C_1, C_2, C_3, C_4, \dots, C_n$ are n number of criteria, then the building of comparison matrix is taken place as below:-

$$\begin{pmatrix} \cdot & C_1 & C_2 & C_3 & C_4 & - & - & - & C_n \\ C_1 & 1 & c_{12} & c_{13} & c_{14} & \dots & \dots & \dots & c_{1n} \\ C_2 & c_{21} & 1 & c_{23} & c_{24} & \dots & \dots & \dots & c_{2n} \\ C_3 & c_{31} & c_{32} & 1 & c_{34} & \dots & \dots & \dots & c_{3n} \\ C_4 & c_{41} & c_{42} & c_{43} & 1 & \dots & \dots & \dots & c_{4n} \\ - & \dots & \dots & \dots & \dots & \dots & \dots & \dots & \dots \\ - & \dots & \dots & \dots & \dots & \dots & \dots & \dots & \dots \\ - & \dots & \dots & \dots & \dots & \dots & \dots & \dots & \dots \\ C_n & c_{n1} & c_{n2} & c_{n3} & c_{n4} & \dots & \dots & \dots & 1 \end{pmatrix}$$

where c_{ij} are the scales assigned after comparing the C_i and C_j criteria

Table 2 Saaty Table [1]

Saaty Scale	Description
1	Equally Important
3	Weakly Important
5	Fairly Important
7	Strongly Important
9	Absolutely Important
2,4,6,8	The intermediate values between corresponding scales

The pairwise comparison matrix for this study is purely based on the Saaty Table. For example, the preference of GSDP over Crime is denoted by the intensity "9". But the preference of Crime over GSDP is denoted by "1/9". The numeric value 9 represents "GSDP is Absolutely Important than Crime" and reversely 1/9 represents "Crime is Absolutely Important than GSDP". Likewise, the weights given between two parameters are summarized in the table mentioned below:-

Table 3 Pairwise comparison table of criteria [4]

Criteria		More Important	Intensity
A	B		
GSDP	Agriculture	A	3
GSDP	Industry	B	1
GSDP	Crime	A	9
GSDP	Literacy rate	A	4
Agriculture	Industry	B	3
Agriculture	Crime	A	9
Agriculture	Literacy rate	B	6
Industry	Crime	A	9
Industry	Literacy rate	A	1
Crime	Literacy rate	B	7

Table 4 Pairwise comparison of sub- criteria belongs to *CRIME* [4]

CRIME			
Criteria		More Important	Intensity
A	B		
Riots	Rape	A	3
Riots	Murder	B	3
Riots	K&A [#]	B	5
Rape	Murder	B	6
Rape	K&A [#]	B	5
Murder	K&A [#]	B	2

#Kidnapping and Abduction

Table 5 Pairwise comparison of sub-criteria belongs to *LITERACY RATE* [4]

LITERACY RATE		
Male Literacy Rate	Female Literacy Rate	1

Step 4 Pairwise comparison matrices of alternatives with respect to each criterion

For each criterion, the preference matrix of different alternatives is prepared as below:-

$$C_1 = \begin{pmatrix} \cdot & A_1 & A_2 & - & - & A_m \\ A_1 & 1 & a_{12} & - & - & a_{1m} \\ A_2 & a_{21} & 1 & - & - & a_{2m} \\ - & - & - & - & - & - \\ - & - & - & - & - & - \\ A_m & a_{m1} & a_{m2} & - & - & 1 \end{pmatrix}$$

$$C_2 = \begin{pmatrix} \cdot & A_1 & A_2 & - & - & A_m \\ A_1 & 1 & a_{12} & - & - & a_{1m} \\ A_2 & a_{21} & 1 & - & - & a_{2m} \\ - & - & - & - & - & - \\ - & - & - & - & - & - \\ A_m & a_{m1} & a_{m2} & - & - & 1 \end{pmatrix}$$

$$C_n = \begin{pmatrix} \cdot & A_1 & A_2 & - & - & A_m \\ A_1 & 1 & a_{12} & - & - & a_{1m} \\ A_2 & a_{21} & 1 & - & - & a_{2m} \\ - & - & - & - & - & - \\ - & - & - & - & - & - \\ A_m & a_{m1} & a_{m2} & - & - & 1 \end{pmatrix}$$

where A_1, A_2, \dots, A_m are m number of alternatives and a_{ij} is the weight given after comparing alternative A_i and A_j .

