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Investment Methods in Sustainable Water Resource Management Using SAW Method

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ABSTRACT: Water crisis resource management originates from limited resources has made it essential to study the prioritization of traditional and modern methods of sustainable water resource management. The objective of such studies is to provide a list of prioritized traditional and modern methods of sustainable water resource management. This research aims to study rainwater harvesting method and qanat as two traditional methods of water production and transfer. cisterns (Ab Anbars) and the water consumption patterns in Persian gardens are considered as two traditional and sustainable methods of water storage and consumption. The modern methods have been extracted from the Tennessee standard. From the existing methods, using ground slope for water transfer, adjusting water pressure based on consumption rate, qanat, cistern, rainwater harvesting system, drip irrigation system, green roof, sustainable vegetative cover, water absorbing pavement, and rainwater collection system on the roof have been selected and the investment options are listed for updating and implementation purposes. The rate of energy consumption, lifetime of facilities, stationary of the method, costs of production and transfer, observing regional management pattern, use of local materials and professionals, and health issues are the criteria applied for the prioritization of the items based on Delphi method. The prioritization was carried out by SAW (simple additive weighting method). According to the results, slope of the ground was the first priority of these items, and rainwater collecting system on the roof, the last priority.

Keywords: Water Management, Sustainable Architecture, Investment, Water Crisis, Simple Additive Weighting Method.

INTRODUCTION

Sustainability (in water domain) means the economic withdrawal of water from a watershed, which does not exceed the sustainable exploitation limits of that watershed during a specified period. The permeability of an aquifer, quality of the water of the aquifer, and the costs of the energy required for withdrawing water from an aquifer are the factors that determine primarily whether the water of that aquifer is sustainably exploitable and consumable in economic terms (Brecht, 2012). From this perspective, there is a close relation between sustainability of exploitation of a water resource and the economic costs of having access to that resource. Economic cost here means a comprehensive cost that includes all costs and expenses in any respect including environmental costs. For example, although the water of dams has a low equilibrium price because of cost saving due to scale, its equilibrium price may be very higher if the environmental effects and ecological changes attributed to the dams are taken into account.

In the world today, factors such as considerable increase in the population of the world and uncontrolled exploitation of environmental resources for meeting economic needs have had noticeable impacts on water resources. The issues regarding water crisis and water management has been introduced by the UN as the second

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main problem of the world after population problem. It must be noted that it is not possible to increase fresh water resources and solve this crisis. The only solution is to improve water exploitation methods (Babran & Honarbakhsh, 2008).

Today, hydrologists and different politicians believe that the manner of use and consumption of water resources is limited and vulnerable. On the other hand the main source of life and development, can play a decisive role in initiation of war or establishment of peace in the recent era. Regarding these facts, the participating members of the Second International Conference on Water held in Netherlands introduced water distribution in the world as the distribution of life (Sadeghi, 2006).

The Purpose of the research is to study sustainable architecture and its methods proposed for water consumption management in order to describe thereafter the traditional and modern methods of this field in details. By determining the criteria effective in the selection of the different choices, the SAW method is chosen from the methods proposed by the sustainable architecture for the optimal management of water resources in the different production, transfer, storage. The output of this method provides us with the priority of investment in each method.

REVIEW OF LITERATURE OF SUSTAINABLE ARCHITECTURE IN RELATION TO WATER CONSUMPTION AND WATER RESOURCE MANAGEMENT

Various researchers have studied and evaluated the different methods of sustainable criteria of water consumption management. In the following, some of these methods are discussed.

In 2003, Cheng studied the performance of green buildings in the control of water consumption in Taiwan. In his case study, Cheng introduces and studies the project of green buildings and provides a water conservation index for consumption economization of water. This index includes scientific and standard quantities that can be employed in pre-design phase (Cheng, 2003).

In 2010, Fioretti et al. studied the performance of green roofs. They believe that green roofs are evaluated in terms of their benefits for the building and urban environment due to their potential advantages for energy and water management. This paper studies and compares different instances of vegetated rooms throughout the world, especially in Mediterranean region, and comprehensive and experimental information are provided from two case studies conducted in the central and northwest part of Italy. The attenuation of solar radiation through the green layer and the thermal insulation performance are evaluated in this paper. According to this study, green roof has a positive effect on the reduction of water consumption by controlling evaporation (Fioretti et al., 2010).

