Portland State University
Maseeh College of Engineering and Computer Science
Department of Engineering and Technology Management

ETM
ENGINEERING & TECHNOLOGY MANAGEMENT

ETM 530/630 – Decision Making
Spring 2017

Individual Project Paper

Decision Making with the Analytic Hierarchy Process for Ranking Water Transfer Projects to Zayanderud-Iran

Shahram Khorasanizadeh

ABSTRACT

The limitations and accessibility of water resources juxtaposed against the increasing demands for water resources due to a combination of growing populations and the scarcity of water for their needs in many regions around the world, specifically in countries located in arid and semi-arid regions. One method to remedy the issue is a transfer of water between basins, which is a huge undertaking as it can involve diverting water from surpluses (such as a river) to the regions with limited access to water. However, due to technological, financial, socio-economic, and environmental constraints, projects of this nature require that several criteria be considering before undertaking a project to transfer water [3].

Iran, which has both arid and semi-arid regions within its borders, faces water shortages in large swaths of the country, particularly the central and southeastern regions. In this research paper, a hierarchical decision model (HDM) was implemented in order to rank four water transfer options to the Zayanderud basin in central Iran. The approach outlined in this study takes the four most reasonable options for transferring water to the basin and outlines major and sub-criteria that were determined by an extensive review of literature and opinions provided by experts on the transfer of water. From here, the HDM is further refined by using the ETM-HDM online software provided. This model allows for a comparison of tangible factors with varying priorities by way of a pairwise comparison. The hierarchy consisted of four levels: goal, criteria, sub-criteria, and alternatives. A group of 7 experts with various backgrounds and more than 15 years of experience in water and environmental issues were invited from companies, governments, and academia. Accordingly their judgments were quantified and incorporated into the online model.

According to the outcomes of this model, four alternatives for transferring water to Zayanderud basin were prioritized using the analytic hierarchy process. The results of the model showed that the Beheshtabad project was the most feasible. The research outcomes revealed the possibility of using different methods to rank possible alternatives for inter-basin water transfer projects. The research also highlighted the importance of selecting the correct criteria and sub-criteria, which can have an impact on the final outcomes of the model.

INTRODUCTION

The purpose of this study is ranking four water transfer options to the Zayanderud Basin in central Iran by implementing a hierarchical decision model (HDM). The uneven distribution of water across the country and increasing water demand due to growing population, have led to conflicts over water supply and water demands and resulting water shortages for urban and domestic uses [11]. As the pressure on water demand is increasing, acting upon a traditional outlook in water management in Iran, water managers see water transfer to arid zones as a solution to meet the demands [11]. “The increasing water demand has caused an alarming decrease in annual per capita water resources” [1]. Inter-basin water transfers move water from one watershed to another basin where water is less available to alleviate water shortages in the receiving basin. Inter-basin water transfers connect hydraulically two or more river basins that hitherto were unconnected [15]. “Reducing water shortages that are considered to account for most serious hindrance to sustained development of regions short of adequate local water resources is a significant advantage of long distance water transfer. However, the fundamental principle of water resource management explicitly states that prior to the development of any inter-basin water transfer (IBWT) scheme, the need for water transfer should be minimized” [11]. Therefore, with consideration to the impact a project of this magnitude can have (i.e. socio-economic, environmental, and conflicts between stakeholders), choosing the right option for transferring water is very important. The broad applications of multi-criteria decision making techniques show they are well-suited to water resource planning as an efficient tool to evaluate these kinds of projects [1][11].

“Since the central and southern regions of the Iran are facing a high degree of water shortage, one of the best ways to improve the socio-economic life of the people is water transfer from Large Karun (including Karun and Dez rivers), a neighboring basin that is the most important basin in Iran with respect to the water potential and possibilities of water resources development” [1]. “The Zayanderud River basin, with a total area of 41,542 km^2, is located in a dry and hot zone in central Iran. The river supplies water for the various agricultural, industrial, and urban needs of the areas and towns located within the Zayanderud River basin as well as several towns outside the basin. Zayanderud River basin hosts a rather high population and is the target of many immigrants due to its location in central Iran, the presence of major industries in the region, its fertile land, as well as its scientific, tourist, cultural, and historical attractions” [16]. As this region suffers from water shortage due to enormous growth in the number and scale of water uses, several inter-basin water transfer projects transferring water from Large Karun have been implemented or are under construction/planning in order to strengthen and augment the water resources in the Zayanderud basin [1] [16]. A schematic picture of Zayanderud basin and inter-basin water transfer projects to this basin are shown in Fig. 1 [17].

This research employed a hierarchical decision model (HDM) for ranking four selected water transfer alternatives from Karun to Zayanderud basin in Iran. “The importance of this selection is due to their high cost, long tunnels, high quantity and quality of water transfer, as well as the social conflicts” [1]. Names and specifications of the selected projects are shown in the Table 1 [1].

