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Water Health in Drought: A Model Integrating Indigenous and Modern Knowledge

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GRAPHICAL ABSTRACT

Introduction: Drought is a natural hazard that limits access to water and threatens health. This study was conducted to present a combined model of indigenous and modern knowledge to combat the effects of drought on water health.

Materials and Methods: This study was a mixed-method design with four phases. In the first and second phases, the components of indigenous and modern knowledge were obtained through qualitative interviews using content analysis method and literature review using narrative method. In the third phase, components obtained from the two previous phases were sent to relevant field experts for validation using Delphi method. Two rounds of Delphi were conducted until reaching a consensus of views of the elites. The components that obtained a sufficient score were used to design the research model.

Results: The final model consisted of three main components including household water management, community water management, and water health in drought conditions.

Conclusion: Indigenous and modern knowledge are complementary and their integration creates synergy for the health of individuals, provided that they are studied in a principled way and integrated correctly. The present model was designed with a realistic view and considered the role of culture and indigenous knowledge in people's behavior and could be reasonably used by managers in the field of water health, passive defense, and various plannings.

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Introduction

It is an unfortunate reality that disasters have become a part of our lives worldwide[1]. The possibility of natural disasters and their aftermath always looms, making them an inevitable aspect of human existence[2]. The frequency, intensity, and scope of the damage caused by these events are increasing worldwide[3, 4]. Analyses of soil moisture

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and drought indices suggest an increased likelihood of drought in the 21st century[3]. Drought is a multifaceted and costly phenomenon that affects more people than any other hazard[5]. This has led to water scarcity, desertification, dust storms, and dry air in both urban and rural areas [6]. With the growing water demand, competition for resources has intensified, particularly in dry and semi-arid regions [7].

Considering the aforementioned conditions and limitations of water resources, effective water management is challenging, requiring expertise, up-to-date knowledge, and an understanding of the social and political context[8]. As drinking water is a vital public service, active public and stakeholder participation is crucial for effective water resource management. This engagement helps communities adapt to climate change, promotes policy acceptance, and prevents conflicts[9].

According to SALVADOR, drought management is a complex issue that affects climate, hydrology, environment, culture, and socio-economics. Therefore, comprehensive management strategies are necessary to address this hazard [5]. GRAINER emphasizes the importance of interdisciplinary research and historical observations, combined with modeling expertise, to assess the potential direct and indirect impacts of climate change on drinking water resources [8]. AL ADAILEH notes that the water crisis is continually worsening due to various factors such as rapid population growth, sudden influxes of refugees, economic progress, and more frequent drought events. They stressed the pressing need to devise drought adaptation plans and recommended the establishment of a risk management system for drought that encompasses preventive and emergency measures. National policies and legal frameworks should be in place to safeguard water resource conservation [9].

KAHIL also presented a model for water resource management to adapt policies to climate change for dry and semi-arid regions. In this model, he emphasizes water market policy as an attractive policy to overcome the negative economic effects of drought [7]. DAS notes that artificial intelligence can help manage water resources[10].

This study ignored indigenous knowledge; therefore, the presented models cannot be used in a participatory manner.

Most studies have focused on meteorology, agriculture, hydrology, and the impact of drought on health. Therefore, given the importance of drinking water safety in individual and community health and the impact of drought on drinking water resources, and considering that there is a serious gap in research examining the impact of drought on drinking water health and its management, this research aimed to present a model that considers the dimensions of modern and indigenous knowledge to respond to communities in water resource management to maintain water health during droughts. This model integrates modern knowledge with the cultural dimensions of communities and household behaviors and is applicable at both the household and management levels.

Material and Methods

This study was conducted in four phases using a mixed-method exploratory approach. This study aimed to identify the effective components of indigenous knowledge for water conservation and resources in Yazd Province, Iran. This study was conducted from April 2017 to June 2018.

The first phase of the study

This section was conducted in Yazd, which is situated in a dry region of Iran. A significant portion of this province (85%) has a hot desert climate. Yazd is recognized as one of Iran provinces grappling with water scarcity throughout its history. Given Yazd desert location and arid, warm climate, the local population possesses extensive firsthand knowledge on adapting to these challenging conditions[11]. The first phase of the study involved conducting semi-structured interviews with local people living in three main plains of Yazd Province–Yazd-Ardakan, Abarkuh, and Herat-Marvdasht–using purposive sampling. Thematic analysis was used to analyze the data gathered from the interviews. All interviews were recorded and transcribed in Microsoft Word by the researcher after repeated listening to the recordings. The findings of this part of the study have been published by the authors in two separate articles. For further details regarding this phase, including the methodology and results, readers are kindly invited to refer to the published articles [11, 12].

