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The method of Analytic Hierachy Process AHP in selecting solution for sustainable exploitation and use to ensure domestic water source and agriculture for water shortage areas in Son La Province

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Abstract: Analytical Hierarchy (AHP) method is a quantitative analysis method and it is widely used to compare alternative options especially in water resources sector. Instead of requiring a large amount of data, this method uses expert opinion and does not require too much numerical data. Therefore, it is suitable for the selection and determination of criteria on water sources, exploitation conditions, socio–cultural, environmental, economic, technical and technological, management and environmental criteria. exploiting and ensuring water supplement for domestic use and agriculture in the water shortage areas of Son La province. This paper introduces the method and apply the method to ensure which explotation solutions are sustainable and suitable for each region with different conditions in Son La province, evaluate the The criteria then serve as a basis for proposing solutions for exploitation and use for each water source.

Keywords: Method of hierarchical analysis; Decision making; Sustainable use of buildings.

1. Introduction

Nowadays, the interrelationship between water resources and social and economic and technical conditions are considered when selecting water exploitation solutions in the world as well as in Viet Nam. The method to assess the sustainability of the solutions that use water sources directly or indirectly, simple or complex, is choosen due to the availablity of data. Normally, the sustainable exploitation of water–using solutions is composed of three factors: water source; socio–economic and technical conditions. For exploitation works use water sources sustainably on economic–financial aspects when the investment rate of the project is low, the cost per cubic meter of water is low and the management, operation and repair and upgrade costs ensure the balance between income and expenditure.

Sustainability in technology is achieved when the local community or the project management unit exploiting and using the water source can master the technical operation of the works and resolve the technical problems of the works on time. Financial, social and technical aspects of sustainability are interrelated. Analytical Hierarchy Process (AHP) is one of the multi–objective decision making methods proposed by [1] a mathematician from Iraq. AHP is a quantitative method, used to sort decision alternatives and select an alternative that satisfies given criteria. The AHP method was created to help to solve complex decision problems [2]. The AHP method has been widely applied to many fields, especially in the field of natural sciences. AHP is used as a flexible tool for decision analysis with multiple criteria, allowing decision criteria based on multiple attributes, which refers to a quantitative technique. Multicriteria methods are used to make decisions of problems composed of intangible aspects or with qualitative variables to evaluate. These methods do not consider the possibility of finding an optimal solution to a problem, but the solution depends on the predefined objective (s) [3]. The AHP provides the feasibility of including quantitative and qualitative data that in a "normal" analysis are left out because of their difficulty in measuring but relevant in obtaining the objective [4]. [5] applied AHP to deal with economic, political, social and engineering design problems, architectural pattern selection, pricing strategy, technology selection, planning, conflict resolution, benefit/cost analysis and resource allocation, etc. Currently, the AHP method is becoming more and more popular with the support of specialized software Expert Choice. Although the AHP method is used in water sustainability assessment, it is better to consult a group of experts to avoid bias and groups make better decisions than individuals, because groups are accepted to be more knowledgeable than individuals [6]. Hence, the standard AHP has been extended as group AHP in group decisions [7–9]. [10] used linear mixed models based on the regression approach to estimate the decision weights of AHP instead of using the geometric means for aggregating experts' judgments.

Some studies on the application of AHP are as follows: [11] has applied the utilizing analytic hierarchy process (AHP) for decision making in water loss management of intermittent water supply systems. [12] was used the AHP (Analytical Hierarchy Process) to highlight the distribution of groundwater recharge areas in the Moldavian Plain area by assigning weight factors to each thematic layer. In the realization of the study were used thematic layers such as drainage density, slope, land use, precipitation distribution, groundwater level, soils, lithology. For the final map, we used the weighted overlay toolbox from the ArcGis software, giving the weight factor for each thematic layer. PIM Consulting Center - Vietnam Institute of Irrigation Science [13] has applied the analytic hierarchical method (AHP) in the selection of design options for Irrigation projects. [14] used an Analytic Hierarchy Process (AHP) to select construction method alternatives. Use of AHP Method in Efficiency Analysis of Existing Water Treatment Plants. [15] has been evaluation model of regional water supply capacity based on AHPCRITIC method. This paper aims at evaluating the ability of a region to provide clean water to meet the needs of its population by establishing a multi-index comprehensive evaluation model. According to the UN water scarcity map, Australia was selected as the representative region to be evaluated by the model in order to analyze the reason of its water shortage. [16] presents the application of the Analytic Hierarchy Process (AHP) related to the operation of the drinking water supply network of the city of Chihuahua, Mexico, where two possible alternatives are delineated with the objective to optimize the service. [17] has been undertaken with an objective to delineate the groundwater potential of a small tropical river basin located in the western side of the Western Ghats in India as an example. A combination of geographical information system and analytical hierarchical process techniques (AHP) was used in the present study.