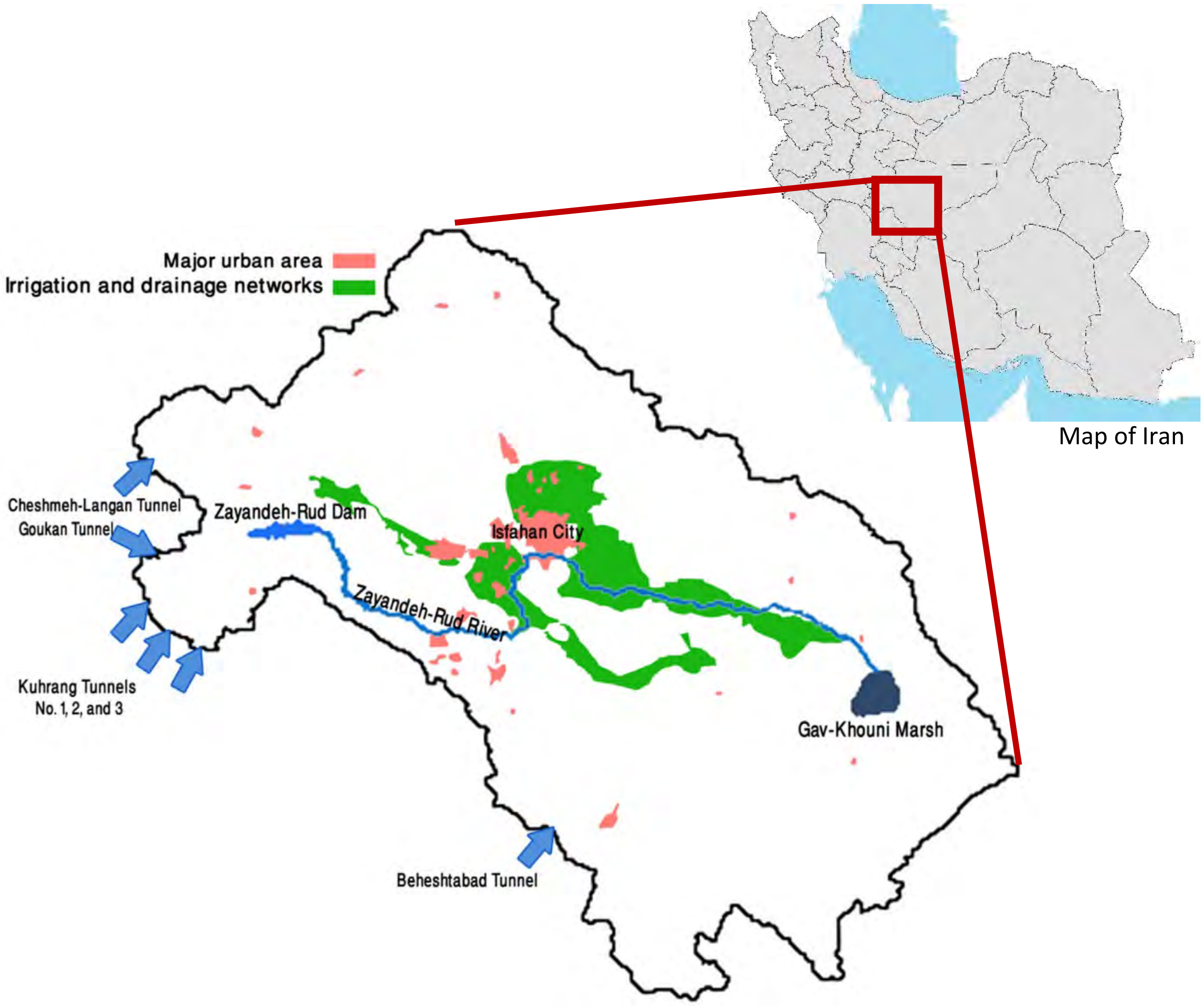


Fig. 1 Schematic picture of Zayanderud basin and inter-basin water transfer projects [17]

Table 1 Selected inter-basin water transfer projects from Karun to Zayanderud basin [1]

PROJECT NAME	PROJECT STATUS UNTIL JUNE 2007	TUNNEL LENGTH (KM)	VOLUME (106 M3 PER YEAR)
GUKAN	Under Design	30	170
CHESHMELANGAN	In Operation since 2005	15	195
BEHESHTABAD	Under Study	65	1000
KUHRANG III	Under Construction	23.4	300

A hierarchical decision model (HDM) was constructed for this study. After the criteria and sub-criteria were prepared by the researcher, the schematic picture of the model was sent to a selected expert who has comprehensive knowledge and a background in projects specifically of this nature, for their validation. After several iterations, the structure of the model in four levels including one goal, four criteria, ten sub-criteria, and four alternatives were finalized. After that, the structure of the model was implemented in the ETM-HDM online software, developed by Portland State University, and the online link of the generated model was sent to selected experts for a their judgement of the various criterion of the model.

METHODOLOGY

“To evaluate water resources projects, it is necessary to construct a hierarchy of criteria from the acts” [1]. The methodology employed in this research is the hierarchical decision modeling (HDM) for ranking four inter-basin water transfer projects to Zayanderud basin, which is one of the most recognizable methods used for multi-variable decision-making [4]. “The HDM is one of the most distinct methods for subjective approaches to help decision makers quantify and incorporate quantitative and qualitative judgments into a complex problem. It was developed from the analytic hierarchical process (AHP)” [4]. In this process, AHP utilizes pair-wise comparisons to develop overall priorities for ranking the alternatives, criteria and sub-criteria based on the experts’ opinions [10].

Based on a review of academic literature and assessments of previous studies along with research questions in mind, this research is comprised of qualitative methodologies for the extraction of modified criteria and sub-criteria in order to develop a model for ranking four selected water transfer options to Zayanderud basin in Iran. In June 2007, a comprehensive study had been modeled by merging fuzzy set theory and multi-attribute decision-making, namely FDM, by Dr. Zarghami, from Tabriz university-Iran and his team on this basin with seven criteria for ranking some alternatives [1]. In this study, the Hierarchical Decision Modeling (HDM) online software designed by Portland State University, Engineering and Technology Management department (ETM-HDM) has been used to develop a new hierarchy of criteria and their attributes to compare four selected water transfer options to Zayanderud basin in Iran.

The author of the above cited study was also invited to review and assess the hierarchy structure of the prepared model with its defined criteria and sub-criteria before building the model in the ETM-HDM online software. Consequently, the model was created using the ETM-HETM software tool. The final schematic of this model is shown in Fig. 2. The screenshot of running the model in the ETM-HDM online software is shown in the Appendix A, as well.