The second phase of the study

In the second phase of this research, a comprehensive narrative scope review was conducted to acquire modern knowledge of water health during drought periods. To avoid redundancy and maintain conciseness, readers are encouraged to refer to the published article for detailed methodology and results of this section[13].

The third and fourth phases of study

After identifying the components of indigenous and modern knowledge influencing water health in the previous two phases, the researchers utilized the Delphi method to validate these components [14]. The specific procedures used in the Delphi study are as follows. The study population consisted of 25 experts[15] in health, climatology, and sociology who met the study criteria, including faculty members with a history of research in disaster management and individuals with at least five years of executive experience in the field of health and drought.

To collect data, a questionnaire was designed that included 48 nine-point Likert scale questions in addition to demographic information. Twenty-five questions were related to indigenous knowledge, and 23 questions were related to modern knowledge. To determine content validity, the tool was sent to five professors via email, and their views were applied to the final questionnaire. The final tool was sent to the target group via email. Based on the scores assigned to the questions, components that scored between 33.34% and 66.67% of the total score were sent to the experts for review. Components that scored more than 66.68% of the total score were considered confirmed in the model design. Questions with a score of less than 33.33% were deleted. The final model was designed after reaching a consensus in the Delphi stage and was approved by the group members. The research group consisted of experts related to research objective and all of them had at least 5 years of work experience in the relevant field.

Results

The findings of the qualitative part of the study

The number of interviews, number of codes obtained, and categories and subcategories have been published in two articles [11, 12]. In general, the qualitative findings showed that indigenous knowledge consists of six main categories: "drinking water conservation," "drinking water collection," "personal hygiene," "conservation of scarce resources," "drought prediction," and "water classification in terms of quality and sources."

The findings of the second phase

The second phase included the identification of four categories: "use of new devices and equipment," "methods to prevent water wastage," "attention to culture and education," and "management and policy methods"[13].

The findings of the third phase of Delphi study

The findings of the third phase of the Delphi study are presented in Table 1.

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Table 1: Comparison of Delphi rounds 1 and 2 results

The rate of consensus increase	Second round	First round	Questions
5.5	74	68.5	Teaching the benefits of using native clay containers to store drinking water in homes
-3.7	72.8	76.5	Learning to collect drinking water only from a safe place and a safe time
4.88	88.88	84	Training on water recycling in homes
- 1.25	73.45	74.7	Teaching how to use the highest quality water for drinking and cooking
3.71	82.71	79	Teaching not to use unsafe water for drinking and cooking
16.5	74.5	58	Teaching alternative behaviors in case of water unavailability according to religious culture during drought
2.77	94.77	92	Teaching how to optimize consumption methods
1.85	83.95	82.1	Learning to collect rainwater for washing or watering gardens
1.88	88.88	87	Saving training about virtual water
- 2.52	85.18	87.7	Significant change in people's consumption pattern
3.72	90.12	86.4	Teaching savings to children and families through games, scenarios, and models
0.8	75.30	74.5	Keeping water at home using local containers (pots and jugs) by people
- 1.07	69.93	71	Maintaining the amount of drinking water in homes by storing it in clay pots
- 0.15	69.75	69.9	Paying attention to keeping the lids of water storage containers closed at home
1.5	75.30	73.8	Keeping the drinking water safe and hygienic
- 2.43	70.37	72.8	Cooling drinking water using methods
1.84	90.74	88.9	Promoting the culture of frugality with legal and managerial support
10.09	81.69	71.6	Promoting religious culture to preserve water resources and use them optimally
- 3.57	69.93	73.5	Using local and nature-friendly plant materials to wash clothes and dishes
7.39	60.49	53.1	Reducing the frequency of bathing once a week or once every two weeks during drought
4.91	68.51	63.6	Attention to daily washing of hands and body with minimal water consumption
1.88	81.48	79.6	The use of popular supervision in the good use of water
- 3.74	66.66	70.4	Free distribution of safe drinking water -
6.21	61.11	54.9	Providing free safe drinking water in a centralized place
7.7	50	42.3	Generalization of high consumption matters such as using public bathrooms during drought
4.77	86.27	81.5	Establishing rules for the use of recycled water or well water for washing dishes and clothes and for other health purposes other than drinking and cooking
3.74	94.44	90.7	Establishing rules and managing the use of recycled water for agricultural purposes
9.87	91.97	82.1	Legal protection to prevent irrigation or cultivation of unnecessary crops or plants during drought
7.36	95.06	87.7	Paying attention to drought or drought conditions for agricultural cultivation programs
3.67	91.97	88.3	Paying attention to the frequency and possibility of drought for future water supply plans
1.87	91.97	90.1	Adaptation of water resource management to climate changes
- 2.57	87.53	90.1	Using daily equipment to predict weather conditions and drought
5.27	77.77	72.5	Reducing thewater demand (such as increasing the price of water, etc.)
7.38	88.88	81.5	Using advanced equipment to reduce water pressure at certain times such as at night
0.57	88.27	87.7	Trying to create social changes in people's lives to reduce water consumption
6.37	91.97	85.6	Providing feedback on the amount of water consumption to the household every month (using the most advanced equipment in the world)
- 3.08	72.22	75.3	Creating restrictions on water consumption (such as rationing water during high consumption times)
- 3.76	80.24	84	The use of advanced and expensive equipment and technologies to control household water consumption, such as meters, providing intelligent feedback on the amount of water consumption
6.83	87.03	80.2	Use of high-quality technologies such as reducing water pressure before the meter
1.83	87.03	85.2	Use of seawater or saltwater desalination technologies
5.48	87.58	82.1	Construction and operation of emergency water pipelines