With the available information of each technical option for exploitation and use of water in extremely difficult areas (information about water sources, information on social and environment, information on economic and technical...), the AHP hierarchical analysis method will be applied in this study. This method is useful to select and determine criteria on water sources, exploitation conditions, socio–cultural, environmental, economic, and social aspects, technology, management and exploitation to ensure water supplement for domestic use and agriculture in water shortage areas of Son La province. AHP hiearchical analysis limits subjectivity and ensures the suitability and harmony among specific objectivess of each project.

2. Materials and Methods

2.1. Study area

Son La is a mountainous province in the Northwest with dangerous terrain, very complex and strongly divided. As a consequence, the water distribution is temperally and spacially variable, i.e., the exceed water causes floods while the water shortage derives drought, some areas have the abundant water sources while water in other areas is very limited. The water scarecity leads to many difficulties for productions and lifes of local people. According to Decision No. 900/QD–TTg of the Prime Minister dated June 20, 2017 approving the list of extremely difficult communes, border communes, and safe zone communes into the investment category of the 135 program. From 2017 to 2020, Son La province had 118 extremely difficult communes eligible for investment, including 7 communes in Yen Chau district, 15 communes in Phu Yen district, 7 communes in Sop Cop district, 10 communes in Van Ho district, 14 communes in the district. Bac Yen, 13 communes in Muong La district, 22 communes in Thuan Chau district, 8 communes in Mai Son district, 5 communes in Moc Chau district, 15 communes in Ma river district, 2 communes in Quynh Nhai district. Among the above–mentioned extremely difficult communes, there are 20 special water shortage communes in Bac Yen districts (Hong Ngai, Chim Van, Hua Nhan, Lang Cuu), Muong La (Chieng Muon, Chieng Lao, Hua Trai, etc.) Nam Gion, Pi Toong, Ta Bu), Phu Yen (Huy Tan), Quynh Nhai (Muong Sai), Ma River (De Mon, Nam Ty), Sop Cop (Sam Kha), Thuan Chau (Bo Muoi, Co Tong) and Yen Chau (Chieng Dong, Chieng Tuong), Van Ho (Long Luong). According to the report of the Department of Agriculture and Rural Development of Son La province [3], the total number of concentrated water supply works in the province is currently 1548 works; the number of rural households granted from the concentrated works is 109,449.0 households; there are 54 sustainable works, 226 relatively sustainable works, 852 unsustainable works and 443 inactive works. The works stop working because (i) the inefficient operation management model led to the highrate of water loss; (ii) flood and rain washed away the main items of the works but; (iii) water sources for the works are gradually reduced and exhausted, the incoming flows are polluted due to cultivation and agricultural production by people in the region.

2.2. Research framework

The proposed technical solution includes a group of solutions for exploitation solutions using rainwater, surface water, and underground water sources. The sustainability of a solution to exploit and use water is considered as a function of the criteria of water sources (NN), social criteria (social) and economic and technical criteria (KT) according to the following formula:

$$E = f(NN, XH, KT) \tag{1}$$

where E is the sustainability index of the solution to exploit and use water; NN is the criterion of water source; Social is the criterion of society; KT is the economic and technical criteria.

Results of the project "Research to identify water sources and solutions for domestic and agricultural water supply for water shortage areas in Son La province" [3] identified areas with scarcity level of surface water in Son La province (Figure 1).