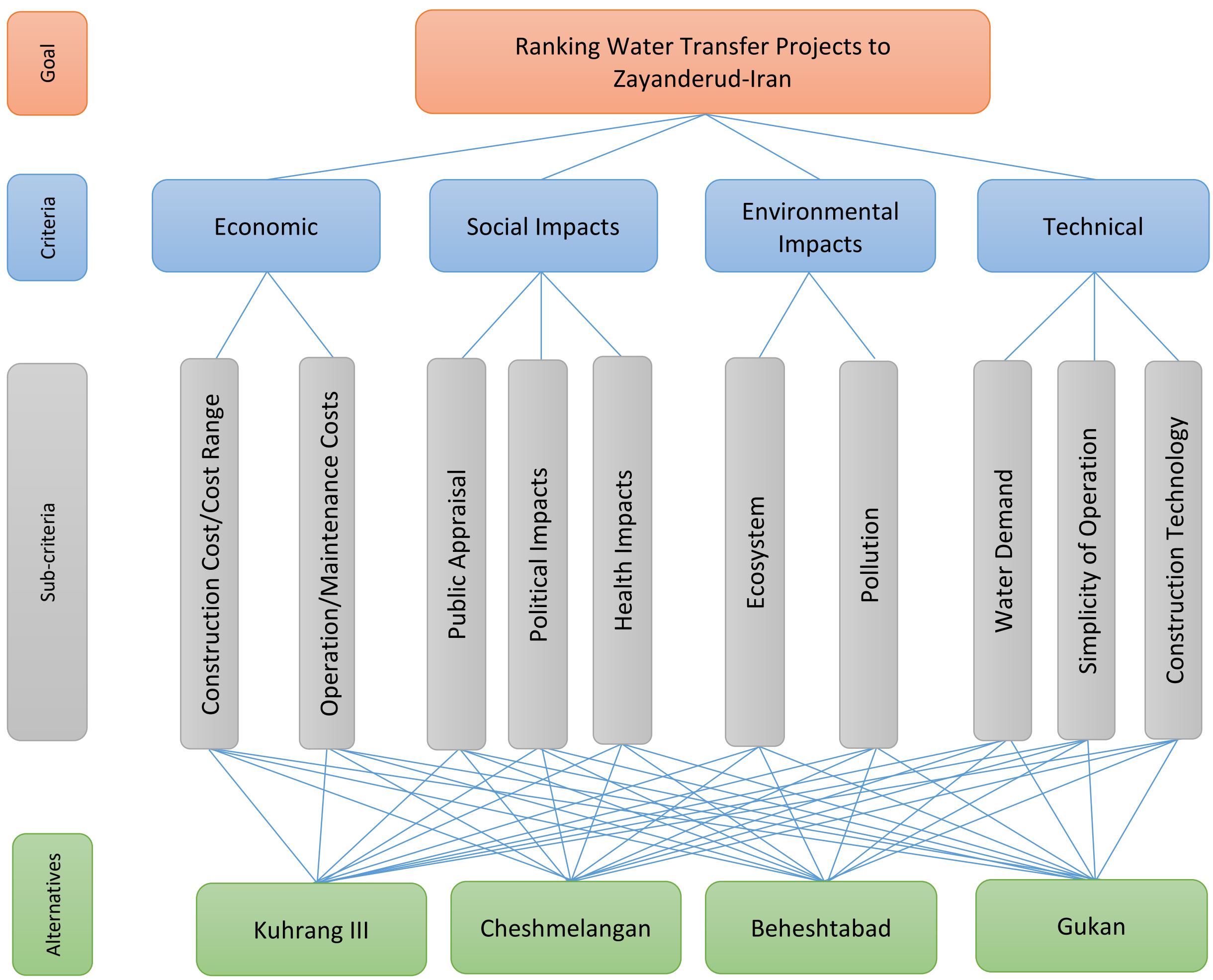


Fig. 2 Final schematic of this model

Four levels including a goal, four criteria, ten sub-criteria and four alternatives have been considered for this model. The top level of this model has been defined as "Ranking Water

Transfer Projects to Zayanderud Basin". Four of the water transfer plans including Kuhrang III, Cheshmelangan, Beheshtabad and Gukan have been selected. Subsequent pair-wise comparisons between elements at each level are developed to give priorities for the alternatives or criteria based on the results provided by the experts' judgments [2].

The definitions of the selected criteria and sub-criteria are as follows:

- **Economic**

  The governmental budget for construction of the projects is limited and also uncertain [1]. These criteria refer to the overall costs that must be incurred to construct a water transfer project followed by operation and maintenance costs.

  - **Construction Cost/Cost Range**

    This sub-criteria includes the overall costs needed for construction which include engineering, procurement and construction, and other costs associated with the water transfer projects.

  - **Operation/Maintenance Costs**

    Operation and maintenance costs are among the most critical components of each plan in order to ensure effective implementation and control of the project. This includes the operation costs for launching the project, modifications, monitoring, engineering supports and training costs.

- **Social Impacts**

Each of the water transfer projects in this study needs a reservoir at its origin [1]. This criteria refers to the social impacts of the resettlement of people, social conflicts in the origin and destination, labor opportunities, health issues and water rights.

- **Public Appraisal**

Inter-basin water transfer projects build social conflicts in the region. If the people have higher participation with a thorough appraisal of related decisions on different aspects of the impacts of these projects in their region, then the plan will be more easily accepted and have a better chance of success [5].

Part of undertaking a water transfer project should include a public appraisal, where the project is discussed with stakeholders and the general public in order to solicit opinions, suggestions and amendments that can be incorporated into the project.

- **Political Impacts**

For water transfer projects, reducing political tensions, paying attention to the range of conflicts among stakeholders, and preventing grievances and migration of residents of the border regions are among the impacts that should be considered. Experts have been asked to rate the alternative in view of their consistency by national, regional and local policies.

- **Health Impacts**

The health impacts of water transfers of the four proposals at local and regional levels are considered.

- **Environmental Impacts**

  Environmental impacts of water transfer plans are incredibly important [1]. This criteria attempts to declare the range of environmental impacts of the four selected water transfer plans.

  - **Ecosystem**

    Because any transfer of water within or between basins will have impacts on the ecosystems for both donor and recipient basins, future ecosystem needs and changes should be considered [6].

  - **Pollution**

    The criteria used in this paper attempts to encompass the most important impacts of water transfer plans on water quality. The water pollution control measures are needed to significantly improve water quality [7]. “Water pollution is not only a threat to public health and the environment, but also diminishes the total resource available to water users” [8]. The pollution sub-criteria allows the experts to examine pollution levels of each project and compare it with one another.

- **Technical**

  Water transfer projects required technical investigations, project design and feasibility studies [1] [8]. The technical criteria encompass the important aspects of water transfer projects that are concerned with the technical challenges.

- **Water Demand**

“The increasing water demand has caused an alarming decrease in annual per capita water resources [1]”. The evaluation of water demand for the selected projects is important sub-criteria to satisfy future water demands. Water demand is one of the key factors for implementing a water transfer project [11].

- **Simplicity of Operation**

The simplicity of operation and ease of maintenance is another important criterion should be taken into consideration in ranking water transfer projects [1].

- **Construction Technology**

Construction technologies offer many advantages in terms of environmentally sensitive construction, simplicity, and can reduce costs while shortening timelines. Thus technology has the potential to become one of the major sub-criteria for the model [7].

DATA AND DATA SOURCE(S)

The approach outlined in this study takes the four most reasonable options for transferring water to the basin and outlines major and sub-criteria that were determined by an extensive review of literature and opinions provided by experts on the transfer of water. From here, the HDM is further refined by using the ETM-HDM online software provided.

Expert panel

To quantify the AHP model, an expert panel, consisting of seven experts who have extensive knowledge and experience on different aspects of the various plans have been selected to evaluate and weigh the different levels of the model. For this portion, experts used the ETM-HDM online tool to evaluate the model. Then, a pairwise comparison among criteria is established based on each expert's opinion for each decision element.