In 2011, Chang, Rivera, and Wanielista studied the interaction of water conservation and energy saving strategies in green buildings. The energy used for the supply of fresh water and drainage system has different variables. The researchers in their paper studied the local systems used for water conservation and provided an equation to determine the energy consumed by these systems. Domestic pumps consume relatively low amounts of electricity, which is usually monitored. In fact, the main amount of energy is used by urban water systems, which are cost consuming by six times more than domestic pumps. Therefore, any economizing method used in urban water consumption decreases considerably the costs of energy (Chang, Rivera & Wanielista, 2011).

In 2012, Ping and Liu conducted a study, and argued that the improvement of the process of water conservation by changing the architecture of existing buildings not only is the solution of water crises but also has a positive relation with industrial development. This paper introduces firstly the measure of water conservation, and then studies the plans for water conservation in regional and international levels. Finally, it introduces a comprehensive model by AHP model for the assessment of the capability of water conservation methods (Liu & Ping, 2012).

In 2006, Esfandiari and Araghinezhad provided a comprehensive definition of integrated water resource management and a list of instruments required for using this approach in water resource development. These instruments were classified into three general parts including policymaking, legal/organizational instruments, and managerial instruments. In conclusion, the general algorithm for the application of integrated water resource management was provided, and the challenges to this approach were discussed. Moreover, it has been emphasized on the economic studies and analysis as the most important components of integrated management. Considering consequential analysis approach, the focus was shifted in this approach on the importance of physical studies and socio-environmental consequences.

In 2011, Goldar conducted a case study on the Qanats[1] of Kashan, and studied their relation to the integrated water resource management. In this paper, a history of Kashan and its qanats are narrated. In the first part, the development of the history of Kashan, and it relation to the water resources of this city especially its qanats have been presented. In the second part, several qanats of Kashan are described, and the distribution method of qanat's water inside the city and its allocation to the different buildings or neighborhoods of Kashan are described. Thereafter, the rules and regulations governing the distribution of water have been discussed by the case study of the water distribution of Soleymanieh spring and Tanbali qanat. In addition, the financial proceeds of qanats and the disputes over the distribution of water of qanats have been explained. These narratives are the supplements of water distribution and its importance. In conclusion, the transfer of the water of qanats to the different neighborhoods of Kashan as well as water supply to the houses of this city has been described. This paper shows the importance of water in the desert city of Kashan and in the opinion of the people of this city.

In 2011, Sedigheh Antik studied the traditional water management in Persian gardens by the case study of Sadri Garden in the city of Taft. Like architecture, the art of garden construction is subject to natural conditions of the related environment, water, and fertile soil. Because of climatic differences of the various parts of Iran, especially regions with hot climate, most importance is attached to gardens. Persian garden is composed of three main elements of water, plant, and architectural space. The most important issue giving life to a garden was water that transferred from the distance to the garden. The architects solved this problem by digging qanats. In Persian gardens, especially those of desert areas, water transfer and management are of great importance. In the desert cities of Iran, there are gardens that have their roots in the past centuries. In these gardens, water distribution and management are based on traditional hydraulic engineering. Sadri garden in the city of Taft is one of these gardens, whose irrigation system with a fountain and 95 jets of water is one of the unique instances of Persian garden that indicates the hydraulic engineering of the past. In her paper, the researcher has introduced this garden, and provided an archeological pictorial report about the irrigation system and the performance of the fountain and jets of water as a model of traditional water management (Antik, 2011).

SUSTAINABLE ARCHITECTURE AND WATER RESOURCE MANAGEMENT

The application of sustainable methods for the modification of water resource management has different aspects including modification of building and facilities of production, transfer, storage, and consumption of water, which is classified as a subset of sustainable architecture.

Sustainable architecture is a type of architecture that is responsive to the local and environmental conditions and uses its capabilities optimally for the creation of appropriate environmental conditions in order to minimize the damages to the environment. In addition, this architecture is sustainable and can conform to the changes, conditions, and requirements. In other words, it is a unique architecture, which not only conforms to the natural and economic capacities of its environment but also pays attention to the aesthetic needs (Golshani Manesh & Abedini, 2009).