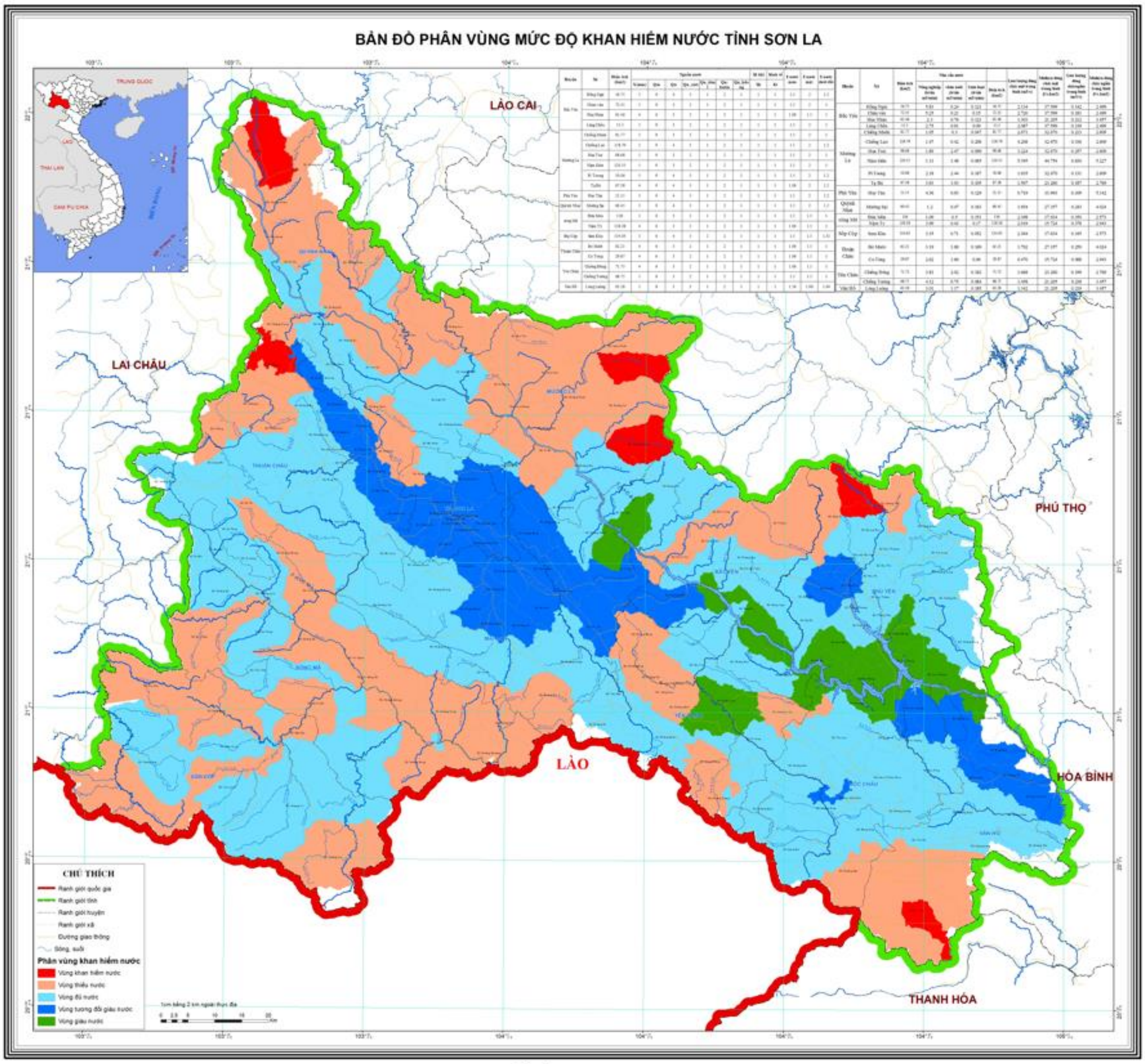

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Figure 1. Map of location of communes with special difficulties in water scarcity in Son La province La.

The analysis and assessment of natural, socio–economic, and cultural norms on using water as well as the current status of water exploitation solutions in mountainous areas and especially difficult communes show that the water source criteria is the most important and followed by the social criteria to meet social security. After consulting experts, the weight of each criterion is determined as follows: WNN = 0.5; WXH = 0.3 and WKT = 0.2. Specifically, the criteria are determined as follows [18]:

Criteria on water sources

- For rainwater: high potential with average rainfall $X_0 > 2,500$ mm/year); medium potential with $1,200 < X_0 \leq 2,500$ mm/year); small potential with $X_0 \leq 1,200$ mm/year)

- For surface water: Average surface flow module is from 60 l/s–km^2 to 80 l/s–km^2 in the area for additional water supply; Average surface flow module is from 40 l/s–km^2 to < 60 l/s–km^2 in the area for additional water supply; Average surface flow module is from 30 l/s–km^2 to < 40 l/s–km^2 in the area for additional water conveyance; Average surface flow mode is from 20 l/s–km^2 to < 30 l/s–km^2 in the area for additional water supply; Average surface flow module is < 20 l/s–km^2 in the area for the additional water supply.