Table 2 shows the distribution and technical background of experts who submitted their evaluation of criteria and sub-criteria in this study.

Table 2 Distribution and background of expert panel

EXPERTS	BACKGROUND	CONSULTING ENGINEERING COMPANY	GOVERNMENT	ACADEMIA
EXPERT-1	Water Resources management			✓
EXPERT-2	water Resources Management	✓		
EXPERT-3	Social Studies	✓		
EXPERT-4	Economic and Financial Studies	✓		
EXPERT-5	Water Diplomacy and Governance			✓
EXPERT-6	Environmental Science		✓	✓
EXPERT-7	Irrigation and Water Resources Management		✓	

ANALYSIS AND KEY FINDINGS

After the data collection, quantified expert judgements were submitted in the model. The screenshot of running the model in the ETM-HDM online software is shown in the Appendix A.

The value of sub-criteria, obtained from the quantified judgments of experts, were normalized by multiplying the contribution of each sub-criteria with relative mean weight of each criteria toward the goal. Thus, the distribution of decision/normalized weights in the model are shown in the Appendix A and Table 3 as well.

The table of final results of the model and pairwise comparisons from the experts are shown in Appendix B.

Table 3 Overall view of the weights for the criteria and sub-criteria

	Goal (G), Criteria (C), Sub-criteria (Sc), Alternatives (A)	Weight (Criteria to Goal)	Weight (Sub-criteria to Criteria)	Normalized Weight (Sub-criteria to Goal)
G	Ranking Water Transfer Projects to Zayanderud-Iran	1		
C	**Economic**	0.25		
Sc	Construction Cost/Cost Range		0.50	0.12
	Operation/Maintenance Costs		0.50	0.12
C	**Social Impacts**	0.26		
Sc	Public Appraisal		0.30	0.08
	Political Impacts		0.39	0.10
	Health Impacts		0.30	0.08
C	**Environmental Impacts**	0.31		
Sc	Ecosystem		0.65	0.20
	Pollution		0.35	0.11
C	**Technical**	0.18		
Sc	Water Demand		0.55	0.10
	Simplicity of Operation		0.21	0.04
	Construction Technology		0.24	0.05
Disagreement		0.034		

Based on the results shown in the Table 3 and Table 4, a majority of the experts rated environmental impacts as the most important priority between selected criteria, followed by social impacts and economic considerations with relative contribution of 0.31, 0.26 and 0.25 respectively.

Table 4 Criteria weights based on experts' opinions

	Economic	**Social Impacts**	**Environmental Impacts**	**Technical**
Expert-1	0.12	0.37	0.47	0.04
Expert-2	0.19	0.31	0.39	0.11
Expert-3	0.22	0.31	0.31	0.16
Expert-4	0.19	0.29	0.16	0.36
Expert-5	0.59	0.06	0.04	0.31
Expert-6	0.21	0.24	0.38	0.17
Expert-7	0.2	0.24	0.44	0.12
Mean	**0.25**	**0.26**	**0.31**	**0.18**

Based on the final results shown in Appendix A and Table 3, Ecosystem, Construction Cost, and Operation and Maintenance Costs are the top 3 sub-criteria with relative contributions of 0.2, 0.12 and 0.12 respectively.

The final results of relative weight of the alternatives is shown in Appendix B and Table 5 as well. Higher weight represents more an important issue in satisfying the decision level (goal). The resulting analyses indicated that Beheshtabad project had the highest rank with a weight of 0.33, followed by Kuhrang III plan, based on the experts' opinions.

Table 5 Relative value of each plan based on the results of the model

	Name of Projects (Alternatives)			
	Kuhrang III	**Cheshmelangan**	**Beheshtabad**	**Gukan**
Expert-1	0.25	0.25	0.25	0.25
Expert-2	0.25	0.16	0.36	0.23
Expert-3	0.23	0.18	0.37	0.21
Expert-4	0.23	0.21	0.35	0.21
Expert-5	0.25	0.19	0.35	0.21
Expert-6	0.2	0.25	0.24	0.31
Expert-7	0.24	0.17	0.39	0.2
Mean	**0.24**	**0.2**	**0.33**	**0.23**

The simulated application of the model shows that environmental concerns are crucial to sustain plans on water transfer between basins. In fact, based on the feedback from result validation, the research shows that the greatest challenge for implementing water transfers may rest on the environmental impacts that these projects can have on complex ecosystems. These impacts lead to serious affects to ecological resources and processes of the areas where water is diverted and received. “Ignoring these affects can results in un-intended unsustainable development in the long run.” [12] [13]. Hence, “environmental considerations should be an organic part, and not just an addendum to the projects. In order to build up consensus among stakeholders and prevent or resolve possible conflicts generated by the project, the planning process must be objective and transparent” [14].

From the experts’ perspective, it is equally important to estimate the corresponding operation and maintenance costs of each alternative in order to analyze the life cycle costs. There are large expenditures needed for operation costs including launching the project, facility maintenance, modifications, monitoring, engineering supports and training costs. Construction costs of water transfer projects are also high, therefore the results of this study showed that construction costs during all stages of study, planning, development, operation and maintenance of these kinds of projects should be considered.

As the result of this study, Beheshtabad project was selected as the most practical among other alternatives to transfer water to the Zayanderud basin. Beheshtabad project is in the study stage, but final results shows it is the most attractive plan between the four. However, this project is ranked higher than the Cheshmelangan plan that is already under operation.

The final results of this research for ranking the inter-basin water transfer projects are compared with the final results of the FDM method [1]. This comparison showed the capability of using different methods in ranking possible alternatives for inter-basin water transfer plans.

Inconsistency and Disagreement

As the value of pairwise comparison relies on subjective judgment, it is necessary to evaluate the consistency of the pairwise comparison between experts before analyzing the decision itself [9]. The online ETM-HDM tool calculates the inconsistency ratio. The inconsistency of each expert is shown at Table 6. All inconsistencies are all within the acceptable level of 0.10, so the consistency of pairwise comparison is accepted. If the inconsistency ratio of each expert judgments fails to meet the required level of 0.1, the process would have to be repeated until such an acceptable value is obtained. Saaty suggests the value of consistency ratio should be less than 0.1 [10].