Iranian traditional architecture has complied in the course of its history with many principles that are today expressed in form of sustainable architecture to meet biological requirements. Many requirements of the modification of water transfer and consumption patterns have been observed in qanats, cisterns (Ab-Anbar), and Persian gardens. On the other hand, the sustainable architecture in the modern era has provided numerous solutions especially for the optimization of the processes of water production, transfer, and consumption as per common standards of sustainability. In the present paper, we focus exclusively on the methods prescribed in TVA government standard.

The Study of the Traditional Methods of Water Production and Transfer

The main traditional method of water collection and transfer, which can be explained under sustainable architecture, is rainwater harvesting and impounding in qanats.

Rainwater Harvesting

The knowledge of rainwater collection or harvesting is the prediction of facilities that can collect rainwater in a reservoir for different uses. This is one of the best techniques of collecting fresh and clean water, whose pollution is less than that of the water of rivers if it is stored appropriately. This method of water supply has been known in Iran from the ancient times. In Bandar Siraf port, the traces of harvesting rainwater can be observed in form of the dug holes in the slopes of the mountains and rocks. The floors of these basins that were dug in rectangular form in the slopes of mountains were covered by black ash mortar (Sarooj) that made them impermeable. Moreover, there are fabricated ponds called Ab-Bandan (Water Impoundment) in the northern parts of Iran for collecting rainwater, and are used from the past times for water supply (Zafarnezhad, 2012). In this technique, rainwater is impounded in ponds for the irrigation of crops during summer.

Fig. 1. Puddles Dugout on the Mountain in Siraf (http://www.comap.ca/kmland)

Qanat

Qanat also known as Kariz is one of the prominent inventions of the Persians, and it has been constructed and used in this territory from the ancient time. The source of Qanat includes groundwater tables, springs, or rivers. The source of some qanats is not necessarily underground. In some cases, the water of a river was directed to other lands, which were even and not stony.

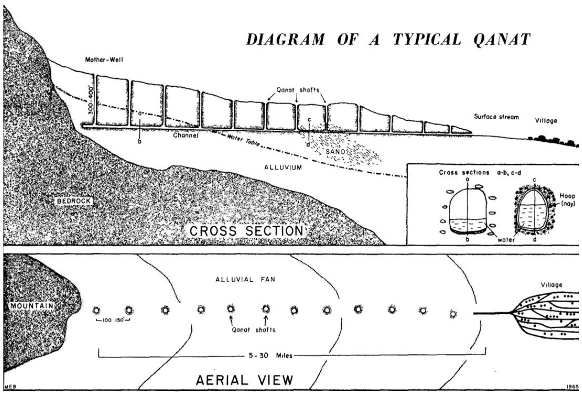

Fig. 2. Schema of Qanat (http://libro.uca.edu)

In the past, there were two types of qanat: covered underground qanat and uncovered qanat that can be watered by water tables.

Uncovered Qanats

Beside a spring, a cone-shaped pipe (Tanoureh), with a hatch at its lower end, was dug. When the hatch was opened, water flowed upwards to the surface of the ground. Beside the upper end of the pipe, a brook was constructed by stone and black mortar to direct water from the upper end of the pipe to the brook. This pipe was called Pardineh, which can be seen in Khorramabad.

Covered Qanats

In this type of qanats, water was directed from a groundwater table located naturally on the mountain slopes to the surface of the earth. Qanat had a subterranean horizontal channel known as Kal, which was accessed by vertical shafts called Mileh. These shafts were used to enter into and dredge the channel. The last shaft that had access to the water source was called mother well. As the channel had a slight slope from mountain slope towards the plain, water streamed from the groundwater table to the outlet of the qanat.

One of the most important principles of the diggers of a qanat was that the channel had to be excavated in a straight line not in curve. In case, they faced a big rock on their way, they had to bore into it. However, there were always barriers such as emptiness of the water source or digging another qanat or well near an existing qanat that prevented a qanat to work permanently. It must be noted that the decrease in the level of groundwater table may dewater a qanat, even if no well is dug near the existing qanat (Pirnia & Memarian, 2008).