- For underground water sources: Potentially rich ($M_d \geq 500$ m^3/day/km^2) water source (exploitable reserve); Potentially median (reservable reserves) water source ($200 \leq M_d <$ 500 m^3/day/km^2); Potential poor (exploitable reserve) water sources (Md < 200

m^3/day/km^2); There are results of research, investigation and assessment of underground water resources by hydrogeological research boreholes with water flow and quality that ensure sufficient exploitation conditions, or have drilled wells being exploited for concentrated water supplycentral; There are results of research, investigation and assessment of underground water resources by hydrogeological research boreholes, but the flow and quality of water have not yet met the conditions for exploitation; There are no results of research, investigation and assessment of underground water resources by hydrogeological research boreholes; There are results of research, investigation, assessment of underground water resources and identification of a route with a flow and quality that meets the conditions for concentrated water supply exploitation (> 1 l/s), and an important route. at least 1 year of hydrology or water injection testing at the piezometers; There are results of research, investigation, assessment of underground water resources and identification of an piezometer with a flow and quality that meets the conditions for concentrated water supply exploitation (Q = 0.1–1 l/s) , the spring has not been observed for at least 1 hydrological year or has not been pumped for testing at the piezometers; There are results of research, investigation and assessment of underground water resources, and it is determined that there is an spring with a flow that ensures a single water supply for a small population cluster (Q < 0.1 l/s), and the spring has been observed less than 1 hydrological year or pumped to test water at the piezometers; There are results of research, investigation, assessment of underground water resources and determination of groundwater level in shallow areas (Ht < 10 m), results of research on water extraction from dug wells; There are results of research, investigation, assessment of underground water resources and determination of groundwater level in shallow areas (Ht < 10 m), but no results of research on water extraction from dug wells; There are results of research, investigation, assessment of underground water resources and determination of groundwater level in relatively deep areas (Ht > 10 m), but no results of research on water extraction from dug wells; There are results of cave investigation, detailed study and assessment that it is capable of exploitation but has not yet been invested in exploiting or is being exploited effectively; There are preliminary investigation and research results, but there are works being exploited; No investigation, preliminary research and no exploitation works.

Social criteria

- The center of a township is an area with high population density, ability to construct works for concentrated water supply, economic conditions affordable to pay for water supply services to make the works operate regularly.

- The center of the communes is an area with relativehigh population density, ability to construct works for concentrated water supply, and economic conditions affordable to pay for water supply services to make the works operate regularly.

- The villages and hamlets in communes, townships and townships have low population density and scattered population, is unable to exploit the works for centralized water supply, and economic conditions not affordable to pay for water supply services.

Economic technical criteria

- The center of a town or township is an area with good technical infrastructure conditions, which is very convenient for investigation as well as exploitation and operation of water supply works. The method of exploitation and use of water has an investment rate (calculated for 27 years) of less than 500 VND/m^3.

- The center of communes with relatively good technical infrastructure conditions makesinvestigation, exploitation and operation of water supply works convenient, Models and solutions for exploitation and use of water with high investment rate (calculated for 27 years) reaches 500–1000 VND/m^3.

- Villages in communes, townships and townships have less favorable technical infrastructure conditions for investigation as well as exploitation and operation of water supply works, Exploitation models and solutions using water with investment rate (calculated for 27 years) greater than 1,000 VND/m^3.

2.3. *The method of hierarchical analysis in AHP in the selection of AHP technical solution options by [19] researched and then developed in the 80s. This method calculate weights to apply for multi–criteria decision problems*

The calculation process consists of six main steps:

1. Decompose an unstructured situation into small pieces.
2. Build the AHP hierarchical tree.
3. Assign numerical values to subjective comparisons of the importance of criteria in decision making.
4. Calculate the weight of the indicators.
5. Consistency check
6. Aggregate results to make final rating

a) Build AHP hierarchy tree

After going through step 1, decompose the problem into small components, hierarchical tree AHP will be built around selection criteria and possibilities.