Table 6 Experts' Inconsistency

Experts	Inconsistency
Expert-1	0
Expert-2	0.01
Expert-3	0.01
Expert-4	0
Expert-5	0.03
Expert-6	0.02
Expert-7	0.02

Disagreement is a measure of the difference between experts' assessments when doing a pairwise comparison. Smaller values indicate commonality among experts. If the values of disagreement is closest to zero, then we can infer a reliable assessment has been made. The disagreement value of 0.034 is a good indicator that the opinions of the experts regarding the decision were very close. Moreover, the model illustrates a small amount of inconsistency that each expert has and two experts have almost zero inconsistency. The disagreement and the inconsistency results illustrate the reliability of the model.

FUTURE RESEARCH

There is a limitation in this paper by inviting only seven professionals as a larger sample of experts would have increased the accuracy of the results obtained by the model. Within the process of making a hierarchal model, public participation among stakeholders as well as decision makers are a fundamental element [1].

While most of the experts agreed on the environmental impacts of water transfer projects, the impacts would vary with different specific transfer cases and mechanisms, it's recommended that future research should focus on evaluating a range of environmental issues including ecosystem, pollution, consistency with climate, watershed conservation and balancing of water resources. Additionally the items mentioned above should be used for implementing a new HDM model to investigate specifically the environmental concerns between these projects. In addition, some other issues like cost-benefit analysis, employment and migration, and resettlement of the people should be considered [1]. These factors will aid in developing an unbiased model which can help decision makers to better understand current and future problems.

The research also highlighted the importance of selecting the correct criteria and sub-criteria, which can have an impact on the final outcomes of the model.

REFERENCES

[1] Zarghaami, M., Ardakanian, R., & Memariani, A. (2007), "Fuzzy Multiple Attribute Decision Making on Water Resources Projects Case Study: Ranking Water Transfers to Zayanderud Basin in Iran," *Water International*, Vol 32 (No.2): 280-293.

[2] Saaty, T. L. (2008), "Decision Making with the Analytic Hierarchy Process," *International Journal of Services Sciences*, Vol 1 (No.1): 83-98.

[3] Zarghami, M., & Szidarovszky, F. (2011), *Multicriteria Analysis, Application to Water and Environment Management*, Heidelberg: Springer.

[4] Daim, T. U., & Kocaoglu, D. F. (2016), *Hierarchical Decision Modeling: essays in Honor of Dundar F. Kocaoglu*, Cham: Springer.

[5] Zarghami, M., Szidarovszky F., & Ardakanian R. (2009), "Multi-Attribute Decision Making on Inter-Basin Water Transfer Projects," *Transaction E: Industrial Engineering*, Vol.16 (No.1):73-80.

[6] Davies, B. R., Thoms, M., & Meador, M. (1992), "An assessment of the ecological impacts of inter-basin water transfers, and their threats to river basin integrity and conservation," *Aquatic Conservation: Marine and Freshwater Ecosystems*, Vol.2 (No.4): 325-349.

[7] Yan, D. H., Wang, H., Li, H. H., Wang, G., Qin, T. L., Wang, D. Y., & Wang, L. H. (2012), "Quantitative analysis on the environmental impact of large-scale water transfer project on

water resource area in a changing environment," *Hydrology and Earth System Sciences*, Vol.16 (No.8): 2685-2702.

[8] Ghassemi, F., & White, I. (2007), *Inter-Basin Water Transfer: Case Studies from Australia, United States, Canada, China and India*, New York: Cambridge University Press.

[9] Sulaiman, A. M. (2016), "Consistency Analysis for Judgment Quantification in Hierarchical Decision Model," *Dissertations and Theses*, Paper 2699.

[10] Saaty T.L., & Vargas L.G. (2012), *The Analytic Hierarchy Process: Planning, Priority Setting, Resource Allocation*, New York: Springer.

[11] Abrishamchi, A., Ebrahimian, A., Tajrishi, M., & Marino, M. A. (2005),"Case study: Application of Multicriteria Decision Making to Urban Water Supply," *Journal of Water Resources Planning and Management*, Vol.131 (No.4): 326-335.

[12] Quan, Y., Wang, C., Yan, Y., Wu, G., & Zhang, H. (2016), "Impact of Inter-Basin Water Transfer Projects on Regional Ecological Security from a Telecoupling Perspective," *Sustainability*, Vol.8 (No.2): 162.

[13] Matete, M., & Hassan, R. (2006), "Integrated Ecological Economics Accounting Approach to Evaluation of Inter-Basin Water Transfers: An Application to the Lesotho Highlands Water Project," *Ecological Economics*, Vol.60 (No.1): 246-259.

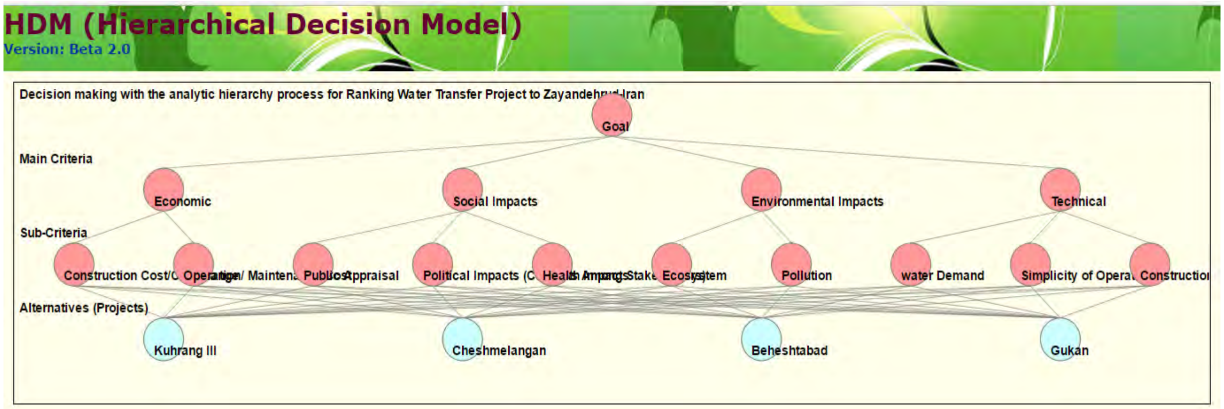
[14] Bogardi, J., Bruk, S., & Vienot, C. (1999), “In Lieu of Conclusions: Some Answers and Many Questions,” *Proceedings of the International Workshop on Interbasin Water Transfer*, *UNESCO*, Paris: 9–16.

[15] Gupta, J., & van der Zaag, P. (2008), “Interbasin Water Transfers and Integrated Water Resources Management: Where Engineering, Science and Politics Interlock,” *Physics and Chemistry of the Earth, Parts A/B/C*, Vol. 33 (No.1): 28-40.