Comparison is made between alternative and weight is assigned on the basis of Saaty Table [1]. The preference matrix for the alternatives against each criterion is summarized into the following table:-

Table 6 Preference matrix with respect to alternatives under defined criteria and sub-criteria

	GSDP	Agriculture	Industry	Crime				Literacy Rate	
				Riots	Rape	Murder	K&A#	Male LR.	Female LR.
More Important	SP	BSP	SP	SP	SP	BSP	SP	BSP	BSP
Intensity	3	5	7	7	7	3	9	3	3

Step 5 Computation of the priority vector.

There are two types of priority calculated here. The first type is local priority and second is global priority. The main concern is the analyzing of global priority. To compute the global priority vector, we first need to compute local priority. Hence, we further divided this step into four sub steps:

Step 5.1 Local priority vectors for criteria and sub-criteria

Firstly, the geometric mean of comparison matrix [6] is calculated using the following equation:-

$$r_i = \left(\prod_{j=1}^n d_{ij} \right)^{1/n} \quad (1)$$

1. GSDP	$(1 \times 3 \times 1 \times 9 \times 4)^{1/5}$ = 0.255
2. Agriculture	$\left(\frac{1}{3} \times 1 \times \frac{1}{3} \times 9 \times \frac{1}{6} \right)^{1/5}$ = 0.698
3. Industry	$(1 \times 3 \times 1 \times 9 \times 1)^{1/5}$ = 1.933
4. Crime	$\left(\frac{1}{9} \times \frac{1}{9} \times \frac{1}{9} \times 1 \times \frac{1}{9} \right)^{1/5}$ = 0.172
5. Literacy Rate	$\left(\frac{1}{4} \times 6 \times 1 \times 9 \times 1 \right)^{1/5}$ = 1.682
Total	7.035

Finally, the calculation is done by dividing the row with the total value i.e.

$$w_i = \frac{r_i}{\sum_{i=1}^n r_i} \quad (2)$$

Table 7 Priority vector of criteria [6]

Criteria	Priority
GSDP	2.550/7.035=0.362
Agriculture	0.698/7.035=0.099
Industry	1.933/7.035=0.274
Crime	0.172/7.035=0.024
Literacy Rate	1.682/7.035=0.240
TOTAL	1

CRIME

Table 8 Priority vector of different

Sub Criteria	Priority
Riots	0.134
Rape	0.065
Murder	0.350
Kidnapping and Abduction	0.450
TOTAL	1

sub-criteria [6]

LITERACY RATE	
Sub Criteria	Priority
Male Literacy Rate	0.5
Female Literacy Rate	0.5
TOTAL	1

Step 5.2 Global priority vectors for different sub criteria.

The priorities of different sub-criteria computed in the step 5.1 are local priorities as they giving their contribution only to its parent criteria. But in order to achieve the goal, we need to find out how the sub-categories contribute globally in terms of the priority.

For example, Criteria *Crime* is categorized into 4 sub-criteria. The global priority of each sub-criterion is computed through formula mentioned below:-

$$gp_i = w_{CRIME} \times w_i \quad \text{where } 0 < i \leq 4 \quad (3)$$

Table 9 Global priorities computed for sub categories of *CRIME* [4]

CRIME		
Sub-Criteria	Local Priority	Global Priority
Riots	0.134	0.003
Rape	0.065	0.001
Murder	0.350	0.008
Kidnapping and Abduction	0.450	0.010
TOTAL	1	0.024

Similarly the global priorities for sub-criteria categorized under *Literacy Rate* are presented below:-

Table 10 Global priorities computed for sub categories of *LITERACY RATE* [4]

LITERACY RATE		
Sub-Criteria	Local Priority	Global Priority
Male Literacy Rate	0.5	0.12
Female Literacy Rate	0.5	0.12
TOTAL	1	0.24

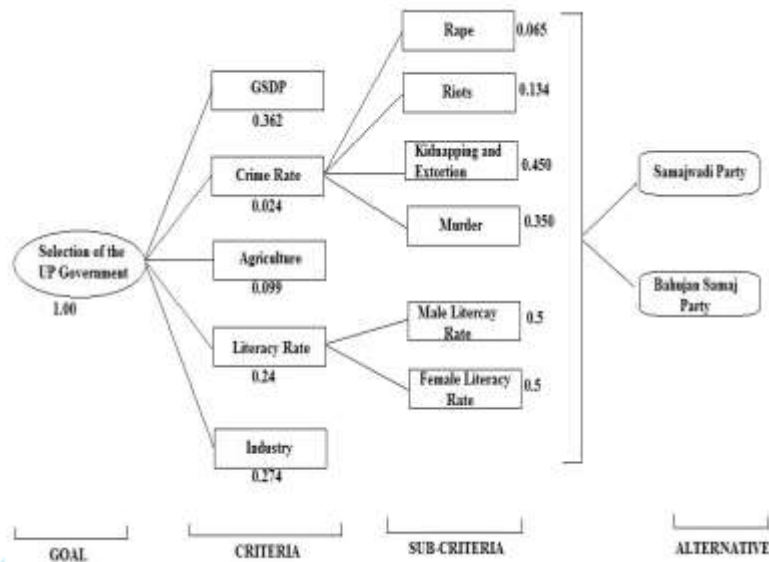


Fig 2 Multilevel structure representing local priorities of sub-criteria [4]