Based on the pairwise comparison principle, the AHP method can be described with 3 main principles, namely analysis, evaluation and synthesis. AHP answers questions like “Which option should we choose?” or “Which option is best?” by selecting the best alternative that satisfies the decision maker's criteria on the basis of comparing pairs of alternatives and a specific computational mechanism. Suppose we have a problem to make a decision (called an objective), which must be based on many criteria (Criterion C_1, Criterion C_2, ..., Criterion Cn). The alternatives that can be compared are PA_1, PA_2, … PA_m. The problems of the problem are modeled in Figure 2.

The method of hierarchical analysis to calculate the weights (importance coefficients) and the impact intensity hierarchy of the component factors is used by the American mathematician Saaty and a number of authors in the world as well as in Vietnam to quantitatively evaluate the intensity of the processes. This theory divides impact intensity (j) into 5 levels: 1, 3, 5, 7, 9 and provides a scale to compare the importance of impact factors. Saaty used the expert method to compare more than 5 levels of impact factors (1, 3, 5, 7, 9) and compare losses at 5 levels (1, 1/3, 1/5, 1/7, 1/9) on a square matrix of order n (n is the number of impact drivers used for comparison) (Table 1). In which, Saaty prescribes that the principal diagonal of the square matrix has a value of 1. This matrix shows that if the important index of factor A to B is n, then vice versa the importance ratio of B to factor A is 1/n. Based on the scale, a comparison matrix between the influencing factors can be established. After that, the weights for each component class is calculated by using the Eigen principle vector (the Eigen principle vector can be approximated by dividing each value of each column by the total number of values in that column to establish a new matrix, then the average value per row of the new matrix is the weight of the influencing factor with values from 0 to 1).

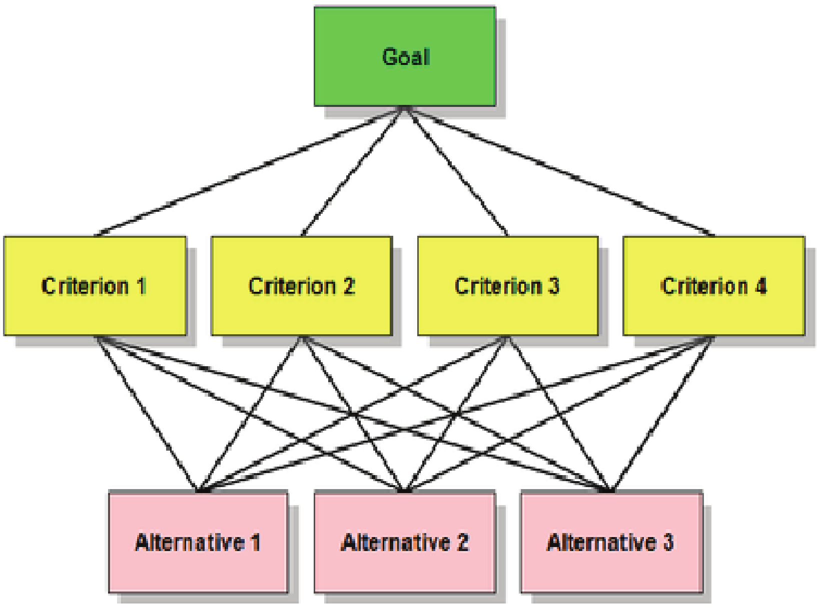

Figure 2. The diagram describes the hierarchical analysis problem [1].

Saaty's AHP method [1] compares two factors according to the principle that if factor A is more important than factor B, then A/B > 1 and vice versa, A is less important than B, then A/B < 1. If A and B are equally important, then A/B = 1. And the importance of A over B increases as the A/B ratio increases. And conversely, the smaller the A/B ratio, the lower the importance of A relative to B. Saaty offers the following scale for a "smart pairwise comparison".

Table 1. AHP's smart pairwise comparison table.

<< Less important					More important >>			
1/9 Less important many times	1/7 less important Much	1/ 5 less important Much less important Much	1/3 less important	1 Equally	3 important	5 More important Much more	7 important Much more important Much more	9 important many times

With the above comparison principle, a matrix of comparison pairs is created. And from this matrix, according to the Eigen Principle Vector, a "set of best–fit weights" can be calculated. Calculate the weight for each factor J in the factor in the set of factors using the Eigen principle vector method by dividing each value in each column by the total value in that column to establish the matrix, the average value on each row of the matrix is the weight of the influencing factors with values from 0 to 1.