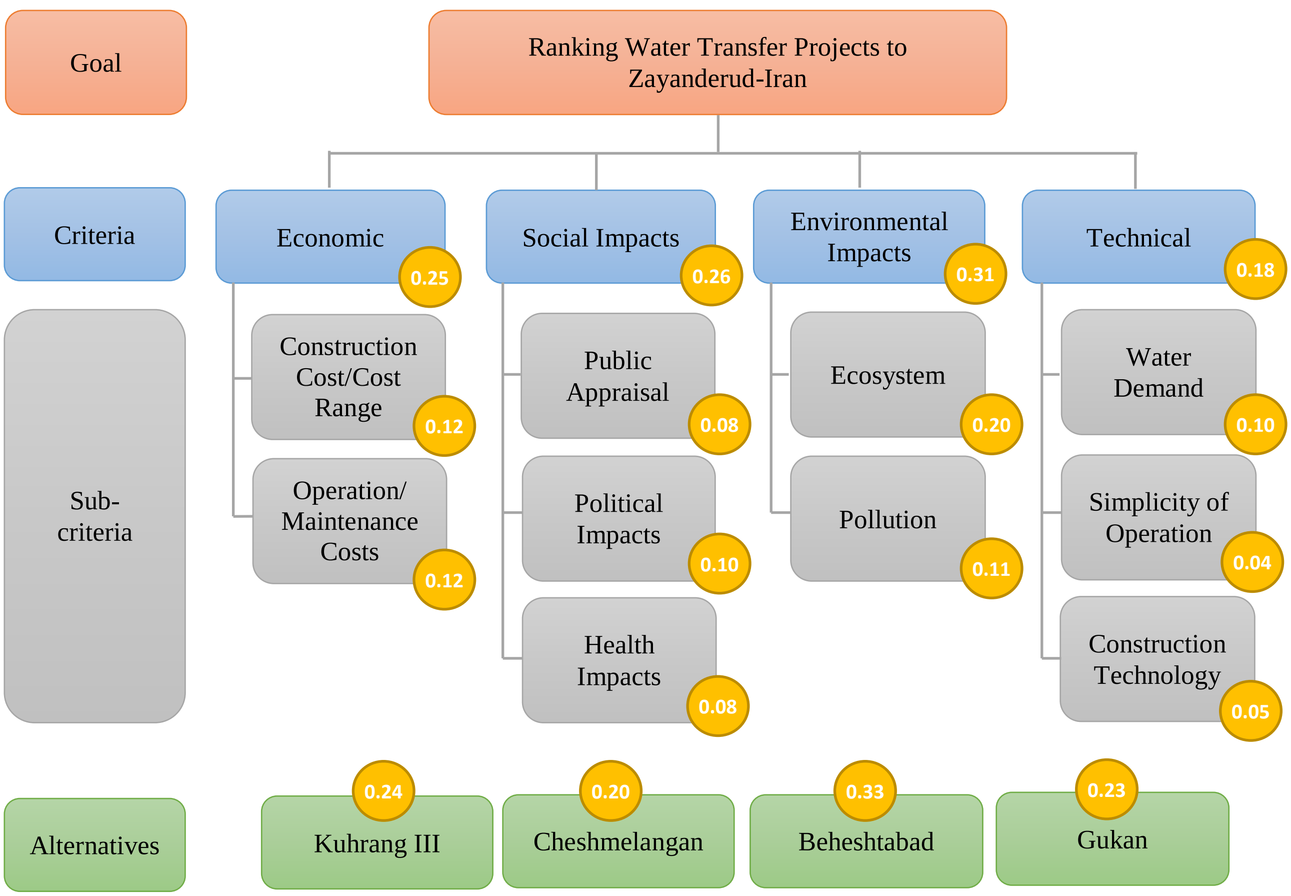
[16] Abrishamchi, A., & Tajrishi, M. (2005), “Interbasin Water Transfer in Iran. In Water Conservation, Reuse, and Recycling,” *Proceedings of an Iranian-American Workshop*: 252-272

[17] Gohari, A., Eslamian, S., Mirchi, A., Abedi-Koupaei, J., Bavani, A. M., & Madani, K. (2013), “Water Transfer as a Solution to Water Shortage: A Fix That Can Backfire,” *Journal of Hydrology*, Vol.491: 23-39.

APPENDIX A – FINAL, QUANTIFIED MODEL



Screenshot of running the model in the ETM-HDM online software



Distribution of decision/normalized weights in the entire model

APPENDIX B – AHP/HDM PCM DATA TABLES

-Screenshot of the final results of the model

Goal	Kuhrang III	Cheshmelangan	Beheshtabad	Gukan	Inconsistency
Ali Bagheri	0.25	0.25	0.25	0.25	0
Alireza Dallalzadeh	0.25	0.16	0.36	0.23	0.01
maryam najibi	0.23	0.18	0.37	0.21	0.01
Maryam Emamjomeh	0.23	0.21	0.35	0.21	0
Mehdi Fasihi Harandi	0.25	0.19	0.35	0.21	0.03
Mehran Afkhami	0.2	0.25	0.24	0.31	0.02
Mehrzad Ehsani	0.24	0.17	0.39	0.2	0.02
Mean	**0.24**	**0.2**	**0.33**	**0.23**	
Minimum	**0.2**	**0.16**	**0.24**	**0.2**	
Maximum	**0.25**	**0.25**	**0.39**	**0.31**	
Std. Deviation	**0.02**	**0.03**	**0.06**	**0.04**	
Disagreement					**0.034**

The statistical F-test for evaluating the null hypothesis (Ho: ric = 0) is obtained by dividing between-subjects variability with residual variability:

Source of Variation	Sum of Square	Deg. of freedom	Mean Square	F-test value
Between Subjects:	0.07	3	.022	**9.71**
Between Conditions:	0.00	6	0.000	
Residual:	0.04	18	0.002	
Total:	**0.11**	**27**		
Critical F-value with degrees of freedom 3 & 18 at 0.01 level:				**5.09**
Critical F-value with degrees of freedom 3 & 18 at 0.025 level:				**3.95**
Critical F-value with degrees of freedom 3 & 18 at 0.05 level:				**3.16**
Critical F-value with degrees of freedom 3 & 18 at 0.1 level:				**2.42**

Screenshot of the final results of the model

Individual analysis results

- Expert-1 analysis results

Level-1	Goal
Economic	0.12
Social Impacts	0.37
Environmental Impacts	0.47
Technical	0.04
Inconsistency	0.02

