12th International Research/Expert Conference
"Trends in the Development of Machinery and Associated Technology"
TMT 2008, Istanbul, Turkey, 26-30 August, 2008

# SELECTION OF WATER UTILIZATION STRATEGY WITH FUZZY AHP AND FUZZY ANP METHODOLOGIES UNDER GLOBAL WARMING RISK

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## ABSTRACT
*Global warming is the today's important problem for all over the world. Due to the global warming, countries come face to face with lots of problems such as shortage of clean and usable water, erosion, usage of natural resources, and climatic problems. That's why; in this paper, we proposed a model for selection of the utilization strategies for water resources in Turkey by using analytical hierarchy process and analytical network process based on linguistic terms under fuzzy environment. In this paper, the AHP/ANP is the useful applications in multi-criteria decision-making problems with numerous intangibles. For fuzzy AHP and fuzzy ANP analysis Chang's (1996) extent analysis method are preferred to having the solutions. In the solution process, the linguistic levels of comparisons produced by the experts for each comparison are tapped in the form triangular fuzzy numbers to construct fuzzy pair-wise comparison matrices. The model is explained by an illustrative example and the results of both fuzzy AHP and fuzzy ANP methodologies are compared. The implementation of the system is demonstrated by a problem having four stages of hierarchy which contains different criteria and attributes.*
**Keywords:** Fuzzy AHP, fuzzy ANP, strategy selection under global warming.

## 1. INTRODUCTION
Global warming is very important problem for all over the World. With its effects some parts of the world face to with torrent and the other face to with drought. To be succeeding in drought the governments have to develop new strategies about water utilization. The results of global warming, if it happens on a significant scale, are likely to be even more severe. Global warming could result in the icecaps melting and this, coupled with the effects of the thermal expansion of the seas, would cause sea levels to rise. On the other hand, global warming could also lead to the disruption of crop growing as climate patterns change. It would not be simply a matter of increased temperatures such as the climate system would become erratic, with more storms and more droughts [1].
The strategy selection is a multi-criteria decision-making problem. In literature, for multi-criteria decision-making problems there are two techniques AHP and ANP. With Zadeh's researches about fuzzy logic, their fuzzy logic forms are created. In literature there are lots of researches about AHP and ANP methodologies and their fuzzy forms. For example, Wong et al. (2007) used these two techniques for evaluating the system intelligence of the building systems; Garuti and Spencer (2007) searched parallels between AHP and ANP; Chang et al. (2007) evaluated digital video recorder systems with AHP and ANP; and Wijnmalen (2007) analysis of benefits, opportunities, costs, and risks with AHP and ANP.
In this paper, the implementation of the system is demonstrated by a problem having four stages of hierarchy which contains five criteria and twenty-eight attributes. The linguistic levels of comparisons

produced by the experts for each comparison are tapped in the form triangular fuzzy numbers to construct fuzzy pair-wise comparison matrices in the study.

## 2. WATER UTILIZATION STRATEGY SELECTION PROBLEM

The problem has a hierarchy with four levels, and the different decision criteria, attributes and the decision alternatives, will be further discussed. In the hierarchy, the overall objective is placed at level 1, criteria at level 2, attributes at level 3, and the decision alternatives at level 4. The main objective here is the strategy selection. The criteria which are considered here in strategy selection are risks, social factors, geographical factors, and economical factors. The hierarchy of the selection criteria, attributes, and decision alternatives can be seen in Figure 1.