The "Smart Pairwise Comparison" method can be clearly analyzed through the following example (5 factors) with the corresponding scores of 1, 3, 5, 7 and 9): Give the factors affecting the occurrence of hazards: A, B, C, D, E and build a matrix to compare smart pairs as in Table 2.

Table 2. Matrix of factors comparison.

Factors	A(1)	B(3)	C(5)	D(7)	E(9)
A(1)	1	3	5	7	9
B(3)	1/3	1	1.67	2.33	3
C(5)	1/5	1/3	1	1.4	1.80
D(7)	1/7	1/5	1/3	1	1.29
E(9)	1/9	1/7	1/5	1/3	1

Calculations of the Eigen principle vector can be approximated manually when dividing the value of the column by the total value of the scores in this column. This gives a matrix with new values between 0 and 1 when the sum of the column values equals 1. The mean of the rows in this matrix corresponds to the weights for that criterion [1]. Based on this matrix, following the Eigen Principle Vector with Jones's weighting method [18], the following combination of appropriate weights can be calculated: A = 0.59; B = 0.20; C = 0.11; D = 0.07; E = 0.04.

The comparison of the criteria in pairs and their importance is implemented. The priorities (aij values, with i running in rows, j running in columns) in pairs of criteria have positive integer values from 1 to 9 or the reciprocal of these numbers we get a matrix square (n × n) as Table 1. The coefficient of the matrix is obtained from the score of the pairwise comparison between components, factors or criteria. Value pairwise comparisons are made through expert opinion. The value of the correlation matrix coefficient is completely dependent on the subjectivity of the researcher in quantifying the weights for the objectives, which is a drawback of this method.

b) Building a matrix to compare indicators

This comparison is made between pairs of indicators and aggregates them into a matrix of n rows and n columns (n is the number of indicators). The element *aij* represents the importance of the index row *i* compared to the index column *j*.

$$A = (a_{ij})_{n\times n} = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ a_{21} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ a_{n1} & a_{n2} & \cdots & 1 \end{bmatrix}$$

The relative importance of indicator i to j is calculated by the ratio k (k from 1 to 9), vise versace importance of indicator j to i is i is 1/k. So $a_{ij} > 0$, $a_{ij} = 1/a_{ji}$, $a_{ii} = 1$.

c) Summarizing results

After calculating the weights of the criteria as well as of the options for each criterion, the above values will be summed up to obtain the appropriate index of each option according to the following formula:

$$Wis = \Sigma wijs * wjamj = 1,\ i=1,...\ n$$

where wijs is the weight of option i corresponding to the criterion j; wja is the weight of indicator j; n is the number of alternatives; m is the number of indicators.

3. Results and discussion

3.1. Determin and estimate weigh factors

a) Create the matrix of importance among factors

To determine the weight W for each influencing factor or the importance of each factor, it is necessary to build a matrix of importance for the influencing factors. Comparison of importance between pairs of factors is carried out qualitatively based on expert consultation, previous studies to determine which factor's influence is more important, collected data and documents to verify the results. The estimated importance matrix for the factors are as shown in Table 3.

Table 3. Matrix of importance for the factors [A].

No.	Factor	KH	Surface water	Flow Under ground flow	Rainfall	Rate underground flow volume exploited through centralized water supply works	Underground flow volume exploiting the main road	Flow rate undergroun d flow for testing	Water exploitation underground flow rate of cave mining	Society	Economy
1	Surface water volume	Qm	1	2	3	4	5	6	7	8	9
2	Rainfall	X	0.5	1	3	3	5	5	7	7	9
3	Underground flow rate	Qn	0.33	0.33	1	3	3	5	7	7	Underground
4	Flow discharge concentrated water	Qn_cntt	0.25	0.33	0.33	1	3	3	5	5	7
5	Underground flow rate of mainline exploitation	Qn_dtml	0.2	0.2	0.33	0.33	1	3	3	3	5
6	Experimental groundwater intake flow	rate Qn–huttn	0.17	0.2	0.2	0.33	0.33	1	3	5	5
7	Underground flow of cave mining	Qn_hdong	0.14	0. 14	0.2	0.2	0.33	0.33	1	3	5
8	Socio–economic	0.14	0.14	0.2	0.2	0.33	0.2	0.33	1	3	9
	Economical	0.11	0.14	0.14	0.2	0.2	0.33	1	Total	2.83	4.46
	0.13		8.35	12.21	18.2	23.73	31.53	39.33	51	b	.

b) Determine the weight for each factor

The weight will be calculated based on the importance of factors. The values of weights are shown in Table 4.