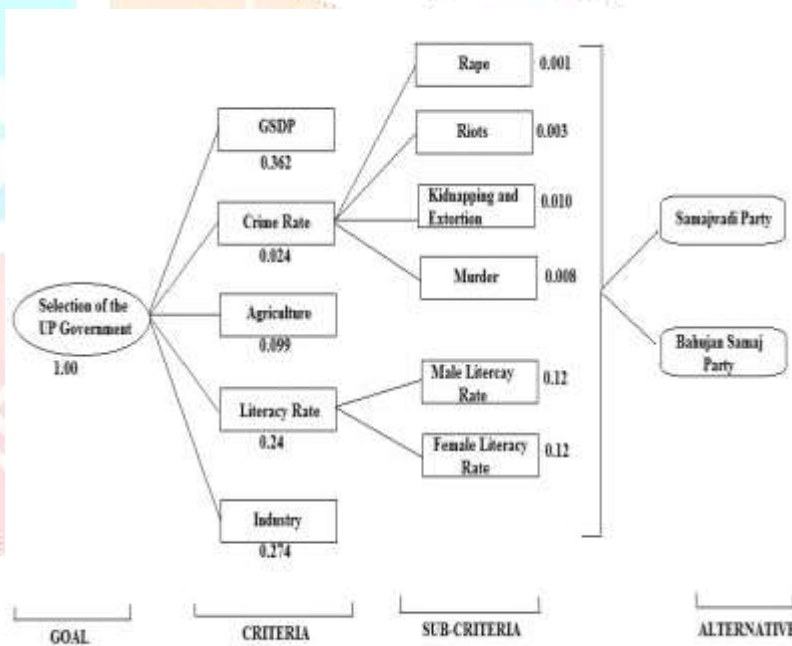


Fig 3 Multilevel structure representing global priorities of sub-criteria [4]

Step 5.3 Local priority vectors of alternatives with respect to each criteria

The local priority of alternatives for underlying criteria is evaluated like the evaluation of local priority vector for criteria has been carried out in the step 5.1. The local priority of each alternative under defined criteria is illustrated in the table below:

Table 11 Local priorities of each alternative with respect to underlying criteria and sub-criteria

W_i	GSDP	Agriculture	Industry	Crime				Literacy Rate	
				Riots	Rape	Murder	K&A [#]	Male LR.	Female LR.
Samajwadi Party(SP)	0.75	0.166	0.875	0.875	0.875	0.25	0.9	0.25	0.25

Bahujan Samaj Party(BSP)	0.25	0.833	0.125	0.125	0.125	0.75	0.099	0.75	0.75
--------------------------	------	-------	-------	-------	-------	------	-------	------	------

where W_i is the local priority of the alternative i .

Step 5.4 Global priority vectors of alternatives

The global priority of alternative, say Samajwadi Party (SP) is carried out by equation given below:-

$$GP_m = \sum_{i=1}^n (gp_i \times W_i) \tag{4}$$

$$GP_{SP} = 0.75 \times 0.362 + 0.166 \times 0.099 + 0.875 \times 0.003 + 0.875 \times 0.001 + 0.25 \times 0.008 + 0.9 \times 0.01 + 0.875 \times 0.274 + 0.25 \times 0.12 + 0.75 \times 0.12$$

Similarly, for second alternative,

$$GP_{BSP} = 0.25 \times 0.362 + 0.833 \times 0.099 + 0.125 \times 0.003 + 0.125 \times 0.001 + 0.75 \times 0.008 + 0.099 \times 0.01 + 0.125 \times 0.274 + 0.25 \times 0.12 + 0.75 \times 0.12$$

Step 6 Ranking of alternatives

The rank given to the alternatives is based on their priority. Higher the priority, higher will be the rank.