The Study of the Modern Techniques of Water Production and Transfer

A major part of the principles concerning water in sustainable architecture is focused on the retreatment of consumable water or adsorption of runoffs. In the following, some standards of TVA[2] as regards the production and transfer of water are reviewed.

The application of absorbing pavement preserves the runoffs inside the system, and it reduces energy consumption. Water absorbing pavement causes water to penetrate into the site and prevents it to be wasted.

Green roofs reduce energy consumption and prevent form the waste of seasonal rainwater.

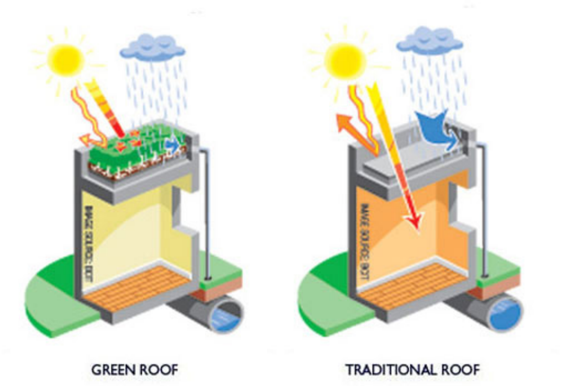

Fig. 3. Schema of Comparison between Green Roof and Traditional Roof (http://commons.bcit.ca/greenroof)

The installation of rainwater harvesting system for irrigation purposes has been strongly advised by sustainable architecture. The design of roof for collecting rainwater and supply of water tanks for irrigation and utilities has been prescribed by TVA standard (Zimmermann, 2003).

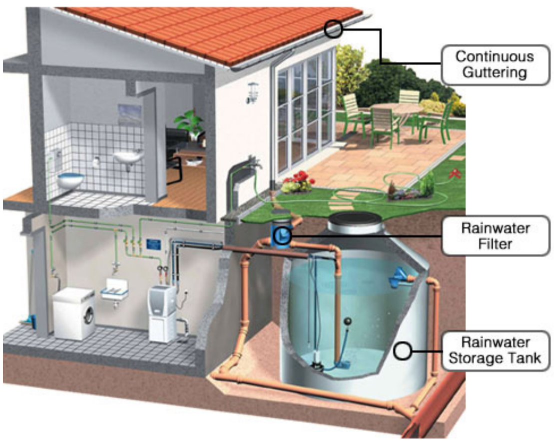

Fig. 4. Schema of Rainwater Harvesting System (www.sustainabilityninja.com)

The Study of Traditional Water Storage and Consumption

Cisterns (Ab Anbar) are the main reservoirs of water in the Iranian traditional architecture, and Persian gardens have been recorded as the most important instances of sustainable water consumption in the traditional architecture.

Cistern

Cisterns may be used in urban areas or in plains. Plain cisterns are like roofed ponds that are composed of a reservoir in a hole, in which rainwater is collected. One side of the reservoir has a staircase immersed in water to let people have access to water, whose level may decrease in the course of time.

Urban cisterns are composed of four main parts.

Water tank (Tanoureh): that is built inside the ground to prevent the pressure imposed by water on the wall. The roof is built sometimes in flat form, but they are mostly dome-shaped, and such a form prevents from the penetration of hot weather into the cistern. The water of the cistern is supplied from mountains and qanats during winter, when there are abundant rainfalls and water is not required for agricultural purposes. For the purification of water from pollutions, three or four small ponds were built close to the water tank. Water was passed through sand layers to be purified from slime and sludge. After filling the water tank, salt and lime were added to prevent infection.

Staircase (Rachineh): that is the staircase used for having access to the Pashir. In the cisterns of Yazd, the staircases are even 60 steps high.

Pashir: that is a chamber, under which there is a well for wastewater. The staircase reaches downwards the Pashir.

Wind Tower: this tower is used to cool water (Pirnia & Memarian, 2008).

Description of Persian Garden in Terms of Water Consumption

One of the main characteristics of the Persian gardens was that no fruitless tree or even a shrub was planted in the garden, as water was respected. For the construction of garden, the land was dug, clods were removed, fertilizers were added, soil was screened, and a tree was planted. They all were carried out to prevent the loss of water. The flowers, annual, perennial, and seasonal plants, as well as shrubs had to be useful. At the foot of cedar and pine, yellow, red, and black flowers were planted to extract perfume, rosewater, and pharmaceuticals, as well as earn money.