Table 4. Matrix of Variations & Weights [B].

No.	Factor	KH	Surface water volume Surface water	Flow Subterranean runoff	Volume Rainfall	Flow through concentrated water supply works	Underground flow volume exploiting open circuit	Flow rate underground water suction experiment	Flow rate underground flow of cave exploitation	Social	Economy	Weight W [B]
1	Surface water flow	Qm	0.35	0.45	0.36	0.33	0.27	0.25	0.22	0.2	0.18	0.29
2	Rainfall	X	0.18	0.22	0.36	0.25	0.27	0.21	0.22	0.18	0.18	0.23
3	Underground runoff	Qn	0.12	0.07	0.12	0.25	0.16	0.21	0.16	0.18	0.14	0.16
4	Underground runoff Centralized water supply system	Qn_cntt	0.09	0.07	0.04	0.08	0.16	0.13	0.16	0.13	0.14	0.11
5	Outflow underground water flow	rate Qn_dtml	0.07	0.04	0.04	0.03	0.05	0.13	0.1	0.08	0.1	0.07
6	Experimental groundwater intake flow	rate Qn–huttn	0.06	0.04	0.02	0.03	0.02	0.04	0.1	0.13	0.1	0.06
7	Underground flow of cave mining	Qn_hdong	0.05	0.03	0.02	0.02	0.02	0.01	0.03	0.08	0.1	0.04
8	Social	0.04	0.03	0.02	0.02	0.02	0.01	0.01	_	0.03	0.06	0.03
9	Economic	0.04	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.02	0.02	_
	Total		1	1	1	1	1	1	1	1	Society	1

c) Check the fitness of the weights

The fitness of the weights is started with the determination ofthe weight sum vector and the consistency vector.

The weight vector is a matrix [C] calculated by [C] = [A]×[B].

Table 5. Weight vector [C] determined by factors.

No.	Factor	KH	[C]=[A]×[B]
1	Surface water discharge	Qm	3.01
2	Rainfall	X	2.43
3	Underground runoff	Qn	1.67
4	underground flow through the centralized water supply facility	Qn_cntt	1.15
5	Outflow groundwater exploitation of the highway	Qn_dtml	0.72
6	Experimental underground flow	rate Qn–huttn	0.58
7	underground flow ratecave mining	Qn_hdong	0.37
8	Social	Xh	0.24
9	Economic economic	0.15	Consistency

Vector [D] is calculated according to the formula = [C]/[B].

Table 6. The consistency vector [D] is determined according to the factors.

No.	Factor	KH	[D]=[C]/[B]
1	Surface water discharge	Qm	10.33
2	Rainfall	X	10.60
3	runoff	Qn	10.66
4	Undergroundunderground flow volume exploited through the centralized water supply works	Qn_cntt	10.32
5	Underground flow volume exploited on the main road	Qn_dtml	10.25
6	Experimental underground water flow volume	Qn–huttn	9.68
7	Underground flow volume exploiting caves Qn_hdong	Xh	9.22
8	Social	KT	9.23
9	Economic	9.50	Consistency

- Index CI = 0.122
- RI is a random index corresponding to 9 factors, look up the table RI = 1.45
- Consistency ratio CR = 0.08 ≤ 0.1

d) Rating scale for each indicator

Based on the opinions of experts, through the workshop and based on the data situation, applicability of the model and the criteria identified above, a 10–point scale is proposed for each indicator. Assessment results for communes with special difficulties in water resources is shown in Table 7. According to the results summaried in Table 7, the total score is analyzed to assess the sustainability of the solutions to exploit and use water sources as below:

- Very sustainable: E > 2.5 points: in which the criterion of water source must be very sustainable
- Sustainable: 1.5 < E ≤ 2.5 points: in which the criterion of water source must be sustainable
- Unsustainable: E ≤ 1.5 points

Table 7. Assessment results for communes with special difficulties in water resources based on the assessment criteria.