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The rate of consensus increase	Second round	First round	Questions
9.48	81.68	72.2	Virtual water business
8.07	88.27	80.2	Establishing laws to control the amount of cultivated area in drought years
3.65	87.65	84	Legislation at the highest levels of the country to deal with the problem of wasting water
- 1.91	82.09	84	Use of alternative management policy for water consumption in rural areas
5.56	84.56	79	Creating mandatory regulations for the use of modern water equipment that can prevent water loss
9.86	84.56	74.7	Favorable pricing policies
0.49	92.59	92.1	All-round education and widespread cultivation to save in all aspects of life

As Table 1 shows, because there was no consensus after the first round about some components, the second round was necessary. In the first round, 18 out of 25 participants completed the questionnaire and returned it to the researcher. The response rate at this stage was 72%. In the second round, after applying the opinions of the experts, the questionnaire was again sent to the respondents from the first round. All 18 experts returned the questionnaires at this stage, and the response rate was 100%.

Based on the above pattern, among the 48 components of the questionnaire, at this stage, the experts did not reach a consensus on five components (their scores ranged from 33.33 to 67.66%); therefore, these components were put to conflicting votes to re-examine and reach a suitable consensus in the second round[16].

At this stage, except for components No. 20-24-25, the other components obtained a suitable level of points. It should be mentioned that component number 23, which had won the consensus in the first round and was only 0.01% away from the quorum in the second round, was not removed at the discretion of the researchers due to its importance. Therefore, a total of 45 components of the entire questionnaire were given appropriate priorities according to the experts.

The fourth stage of model presentation

After the Delphi analysis, the components that gained the necessary credibility with the approval of experts were used to design the initial model. This model was examined by the research team in three sessions, and after applying the comments and fixing the shortcomings of the initial model, the final model was designed and compiled (Figure 1).