Between the plots, espest a species of alfalfa was planted to prevent the loss of water, to remove insects, and to be used as the winter feed of livestock.

In the garden, qanat water flowed into the lateral man-made brooks through the main watercourse and it was distributed in the garden. In the gardens such as Fin Garden in Kashan, as the source of water is located higher than the brooks are, water streams rapidly in the brooks and form the jets.

It was tried to reflect the stream of water very well. Therefore, the watercourses were so designed and constructed that the flow of water was shown as good as possible. Stepped and steeply stepped brooks were used for this purpose. This system was completed by the construction of fountain, which was a basin built to make the aridness of the lands pleasant (Pirnia & Memarian, 2008).

The Study of the Modern Method of Water Storage and Consumption

According to TVA standard, the main methods of water consumption sustainability are based on the optimization of consumption. For this purpose, the following solutions have been suggested:

Use plants that are consistent with the climate for landscaping in order to minimize irrigation, use of pesticides, and costs of maintenance; if a species cannot grow as expected under the normal conditions of that environment, it should not be planted.

Fig. 5. Schema of Proper Vegetative Cover (http://www.wbdg.org)

- In case, more irrigation is required, drip irrigation system is preferred, since by this system, water penetrates into the ground instead of the surroundings.
- The pressure of water is to be controlled based on the consumption rate.
- Although the application of some other parts of this standard may lead to the improvement of water consumption, these three techniques are exclusively for the reduction of water consumption.

RESEARCH METHOD

At first, a modified classical Delphi method has been employed to determine the variables that are effective in the rating of the different sustainable systems.

Delphi Method

Delphi is a systematic approach or method of research for collecting the opinion of a panel of experts on a special issue or question, and reaching consensus by a set of questionnaires submitted to the respondents, whose identity are kept confidential, and whose feedbacks are reflected to the other members. In other words, independent heterogeneous experts are asked to provide their professional judgments on a special issue in a geographically broad level using questionnaires. The questionnaires are to be answered in two or more rounds until the consensus is achieved. In most references, Delphi method has been classified into three classes: classical Delphi, decision-making Delphi, and policy Delphi. In classical Delphi, the identity of experts is kept confidential, the rounds are iterated, the feedback is controlled, the answers of the members are provided in statistical form, and the focus is on consensus. This class of Delphi method has been modified (modified classical Delphi) to meet the needs of the researchers.

In modified classical Delphi, the panel members are known, there is no need to reach consensus, the questions are of open/closed type, and qualitative/quantitative analyses are applied.

In policy Delphi, the input and data are verbal, it is not required to achieve consensus, or to use necessarily experts. The final purpose is to develop the most appropriate policy. In decision-making Delphi, a panel of people making decisions on a special issue (Ahmadi, 2009).

In this research, Delphi method is applied between five senior experts in the fields of environment and sustainable architecture to find out the factors that are effective in rating. These factors include energy consumption, the lifetime of utilities, the stationarity of the method, costs of production and transfer, observing regional management pattern, use of locally available materials and personnel, and health issues.

Questionnaire and Data Collection

31 master students of the field of study of environment from university of Tehran and sustainable architecture from University of Science and Technology were asked to respond to the 5-point Likert items of the questionnaire on the investment in sustainable management of water resources. In this questionnaire, the items with the score 5 have the highest point, and those with score 1 the lowest point. The priority of the items was determined by Simple Additive Weighting method (SAW).

Simple Additive Weighting

SAW is one of the most widely known methods of MADM. In this method, the decision-maker gives weight to each attribute, the attribute value is multiplied by its weight, and the results are added up. The result is recorded as the score of that item. The item with the highest score is selected as the best one. It can be formulated mathematically as follows:

The weight vector for attribute n is w= (w1, w2, w3, …, wn). In this case, the best selected item, i.e. A*, is equal to:

$$(1)\ A^* = \left\{A_i | max_i \sum_{j=1}^{n} w_j x_{ij} / \sum_{j=1}^{n} w_j\right\}$$

X_{ij} is the j[th] attribute value. Usually, the weights are so selected that we have:

$$(2)\ \sum_{j=1}^{n} w_j = 1$$

It must be noted that the matrix of decision must be normalized. Moreover, the entropy method has been applied in this research to determine the weights (Makoui, 2007).