District	Commune	Area (km^2)	Water source							Society	Economy	E rain water	Surface water	Groun dwater	Proposed solutions
			X (mm)	Qm	Qn	Qn_ cntt	Qn_ dtml	Qn- huttn	Qn_ hdong	Xh	Kt				
Bac Yen	Hong Ngai	56.75	5	9	4	3	1	2	1	1.0	1.0	1.50	2.00	1.20	Exploiting springs
	Chim Van	72.35	5	9	3	2	1	2	1	1.0	1.0	1.50	2.00	1.00	Building reservoirs, hanging tanks
	Hua Nhan	61.46	4	6	3	2	1	2	1	1.0	1.0	1.06	1.50	1.00	Building reservoirs, hanging tanks
	Lang Cheu	55.5	5	9	3	2	1	2	1	1.0	1.0	1.50	2.00	1.00	Building reservoirs,

District	Commune	Area (km^2)	Water source							Society	Economy	E rain water	Surface water	Groundwater	Proposed solutions
			X (mm)	Qm	Qn	Qn_cntt	Qn_dtml	Qn-huttn	Qn_hdong	Xh	Kt				
															hanging tanks
Muong La	Chieng Muon	81.77	5	9	3	2	1	2	1	1.0	1.0	1.50	2.00	1.00	Building reservoirs, hanging tanks
	Chieng Lao	128.79	5	9	4	3	1	2	1	1.0	1.0	1.50	2.00	1.20	Exploiting springs + Building reservoirs, hanging tanks
	Hua Trai	98.68	5	9	3	2	1	2	1	1.0	1.0	1.50	2.00	1.00	Building reservoirs, hanging tanks
	Nam Gion	120.55	5	9	3	2	1	2	1	1.0	1.0	1.50	2.00	1.00	Exploiting springs + Building reservoirs, hanging tanks
	Pi Toong	50.06	5	9	4	3	1	2	1	1.0	1.0	1.50	2.00	1.20	Exploiting springs + Building reservoirs, hanging tanks
	Ta Bu	67.38	4	9	4	3	1	2	1	1.0	1.0	1.06	2.00	1.20	Building reservoirs, hanging tanks
Phu Yen	Huy Tan	21.15	5	9	4	3	1	2	1	1.0	1.0	1.50	2.00	1.20	Exploiting springs
Quynh Nhai	Muong Sai	60.45	5	9	4	3	1	2	1	1.0	1.0	1.50	2.00	1.20	Exploiting springs
sông Mã	Daa Mon	136	5	6	3	2	1	2	1	1.0	1.0	1.50	1.50	1.00	Building reservoirs, hanging tanks
	Nậm Ty	128.38	4	6	3	2	1	2	1	1.0	1.0	1.06	1.50	1.00	Building reservoirs, hanging tanks
Sop Cop	Sam Kha	134.03	5	6	4	3	2	2	1	1.0	1.0	1.50	1.50	1.32	Exploiting springs
Thuan Chau	Bo Muoi	62.21	4	6	3	2	1	2	1	1.0	1.0	1.06	1.50	1.00	Exploiting springs + Building reservoirs, hanging tanks
	Co Tong	29.87	4	6	3	2	1	2	1	1.0	1.0	1.06	1.50	1.00	Exploiting springs + Building reservoirs, hanging tanks
Yen Chau	Chieng Dong	71.73	4	6	3	2	1	2	1	1.0	1.0	1.06	1.50	1.00	Exploiting springs + Building reservoirs, hanging tanks
	Chieng Tương	68.75	5	6	3	2	1	2	1	1.0	1.0	1.50	1.50	1.00	Building reservoirs, hanging tanks
Van Ho	Long Luong	63.28	5	8	3	3	1	2	1	1.2	1.0	1.56	1.96	1.04	Building reservoirs, hanging tanks

4. Conclusion

It is no doubt that when there is not enough data to calculate for the alternative selection, especially for mountainous areas with special difficulties such as in Son La province, the AHP method proves to be useful. By comparing pairs of criteria based on their importance to water resources, society and economy, to establish solutions for sustainable exploitation and use to ensure water sources for domestic and agricultural use.

industry for water–deficient areas, then compare and evaluate each pair of options based on the priority of selection if each criterion is considered separately, and combine these evaluation angles, the results of comprehensive comparison are explicitly more convincing. The article applies for Son La province, based on a set of comparison criteria to illustrate the application of the solution. When there are more comparison criteria, detailed evaluation results of the criteria, it is possible to use specialized software, or group the criteria into more groups and solve the problem combined with the analytical Network (Analytical Network Process) to better reflect reality as well as save more computation time.

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