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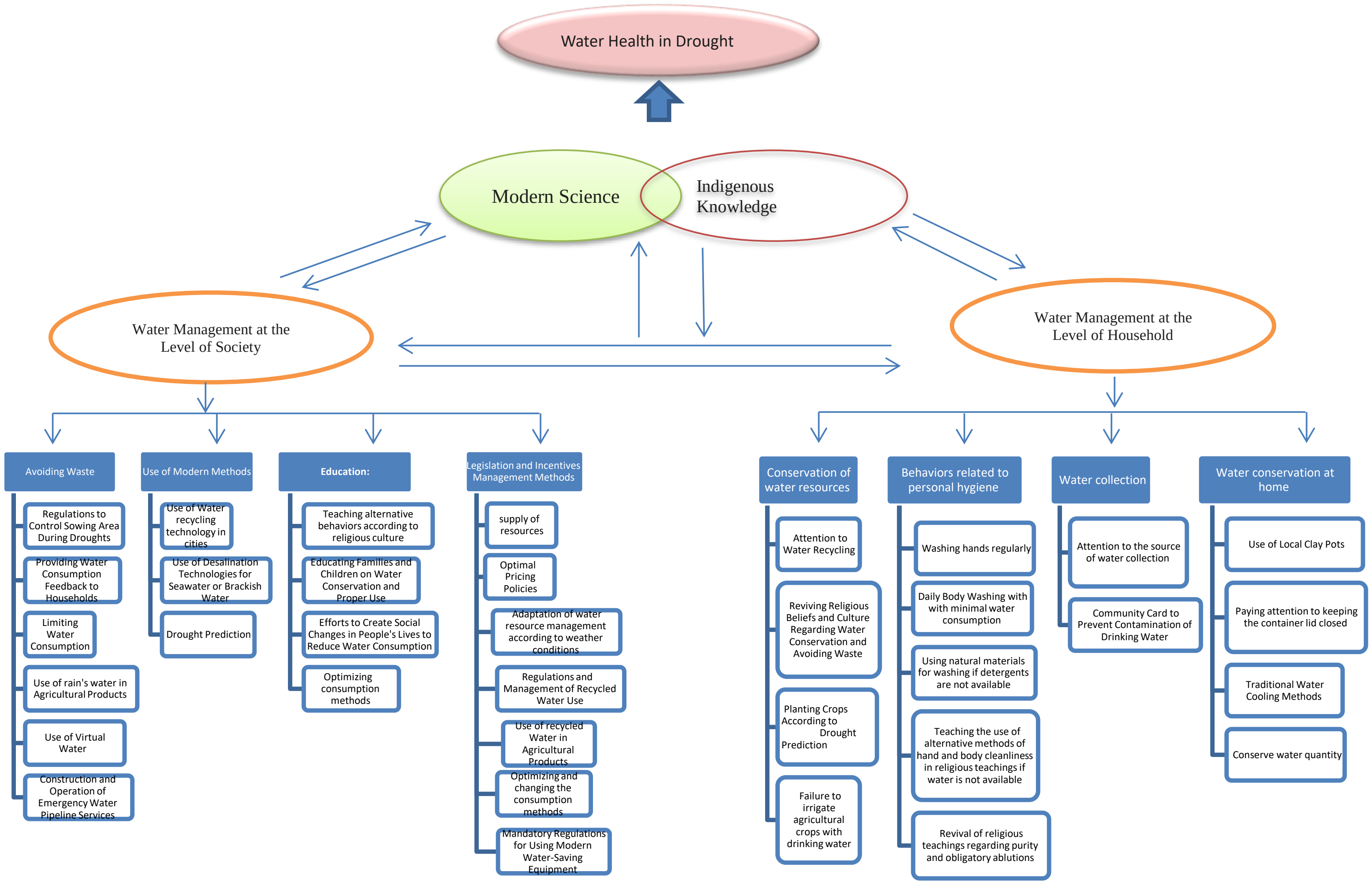

Figure 1: Integrated model of indigenous and modern knowledge to deal with the consequences of drought on water health.

This model is the result of combining information obtained from a qualitative study through interviews with people and a review of studies in the mentioned databases regarding modern knowledge. While showing the interaction between local and modern knowledge, it emphasizes water management at the household and community levels. In this model, the oval components represent hidden variables, and the rectangular components represent obvious variables.

The above model conveys the message that water health during droughts is affected by local knowledge, modern knowledge, and people's behavior at the household and community levels. Water management at the family and community levels is affected by other factors, as shown in the figure.

Discussion

Indigenous populations have learned how to adapt to gradual changes in the environment and formulate their survival strategies; therefore, not using this knowledge to reduce the risk of disasters is a great risk. However, indigenous knowledge alone is not suitable for this purpose. It is necessary to combine and integrate this knowledge with modern disaster risk reduction strategies to prepare for the effects of natural disasters and reduce the vulnerability of local communities to natural hazards [17].

It should be noted that acquiring indigenous knowledge for this study was not easy. To acquire this knowledge, we had to find people who met the inclusion criteria for the study, but most of these people had died or were very old, and it was not possible to establish good communication with them. This is one of the challenges of indigenous knowledge that needs to be considered in all areas, and this knowledge needs to be collected and recorded properly before it is lost.

This point should also be considered when seeking solutions for water-related issues and services, as it is vital to prioritize the unique local conditions, methods, and people involved. These factors should serve as the foundation for decision-making. While water and its associated services are heavily influenced by local circumstances, comparative studies can help identify effective and reproducible techniques that transcend different regions and cultures [18]. Various studies have shown that enabling access to the conventional lifestyles of indigenous communities is an essential step in addressing the global water crisis. To this end, it is crucial to promote collaboration between indigenous knowledge and modern scientific methods [19]. Indigenous knowledge should be recognized through the maintenance of promotional records[20]. In this study, the importance of local knowledge in maintaining water health was demonstrated. It should be kept in mind that different methods and behaviors of people in the field of obtaining and consuming drinking water and maintaining these resources or wasting them with wrong behaviors can play a significant role in the health of the family. In the following section, we discuss the dimensions of the proposed model.