Entropy Method

If decision-making matrix is D, then

$$(3)\ D = \begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix}$$

The value of the entry X_{ij} can be converted to P_{ij} using the following equation:

$$(4)\ p_{ij} = = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}}$$

The entropy value of j[th] attribute is calculated by the following equation:

$$(5)\ E_j = -K \sum_{l=1}^{m} p_{ij} ln p_{ij}$$

$$(6)\ k = \frac{1}{lnm}$$

Where, $1 > E_j > 0$; d_j is calculated for each attribute using E_j.

$$(7)\ d_j = 1 - E_j$$

The weight w_j of the j[th] attribute is calculated by the following equation:

$$(8)\ w_j = \frac{d_j}{\sum_{j=1}^{n} d_j}$$

Normalization of Decision Matrix

A simple operation is to divide different values of an attribute by their maximum value. In such a case, xij results in the following:

$$(9)\ \pi_{ij} = \frac{x_{ij}}{x_j^*}\ x_j^* = max_i x_{ij}$$

PRIORITIZATION OF THE INVESTMENT IN SUSTAINABLE WATER MANAGEMENT USING SAW

After receiving the answered questionnaires, the total average score is calculated, and the decision matrix is determined:

Table 1. The Entries of the Decision Matrix

Prioritization Factors & Proposed Methods	Economical Energy Consumption	Lifetime of Facilities	Decreasing Costs of Production and Transfer	Regional Management inclination	Use of Local Materials and Personnel	Health Issues
Rainwater Harvesting	4.18	2.57	3.31	2.59	4.06	0.95
Qanat	4.18	2.54	2.41	2.59	4.14	1.66
Water Absorbing Pavement	4.08	1.69	2.5	4.01	0.81	3.31
Green Roof	4.03	0.87	2.4	4.11	1.75	4.09
Rainwater Collecting System on the Roof	4.04	1.65	1.64	4.17	0.9	3.28
Cistern (Ab Anbar)	4.09	2.55	3.39	3.39	4.01	0.93
Sustainable Vegetative Cover	4.03	1.63	3.29	4.1	1.64	3.21
Use of Slope	4.05	3.3	4.14	3.35	4.03	2.54
Drip Irrigation System	1.79	2.44	1.64	4.14	2.52	4.18
Control of water Pressure based on Consumption	4.69	3.23	4.04	3.26	1.64	4.19

The equation (9) is applied to normalize the decision matrix:

Table 2. The Entries of the Normalized Decision Matrix

Prioritization Factors & Proposed Methods	Economical Energy Consumption	Lifetime of Facilities	Decreasing Costs of Production and Transfer	Regional Management inclination	Use of Local Materials and Personnel	Health Issues
Rainwater Harvesting	0.891258	0.778788	0.799517	0.621103	0.980676	0.22673
Qanat	0.891258	0.769697	0.582126	0.621103	1	0.396181
Water Absorbing Pavement	0.869936	0.512121	0.603865	0.961631	0.195652	0.789976
Green Roof	0.859275	0.263636	0.57971	0.985612	0.422705	0.976134
Rainwater Collecting System on the Roof	0.861407	0.5	0.396135	1	0.217391	0.782816
Cistern (Ab Anbar)	0.872068	0.772727	0.818841	0.81295	0.968599	0.221957
Sustainable Vegetative Cover	0.859275	0.493939	0.794686	0.983213	0.396135	0.76611
Use of Slope	0.863539	1	1	0.803357	0.97343	0.606205
Drip Irrigation System	0.381663	0.739394	0.396135	0.992806	0.608696	0.997613
Control of water Pressure based on Consumption	1	0.978788	0.975845	0.781775	0.396135	1
Total	8.34968	6.809091	6.94686	8.563549	6.15942	6.763723

The equation (4) is applied to calculate Pij:

Table 3. The Entries of P Matrix

Prioritization Factors & Proposed Methods	Economical Energy Consumption	Lifetime of Facilities	Decreasing Costs of Production and Transfer	Regional Management inclination	Use of Local Materials and Personnel	Health Issues
Rainwater Harvesting	0.106742	0.114375	0.11509	0.072529	0.159216	0.033522
Qanat	0.106742	0.11304	0.083797	0.072529	0.162353	0.058574
Water Absorbing Pavement	0.104188	0.075211	0.086926	0.112293	0.031765	0.116796
Green Roof	0.102911	0.038718	0.083449	0.115094	0.068627	0.144319
Rainwater Collecting System on the Roof	0.103166	0.073431	0.057024	0.116774	0.035294	0.115737
Cistern (Ab Anbar)	0.104443	0.113485	0.117872	0.094931	0.157255	0.032816
Sustainable Vegetative Cover	0.102911	0.072541	0.114395	0.114814	0.064314	0.113267
Use of Slope	0.103422	0.146862	0.14395	0.093811	0.158039	0.089626
Drip Irrigation System	0.04571	0.108589	0.057024	0.115934	0.098824	0.147495
Control of water Pressure based on Consumption	0.119765	0.143747	0.140473	0.091291	0.064314	0.147848

The Ej of each attribute is calculated using the equation (5) and based on the above results:

Table 4. The Entropy Values

Ej	0.99081	0.975245	0.98047	0.993716	0.939512	0.955318

To calculate dj, the equation (7) is used, and the relative weight of each attribute is determined by entropy method and equation (8).

Table 5. The Values of Decision Weights

Dj	0.00919	0.024755	0.01953	0.006284	0.060488	0.044682
Wj	0.055723	0.150093	0.118414	0.0381	0.36675	0.270917

The score and rating of each item is calculated using the equation (1).

Table 6. The Final List of Priorities

Rainwater Harvesting	0.70598
Qanat	0.731867
Water Absorbing Pavement	0.519258
Green Roof	0.613126
Rainwater Collecting System on the Roof	0.49986
Cistern (Ab Anbar)	0.707876
Sustainable Vegetative Cover	0.606415
Use of Slope of the ground	0.86847
Drip Irrigation System	0.710488
Control of water Pressure based on Consumption	0.76417

According to the results, the order of priorities is as follows: slope of the ground, modification of the valves based on water consumption, qanat, Drip Irrigation System, Cistern (Ab Anbar), Rainwater Harvesting, green roof, sustainable vegetative cover, water absorbing pavement, and rainwater collecting system on the roof.

CONCLUSION

For the modification and optimization of water consumption and coping with water crisis, sustainable architecture provides various solutions. It is clear that not all proposed solutions can be implemented as the first priority. According to the findings of this research presented in the table 6, the optimal use of the slope of the ground has the highest priority for investment. It must be noted that the necessity of having access to technology or existing obstacles in the industrialization of some technologies have caused the modern methods to be scored more than traditional ones. The investment in the study of the industrialization of some solutions such as water absorbing pavement or domestic rainwater harvesting system may improve the priority of investment. Despite the high score of qanat, its status has been undermined considerably because the required equipments and labor required for this method are only accessible locally, and there is the threat of forgetting this traditional technique. According to this study, the increase in the investments in the improvement of the use of the slope of the ground instead of mechanical transfer of water is recommended.

One of the solutions with high score is to control the pressure of water based on consumption, which can be implemented by using valves with adjustable pressure. Considering the considerable impacts of the use of such valves in comparison to the consumption costs, it is recommended that consumption subsidy be allocated for such valves.

The restore and updating of qanats requires the regional management pattern of water resources to be recognized. In this method, the cost price depends on the geographical conditions of the guiding body of the regional water management.

It is also recommended that the patterns of green roof to be adapted to the climatic conditions of each region to reduce costs price of this method and extend it. It is also recommended that some future studies be carried out based on the existing research budgets and investment requirements in updating each technique and method discussed above based on the linear planning techniques of prioritization. Certainly, the reuse of the methods of sustainable water resource management can pave the way for fighting effectively against water crisis.

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ENDNOTES

1- Qanat (aka Kariz) is a man-made subterranean water canal

2- Tennessee Valley Authority