Step 7 Visualization of the analysis

The following table illustrating the summary of the analysis:-

Table 12 AHP Final Priorities [5]

Selection of UP Government In 2012 Assembly Elections										
Political Party	GSDP	Agriculture	Crime				Industry	Literacy Rate		Priority
			Riots	Rape	Murde	K & A		Male L. Rate	Female L. Rate	
Samajwadi Party(SP)	0.362	0.099	0.003	0.001	0.008	0.01	0.274	0.12	0.12	0.6
	0.75	0.166	0.875	0.875	0.25	0.9	0.875	0.25	0.75	
Bahujan Samaj Party (BSP)	0.25	0.833	0.125	0.125	0.75	0.099	0.125	0.25	0.75	0.4
Total										1

Step 8: Implementation using AHP tool

The implementation task has been achieved using RStudio where we apply the AHP algorithm. The AHP package is installed from the CRAN repository “http://cran.us.r-project.org”. The results obtained in RStudio are discussed in the next section.

III. RESULTS AND DISCUSSION

The analysis has been verified using AHP tool included in R platform. The priority is indicated in front of parameters and alternatives as shown below:-


```

levelName      priority
1 Choose UP Government in 2012      NA
2 --GSDP                          0.38009834
3   |--Samajwadi Party(SP)          0.75000000
4   |--Bahujan Samaj Party(BSP)     0.25000000
5 --Agriculture                     0.09996868
6   |--Samajwadi Party(SP)          0.16666667
7   |--Bahujan Samaj Party(BSP)     0.83333333
8 --Industry                        0.24690624
9   |--Samajwadi Party(SP)          0.87500000
10  |--Bahujan Samaj Party(BSP)     0.12500000
11 --Crime                          0.02348164
12   |--Riots                      0.12430311
13   |--Samajwadi Party(SP)          0.87500000
14   |--Bahujan Samaj Party(BSP)     0.12500000
15   --Rape                        0.06171845
16     |--Samajwadi Party(SP)        0.87500000
17     |--Bahujan Samaj Party(BSP)    0.12500000
18   --Murder                      0.31613761
19     |--Samajwadi Party(SP)        0.25000000
20     |--Bahujan Samaj Party(BSP)    0.75000000
21   --K&A                         0.49784084
22     |--Samajwadi Party(SP)        0.90000000
23     |--Bahujan Samaj Party(BSP)    0.10000000
24 --Literacy Rate                  0.24954510
25   |--Male Literacy Rate          0.50000000
26     |--Samajwadi Party(SP)        0.25000000
27     |--Bahujan Samaj Party(BSP)    0.75000000
28   |--Female Literacy Rate        0.50000000
29     |--Samajwadi Party(SP)        0.25000000
30     |--Bahujan Samaj Party(BSP)    0.75000000
>
    
```

Fig 4 AHP priority table

The final result is comprised of assessment of each criteria and ranking the political parties. The table depicts the outcome summary:-

	Weight	Samajwadi Party(SP)	Bahujan Samaj Party(BSP)
Choose UP Government in 2012	100.0%	50.0%	40.4%
GSDP	38.0%	28.5%	9.5%
Literacy Rate	25.0%	6.2%	18.7%
Male Literacy Rate	12.5%	3.1%	9.4%
Female Literacy Rate	12.5%	3.1%	9.4%
Industry	24.7%	21.6%	3.1%
Agriculture	10.0%	1.7%	8.3%
Crime	2.3%	1.6%	0.7%
K&A	1.2%	1.1%	0.1%
Murder	0.7%	0.2%	0.6%
Riots	0.3%	0.3%	0.0%
Rape	0.1%	0.1%	0.0%

Fig 5 Outcome Summary

IV. CONCLUSION

From the above analysis and implementation in R platform, we concluded that Samajwadi Party (SP) leads with the highest priority. Even in 2012, Samajwadi Party (SP) formed the government with the majority of votes in the Uttar Pradesh. It is observed that AHP produces acceptable results. It can be verified using AHP package in any platform supported machine learning. In the same way, we can apply this AHP model during elections to evaluate the performance of political parties and to rank them according to their computed weights.

REFERENCES

[1] Thomas L. Saaty, How to make a decision- Analytic Hierarchy Process, J. European Journal of Operation Research, vol 48 (1990) pp: 9-26.

[2] <http://cran.us.r-project.org>.

[3] Thomas L. Saaty, Decision Making for Leaders – The Analytic Hierarchy Process for Decisions in a Complex World, vol 3 (2001).

[4] https://en.wikipedia.org/wiki/Analytic_hierarchy_process_%E2%80%93_car_example.

[5] <https://cran.r-project.org/web/packages/ahp/vignettes/examples.html>.

[6] Thomas L. Saaty, Fundamentals of Decision Making and Priority Theory, J. RWS Publications, Pittsburgh, Pennsylvania.

[7] <https://en.wikipedia.org/wiki/YAML>