Household water management:

In this section, by acquiring local knowledge and analyzing it with the help of current knowledge, components that can help in obtaining water health were identified and classified. One of the important dimensions of water management at the household level is keeping water at home; the smallest wrong behavior can have negative effects on the health of the family. In the aspect of water storage at home, paying attention to the containers used, methods of maintaining the palatability of stored water, including keeping drinking water cool and paying attention to not contaminating this water, as well as being careful in maintaining the right amount of water at home are important. Clay pots have cooling properties due to their natural pores, and they absorb waste materials and salts from the water and create pleasant and cool water. These properties of earthenware are very important because all these properties are available to the household without consuming electricity or needing a special infrastructure, and not only in drought but in other critical situations such as

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earthquakes or war. If the infrastructure of the area is damaged, these containers can be easily used by households until conditions are balanced. Their narrow openings reduce the possibility of insects and animals entering the containers and the possibility of water leakage when emptying. In the past, this narrow and small entrance of the container was always kept closed with special lids.

Trot et al. (2005) also pointed out the importance of water storage containers and avoiding water contact with contaminated things and the role of contaminated drinking water in water-borne diseases in infants and people with immune deficiency [21]. In the present study, people stated that by keeping the jars moist and exposing them to the wind, the water inside the jars cooled down. The use of these jars was so common that all the interviewees referred to them. A good example of indigenous knowledge in this field is in Kenya, where the people of this region used clay pots to store drinking water, and in the hot climate of this region, less water evaporated. Therefore, pots were modified for safe storage and then given to people for use[22].

Ibrahim et al. (2024) stated that, because of their special characteristics, clay containers are an excellent and affordable alternative for storing water [23]. Owing to the acceptable culture in the research area, it is better to protect and recommend these containers.

Another dimension is the collection of drinking water. Households pay attention to the source of drinking water. Households should not store water for a long time and should drink it every day or several times a day from safe sources, such as running water and untouched water, and at certain times (at the end of the night or dawn). As the findings showed, the native people did not allow the use of water from stagnant points for drinking, and only collected water from certain places and times. These behaviors played a positive role in obtaining healthy drinking water. Studies have shown that the most important factor in water pollution is the type of source used, although the duration of storage and the containers used also affect the microbial quality of water [24].

Latchmore et al. have pointed out in their research that not all water obtained from natural sources is reliable, but reliable water is obtained from high-speed sources such as springs, streams, and rivers [25]. If water is concentrated and distributed in specific places by health and government bases, individuals must use these sources. However, if the person collects water themselves, it is important to collect water from specific places, such as springs or rivers, that are approved by health authorities. It should be used at specific times when the probability of contamination is low, and it is very important that people feel responsible for the preservation of water resources and closely monitor these issues. In this regard, the forces of the people should be helped.

Another component is the behavior related to personal hygiene. Paying attention to daily hand washing, paying attention to daily washing of the body with minimal water consumption, and use of local natural materials can be effective in maintaining the health of people. In this regard, the use of acceptable recycled water for washing purposes can be effective in preserving drinking water resources and preventing water wastage [26]. The findings of the present study showed that the link between worship and personal and social health[27] is important in this dimension. In the interviews with the participants, a lot of emphasis was placed on maintaining personal hygiene while performing worship. Water and sewage rehabilitation is one of the main priorities after disasters; therefore, public health education about personal hygiene, along with liquid soap and clean water for cleaning hands, is very important [28]. This is specifically emphasized in this pattern.

Another dimension of the pattern of water management at the household level is the importance of reviving behaviors related to preserving scarce resources. One of the solutions to increase the efficiency of water use is to improve irrigation methods and domestic use and reuse water [29]. Researchers mentioned that one of the effective factors for responding to water demand and ensuring the quality of recycled water for non-

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drinking purposes [30]. The findings of the present study showed that water recycling, which was observed in the behavior of the natives, is a positive aspect of the management of scarce water resources. It is possible to obtain ideas from their positive behavior and use them during times of crisis. Moreover, the use of religious teachings and the revival of beliefs related to preserving resources and not wasting them, especially drinking water, will be very helpful in this field, considering the religious culture that governs the society under study.