Level 2	Economic	Social Impacts	Environmental Impacts	Technical
Construction Cost/Cost Range	0.50	0.00	0.00	0.00
Operation/ Maintenance Cost	0.50	0.00	0.00	0.00
Public Appraisal	0.00	0.18	0.00	0.00
Political Impacts (Conflicts Among Stakeholders)	0.00	0.60	0.00	0.00
Health Impacts	0.00	0.22	0.00	0.00
Ecosystem	0.00	0.00	0.80	0.00
Pollution	0.00	0.00	0.20	0.00
water Demand	0.00	0.00	0.00	0.48
Simplicity of Operation	0.00	0.00	0.00	0.26
Construction Technology	0.00	0.00	0.00	0.26
Inconsistency	0.00	0.01	0.00	0.00

Level-3	Construction Cost/Cost Range	Operation/ Maintenance Cost	Public Appraisal	Political Impacts (Conflicts Among Stakeholders)	Health Impacts	Ecosystem	Pollution	water Demand	Simplicity of Operation	Construction Technology
Kuhrang III	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Cheshmelangan	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Beheshtabad	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Gukan	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Inconsistency	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

The final result:

Level-1	Goal
Kuhrang III	0.25
Cheshmelangan	0.25
Beheshtabad	0.25
Gukan	0.25
Inconsistency	0.00

- Expert-2 analysis results

Level-1	Goal
Economic	0.19
Social Impacts	0.31
Environmental Impacts	0.39
Technical	0.11
Inconsistency	0.01

Level-2	Economic	Social Impacts	Environmental Impacts	Technical
Construction Cost/Cost Range	0.75	0.00	0.00	0.00
Operation/ Maintenance Cost	0.25	0.00	0.00	0.00
Public Appraisal	0.00	0.35	0.00	0.00
Political Impacts (Conflicts Among Stakeholders)	0.00	0.42	0.00	0.00
Health Impacts	0.00	0.23	0.00	0.00
Ecosystem	0.00	0.00	0.75	0.00
Pollution	0.00	0.00	0.25	0.00
water Demand	0.00	0.00	0.00	0.48
Simplicity of Operation	0.00	0.00	0.00	0.24
Construction Technology	0.00	0.00	0.00	0.28
Inconsistency	0.00	0.01	0.00	0.00

Level-3	Construction Cost/Cost Range	Operation/ Maintenance Cost	Public Appraisal	Political Impacts (Conflicts Among Stakeholders)	Health Impacts	Ecosystem	Pollution	water Demand	Simplicity of Operation	Construction Technology
Kuhrang III	0.19	0.22	0.28	0.25	0.24	0.29	0.22	0.24	0.34	0.21
Cheshmelangan	0.08	0.18	0.28	0.13	0.17	0.14	0.19	0.21	0.25	0.14
Beheshtabad	0.47	0.36	0.27	0.37	0.33	0.36	0.36	0.38	0.15	0.38
Gukan	0.26	0.24	0.17	0.25	0.26	0.21	0.23	0.18	0.25	0.27
Inconsistency	0.01	0.01	0.05	0.01	0.00	0.00	0.00	0.01	0.01	0.01

The final result:

Level-1	Goal
Kuhrang III	0.25
Cheshmelangan	0.16
Beheshtabad	0.38
Gukan	0.23
Inconsistency	0.01

- Expert-3 analysis results

Level-1	Goal
Economic	0.22
Social Impacts	0.31
Environmental Impacts	0.31
Technical	0.16
Inconsistency	0.01

Level-2	Economic	Social Impacts	Environmental Impacts	Technical
Construction Cost/Cost Range	0.60	0.00	0.00	0.00
Operation/ Maintenance Cost	0.40	0.00	0.00	0.00
Public Appraisal	0.00	0.36	0.00	0.00
Political Impacts (Conflicts Among Stakeholders)	0.00	0.50	0.00	0.00
Health Impacts	0.00	0.14	0.00	0.00
Ecosystem	0.00	0.00	0.75	0.00
Pollution	0.00	0.00	0.25	0.00
water Demand	0.00	0.00	0.00	0.43
Simplicity of Operation	0.00	0.00	0.00	0.31
Construction Technology	0.00	0.00	0.00	0.27
Inconsistency	0.00	0.00	0.00	0.00

Level-3	Construction Cost/Cost Range	Operation/ Maintenance Cost	Public Appraisal	Political Impacts (Conflicts Among Stakeholders)	Health Impacts	Ecosystem	Pollution	water Demand	Simplicity of Operation	Construction Technology
Kuhrang III	0.17	0.19	0.22	0.26	0.25	0.25	0.24	0.24	0.27	0.29
Cheshmelangan	0.10	0.22	0.18	0.17	0.25	0.17	0.20	0.30	0.19	0.19
Beheshtabad	0.54	0.37	0.42	0.37	0.25	0.35	0.36	0.27	0.30	0.28
Gukan	0.20	0.22	0.19	0.21	0.25	0.23	0.20	0.19	0.24	0.24
Inconsistency	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00

The final result:

Level-1	Goal
Kuhrang III	0.23
Cheshmelangan	0.18
Beheshtabad	0.37
Gukan	0.21
Inconsistency	0.01

- Expert-4 analysis results

Level-1	Goal
Economic	0.19
Social Impacts	0.29
Environmental Impacts	0.16
Technical	0.36
Inconsistency	0.02

Level-2	Economic	Social Impacts	Environmental Impacts	Technical
Construction Cost/Cost Range	0.70	0.00	0.00	0.00
Operation/ Maintenance Cost	0.30	0.00	0.00	0.00
Public Appraisal	0.00	0.33	0.00	0.00
Political Impacts (Conflicts Among Stakeholders)	0.00	0.25	0.00	0.00
Health Impacts	0.00	0.43	0.00	0.00
Ecosystem	0.00	0.00	0.50	0.00
Pollution	0.00	0.00	0.50	0.00
water Demand	0.00	0.00	0.00	0.59
Simplicity of Operation	0.00	0.00	0.00	0.13
Construction Technology	0.00	0.00	0.00	0.28
Inconsistency	0.00	0.00	0.00	0.00