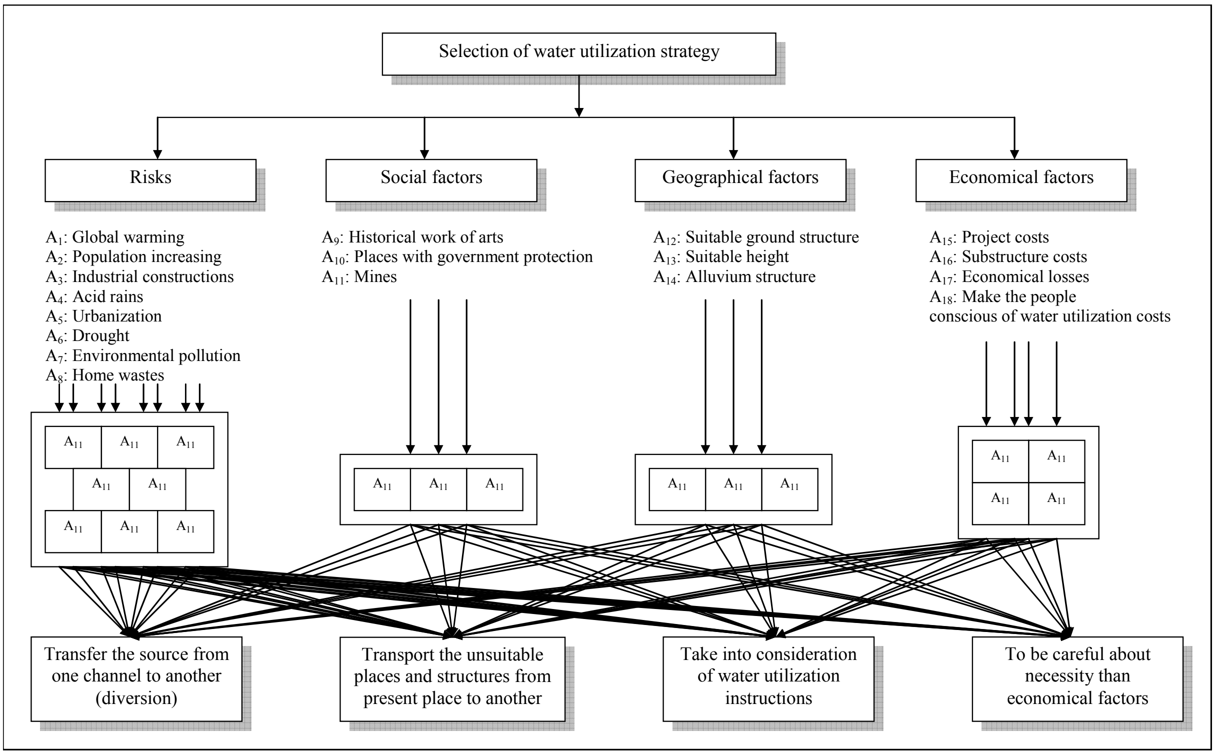


*Figure 1. The hierarchical structure of the problem*

### 2.1 Building criteria and attributes for a problem

In this paper, for the best supplier selection problem there are three different criteria. They are stated as follows:

- Risks ($C_1$): The first criteria's attributes are global warming, population increasing, industrial constructions, acid rains, urbanization, drought, environmental pollution, home wastes.
- Social factors ($C_2$): The second criteria's attributes are historical work of arts, places with government protection, mines.
- Geographical factors ($C_3$): The third criteria's attributes are suitable ground structure, suitable height, alluvium structure.
- Economical factors ($C_4$): The fourth criteria's attributes are project costs, substructure costs, economical losses, make the people conscious of water utilization costs.

### 2.2 Selection Alternatives

In this paper, depending on the selection criteria and attributes there are four different alternative strategies for Turkey. The alternatives are transfer the source from one channel to another (diversion), transport the unsuitable places and structures from present place to another, take into consideration of water utilization instructions, to be careful about necessity than economical factors.

### 2.3 Application of Fuzzy AHP and Fuzzy ANP methodologies

After the construction of the hierarchy, the different priority weights of each criteria, attributes and alternatives are calculated by using the fuzzy AHP approach. The comparison of the importance or preference of one criterion, attribute or alternative over another can be done with the help of the questionnaire. For AHP calculations Chang's (1996) methodology is used.

The fuzzy evaluation matrix relevant to the goal is given in Table 1. The decision-making group compared the attributes with respect to criteria and they compared the alternative strategies with respect to attributes.

*Table 1. The fuzzy evaluation matrix with respect to the goal*

| | Risk | Social factors | Geographical factors | Economical factors |
|---|---|---|---|---|
| Risk | (1, 1, 1) | (5/2, 3, 7/2) | (3/2, 2, 5/2) | (3/2, 2, 5/2) |
| Social factors | (2/7, 1/3, 2/5) | (1, 1, 1) | (2/5, 1/2, 2/3) | (2/5, 1/2, 2/3) |
| Geographical factors | (2/5, 1/2, 2/3) | (3/2, 2, 5/2) | (1, 1, 1) | (2/3, 1, 3/2) |
| Economical factors | (2/5, 1/2, 2/3) | (3/2, 2, 5/2) | (2/3, 1, 3/2) | (1, 1, 1) |

Now the different attributes are compared under each of the criteria separately by following the same procedure as above. In fuzzy AHP methodologies last step, the priority weights are combined.