Another issue is to pay attention to the warnings of relevant organizations regarding droughts. In the event of drought and water shortages, it is important not to plant and irrigate unnecessary plants, and to make social changes in people's lives, even using virtual water if possible [26, 30-35].

Water management at the community level:

It includes different dimensions, such as management methods, policy-making, legislation, and motivation.

In this sector, by providing resources and formulating laws related to price correction, it is possible to reduce water waste [36]. The adaptation of water resource management to weather conditions also affects the level of performance of the water storage system[33, 37, 38].

Establishing laws related to water recycling and establishing laws for the use of water for agricultural purposes is another component that has been proposed in this category. It is important to know that the use of fresh water is more suitable for edible purposes, and on the other hand, recycled water is more suitable for irrigation, car washing, and household washing purposes[26, 32, 39]. In other words, it is necessary to emphasize the reuse of water in the industry and agriculture sectors and, in general, for non-drinking purposes[30-40]. Therefore, policymakers should pay attention to this issue.

Optimizing water use and changing consumption patterns are other components of this class. Building new houses with smart water appliances, replacing existing appliances with smart water appliances, covering and closing swimming pools in residential houses, reducing the frequency of going to the bathroom, learning and teaching optimal ways to use water and prevent bad habits in water consumption, rationing water consumption, and warning people to reduce consumption are all things that can be paid attention to in this section[35, 41, 42]. These measures can save 23–25% of water consumption[42].

Cultivation and education is another category that is raised in this dimension. Teaching alternative behaviors according to religious culture, teaching optimal consumption and saving methods, creating social changes in people's lives, and teaching and optimizing consumption methods are all important and effective components at this level.

It is very important to pay attention to the culture of the society in the management of water resources[43] and if there is a need for changes in the consumption patterns of families and their lifestyles, educating people through schools, public information campaigns, and providing public consultations will be helpful [35, 40, 41, 44]

The next level of water management at the community level is the use of new methods to predict drought, desalination of water if needed, and water recycling technologies[30, 34, 39].

The last layer in the model at the community water management level is related to the prevention of water waste. Planting crops that are drought-adapted, as well as providing feedback on household water consumption to manage water consumption by the household, which was discussed above, creating consumption restrictions, and establishing emergency pipelines, are considered important items in this category[30]. The use of virtual water[31] and collecting rainwater for agricultural purposes[26, 29, 34] all have an effect on reducing water loss.

Finally, by combining these items, it is possible to achieve the provision of safe drinking water under drought conditions. Water health can affect the health of society.

Conclusion

Presenting a model for integrating local and

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modern knowledge to deal with the health consequences of drought requires multiple studies with different qualitative research approaches and Internet searches. This model can be effective in the direction of water health during droughts. In this study, the importance of local knowledge was again observed. It was found that this knowledge is valuable and familiar with the culture, habits, and customs of the borders and landscapes, but sometimes there are superstitious methods far from science and health methods in this knowledge, all of which are necessary for its scientific development. Therefore, this knowledge must be carefully identified and recorded and then subjected to scientific analysis to eliminate superstitious and unhealthy methods and use other methods that are both familiar with culture, habits, and customs and are cheap and require technology. If the equipment is not expensive, it should be revived and made available to people, and the necessary training should be provided. This is a combination of indigenous and modern knowledge that can be complementary and synergistic for people's health, provided that they are examined in a principled way and integrated in the right way.

Acknowledgment

This study was approved by the Ethics Committee of Shahid Beheshti University of Medical Sciences (IR.SBMU.RETECH.REC.1396.1151).

Conflicts of Interest

The authors declare no conflicts of interest.

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Ethical Considerations

In accordance with the commitments made to the ethics committee, all participants were informed about the confidentiality of their information in all our study reports. The consent form was read aloud to participants who were illiterate or unable to write. In general, informed consent was obtained from all individuals who participated in the study.

Code of Ethics

The present study was approved by the Ethics Committee of the Shahid Beheshti University of Medical Sciences (IR.SBMU.RETECH.REC.1396.1151)

Authors' Contributions

All authors have contributed to the study conception and design. Material preparation, data collection and analysis were performed by Dr. Azadeh Fatehpanah. The first draft of the manuscript was written by Dr. Azadeh Fatehpanah and Dr Katayoun Jahangiri. All authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

The authors ethically approved the submission and declared that it had not been submitted elsewhere.

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