Level-3	Construction Cost/Cost Range	Operation/ Maintenance Cost	Public Appraisal	Political Impacts (Conflicts Among Stakeholders)	Health Impacts	Ecosystem	Pollution	water Demand	Simplicity of Operation	Construction Technology
Kuhrang III	0.19	0.19	0.25	0.23	0.25	0.19	0.19	0.27	0.17	0.23
Cheshmelangan	0.11	0.11	0.13	0.25	0.25	0.27	0.27	0.27	0.12	0.17
Beheshtabad	0.47	0.47	0.34	0.28	0.25	0.41	0.41	0.27	0.49	0.33
Gukan	0.22	0.22	0.28	0.24	0.25	0.13	0.13	0.18	0.22	0.26
Inconsistency	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00

The final result:

Level-1	Goal
Kuhrang III	0.23
Cheshmelangan	0.21
Beheshtabad	0.35
Gukan	0.21
Inconsistency	0.00

- Expert-5 analysis results

Level-1	Goal
Economic	0.59
Social Impacts	0.06
Environmental Impacts	0.04
Technical	0.31
Inconsistency	0.08

Level-2	Economic	Social Impacts	Environmental Impacts	Technical
Construction Cost/Cost Range	0.25	0.00	0.00	0.00
Operation/ Maintenance Cost	0.75	0.00	0.00	0.00
Public Appraisal	0.00	0.22	0.00	0.00
Political Impacts (Conflicts Among Stakeholders)	0.00	0.38	0.00	0.00
Health Impacts	0.00	0.40	0.00	0.00
Ecosystem	0.00	0.00	0.90	0.00
Pollution	0.00	0.00	0.10	0.00
water Demand	0.00	0.00	0.00	0.98
Simplicity of Operation	0.00	0.00	0.00	0.01
Construction Technology	0.00	0.00	0.00	0.01
Inconsistency	0.00	0.00	0.00	0.00

Level-3	Construction Cost/Cost Range	Operation/ Maintenance Cost	Public Appraisal	Political Impacts (Conflicts Among Stakeholders)	Health Impacts	Ecosystem	Pollution	water Demand	Simplicity of Operation	Construction Technology
Kuhrang III	0.25	0.25	0.18	0.21	0.56	0.25	0.25	0.23	0.25	0.25
Cheshmelangan	0.25	0.25	0.12	0.08	0.08	0.25	0.25	0.10	0.25	0.25
Beheshtabad	0.25	0.25	0.59	0.52	0.26	0.25	0.25	0.55	0.25	0.25
Gukan	0.25	0.25	0.11	0.19	0.10	0.25	0.25	0.13	0.25	0.25
Inconsistency	0.00	0.00	0.04	0.13	0.10	0.00	0.00	0.16	0.00	0.00

The final result:

Level-1	Goal
Kuhrang III	0.25
Cheshmelangan	0.19
Beheshtabad	0.35
Gukan	0.21
Inconsistency	0.03

- Expert-6 analysis results

Level-1	Goal
Economic	0.21
Social Impacts	0.24
Environmental Impacts	0.38
Technical	0.17
Inconsistency	0.00

Level-2	Economic	Social Impacts	Environmental Impacts	Technical
Construction Cost/Cost Range	0.39	0.00	0.00	0.00
Operation/ Maintenance Cost	0.61	0.00	0.00	0.00
Public Appraisal	0.00	0.29	0.00	0.00
Political Impacts (Conflicts Among Stakeholders)	0.00	0.26	0.00	0.00
Health Impacts	0.00	0.45	0.00	0.00
Ecosystem	0.00	0.00	0.35	0.00
Pollution	0.00	0.00	0.65	0.00
water Demand	0.00	0.00	0.00	0.41
Simplicity of Operation	0.00	0.00	0.00	0.20
Construction Technology	0.00	0.00	0.00	0.39
Inconsistency	0.00	0.01	0.00	0.01

Level-3	Construction Cost/Cost Range	Operation/ Maintenance Cost	Public Appraisal	Political Impacts (Conflicts Among Stakeholders)	Health Impacts	Ecosystem	Pollution	water Demand	Simplicity of Operation	Construction Technology
Kuhrang III	0.26	0.16	0.17	0.17	0.20	0.26	0.15	0.20	0.22	0.25
Cheshmelangan	0.17	0.29	0.26	0.27	0.28	0.22	0.27	0.24	0.24	0.21
Beheshtabad	0.21	0.23	0.32	0.27	0.29	0.18	0.23	0.22	0.21	0.28
Gukan	0.35	0.31	0.25	0.29	0.23	0.34	0.34	0.34	0.34	0.26
Inconsistency	0.04	0.02	0.02	0.03	0.00	0.02	0.01	0.02	0.01	0.04

The final result:

Level-1	Goal
Kuhrang III	0.20
Cheshmelangan	0.25
Beheshtabad	0.24
Gukan	0.31
Inconsistency	0.02

- Expert-7 analysis results

Level-1	Goal
Economic	0.20
Social Impacts	0.24
Environmental Impacts	0.44
Technical	0.12
Inconsistency	0.00

Level-2	Economic	Social Impacts	Environmental Impacts	Technical
Construction Cost/Cost Range	0.30	0.00	0.00	0.00
Operation/ Maintenance Cost	0.70	0.00	0.00	0.00
Public Appraisal	0.00	0.40	0.00	0.00
Political Impacts (Conflicts Among Stakeholders)	0.00	0.35	0.00	0.00
Health Impacts	0.00	0.25	0.00	0.00
Ecosystem	0.00	0.00	0.50	0.00
Pollution	0.00	0.00	0.50	0.00
water Demand	0.00	0.00	0.00	0.51
Simplicity of Operation	0.00	0.00	0.00	0.29
Construction Technology	0.00	0.00	0.00	0.21
Inconsistency	0.00	0.00	0.00	0.02

Level-3	Construction Cost/Cost Range	Operation/ Maintenance Cost	Public Appraisal	Political Impacts (Conflicts Among Stakeholders)	Health Impacts	Ecosystem	Pollution	water Demand	Simplicity of Operation	Construction Technology
Kuhrang III	0.24	0.23	0.24	0.37	0.20	0.20	0.24	0.19	0.31	0.25
Cheshmelangan	0.11	0.18	0.15	0.09	0.18	0.18	0.19	0.16	0.34	0.16
Beheshtabad	0.41	0.37	0.55	0.39	0.35	0.44	0.35	0.40	0.17	0.35
Gukan	0.24	0.23	0.06	0.16	0.27	0.19	0.22	0.25	0.18	0.24
Inconsistency	0.02	0.01	0.00	0.16	0.03	0.00	0.00	0.01	0.01	0.01

The final result:

Level-1	Goal
Kuhrang III	0.24
Cheshmelangan	0.17
Beheshtabad	0.39
Gukan	0.20
Inconsistency	0.02