*Table 2. Summary combination of priority weights: main criteria of the overall objective*

| | Risk | Social factors | Geographical factors | Economical factors | Alternative Priority weight |
|---|---|---|---|---|---|
| Weight | 0.55 | 0.09 | 0.18 | 0.18 | |
| Alternative Strategies | | | | | |
| Strategy I | 0.07 | 0.55 | 0.14 | 0.20 | 0.15 |
| Strategy II | 0.11 | 0.23 | 0.12 | 0.07 | 0.12 |
| Strategy III | 0.37 | 0.11 | 0.48 | 0.18 | 0.33 |
| Strategy IV | 0.45 | 0.11 | 0.26 | 0.55 | **0.40** |

Fuzzy AHP methodology can be continued with fuzzy ANP methodology. It starts with the inner dependence matrixes of the factors with respect to each other.

- The inner dependence matrix with respect to risk. $W_1 = (0.02, 0.18, 0.82)^T$.
- The inner dependence matrix with respect to social factors. $W_2 = (0.47, 0.47, 0.06)^T$.
- The inner dependence matrix with respect to geographical factors. $W_3 = (0.16, 0.02, 0.82)^T$.
- The inner dependence matrix with respect to economical factors. $W_4 = (0.82, 0.02, 0.16)^T$.

Using the computed relative importance weights, the dependence matrix of the criteria is formed. Significant differences are observed in the results obtained for the criteria weights when the interdependent weights of the criteria.

$$\begin{bmatrix} Risk \\ Socialfactors \\ Geographicalfactors \\ Economicalfactors \end{bmatrix} = \begin{bmatrix} 1.00 & 0.47 & 0.16 & 0.82 \\ 0.02 & 1.00 & 0.02 & 0.02 \\ 0.16 & 0.47 & 1.00 & 0.16 \\ 0.82 & 0.06 & 0.82 & 1.00 \end{bmatrix} \times \begin{bmatrix} 0.15 \\ 0.12 \\ 0.33 \\ 0.40 \end{bmatrix} = \begin{bmatrix} 0.29 \\ 0.07 \\ 0.24 \\ 0.40 \end{bmatrix}$$

Using interdependent weights of the criteria and local weights attributes, global weights for the attributes are calculated. The values are shown in Table 3.

Finally, the overall priorities of the alternative strategies, reflecting the interrelationships within the criteria, are calculated. The same hierarchical model given in Figure 1 is analyzed with the Fuzzy ANP. According to the ANP analysis, alternative strategies are ordered as 4-3-1-2. According to the AHP analysis, alternative strategies are ordered as 4-3-1-2, too.

$$\begin{bmatrix} weight \\ vectors \\ of \\ attributes \end{bmatrix} \times \begin{bmatrix} global \\ weight \\ of \\ attributes \end{bmatrix} = \begin{bmatrix} 0.17 \\ 0.11 \\ 0.30 \\ 0.42 \end{bmatrix}$$

*Table 3. Computed global weights of attributes*

| Criteria, attributes and local weights | | Local weights | Global weights |
|---|---|---|---|
| Risk | 0.29 | | |
| 1. Global warming | | 0.29 | 0.08 |
| 2. Population increasing | | 0.14 | 0.04 |
| 3. Industrial constructions | | 0.09 | 0.03 |
| 4. Acid rains | | 0.11 | 0.03 |
| 5. Urbanization | | 0.01 | 0.00 |
| 6. Drought | | 0.29 | 0.08 |
| 7. Environmental pollution | | 0.00 | 0.00 |
| 8. Home wastes | | 0.07 | 0.02 |
| Social factors | 0.07 | | |
| 9. Historical work of arts | | 0.82 | 0.06 |
| 10. Places with government protection | | 0.16 | 0.01 |
| 11. Mines | | 0.02 | 0.00 |
| Geographical factors | 0.24 | | |
| 12. Suitable ground structure | | 0.82 | 0.20 |
| 13. Suitable height | | 0.02 | 0.00 |
| 14. Alluvium structure | | 0.16 | 0.04 |
| Economical factors | 0.40 | | |
| 15. Project costs | | 0.42 | 0.17 |
| 16. Substructure costs | | 0.42 | 0.17 |
| 17. Economical losses | | 0.12 | 0.05 |
| 18. Make the people conscious of water utilization costs | | 0.04 | 0.02 |

## 3. CONCLUSION

Selection of water utilization strategy is one of the government's most important processes because of the global warming risk. For this reason, in this paper fuzzy AHP and fuzzy ANP approaches have been presented to select the best water utilization strategy for Turkey.

In conclusion, according to the final score both fuzzy AHP analysis and fuzzy ANP analysis, the strategy $S_4$ is the most preferred strategy because it has the highest priority weight and strategy $S_3$ is the next recommended alternative strategy.

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