



## Review Article



# Reducing Pressure on Drinking Water Resources in Droughts: A Narrative Study

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**Abstract**

The long trends of drought have caused much damage to the society. This phenomenon leads to an imbalance between water supply and demand with the abnormal dominance of arid climate over an area. Given the recent widespread climate changes in the world and the importance of conserving water resources, the present study aimed to identify methods to reduce pressure on drinking water resources in drought conditions. This study was conducted by using the narrative method (scope review). The research environment included Embase, Scopus, Web of Science and PubMed databases and the articles were selected and reviewed according to the defined and peer-reviewed inclusion criteria. The period searched was 2000-2020. The findings showed that the effective components in reducing the pressure on drinking water resources are the use of new devices such as water desalination equipment, the use of methods to reduce water loss, culture and community education, and policy and adoption of water management strategies to prevent waste and recycling. Given the level of economic growth of each country and the prevailing culture, it is necessary to take managerial measures, educate members of society and use modern equipment to reduce water consumption. The results of this study showed that the recycling of drinking water and the use of gray water is also an important factor that needs special attention.

**Keywords:** Drinking water, Water supply, Climate changes, Drought, Disaster

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**Introduction**

Disasters are a part of human life and there is no region of the earth that is safe from disasters.<sup>1,2</sup> The Asian region is vulnerable to natural disasters due to its geographical location.<sup>3</sup> Problems related to natural disasters are also increasing in the world.<sup>4</sup> According to the Center for Research on the Epidemiology of Disasters (CRED), in 2021, disasters will be divided into two categories in terms of origin.<sup>5</sup> Drought is one of the natural disasters and one of the most damaging disasters.<sup>6,7</sup> Drought is a complex natural disaster and has tremendous impacts on ecosystem performance, the environment and local and global economies.<sup>8,9</sup> The analysis of soil moisture and drought indices indicates an increased risk of drought in the 21st century.<sup>10,11</sup> This phenomenon leads to an imbalance between water supply and demand with the dominance

of abnormally dry climate<sup>12</sup> and it contributes to water insecurity.<sup>13-15</sup> Research shows that global communities are becoming more aware of drought.<sup>6</sup> Drought events affect various economic sectors and the environment.<sup>16</sup> Drought causes water scarcity, desertification and dust storms.<sup>17</sup> Given that drought is a creeping disaster and affects water health, therefore, the present study aimed to identify methods to reduce pressure on drinking water resources in drought conditions.

**Material and Methods**

A comprehensive literature in various computerized databases with a narrative review method was conducted. The research environment included Embase, Scopus, Web of Science and PubMed databases. Inclusion criteria are as follows: articles on the methods of collecting, storing and



consuming water in households in drought conditions, being in English and with full text, which were in the period of 2000-2020.

By searching in MeSH terms and referring to some of the main articles related to the research topic and reviewing their keywords, English keywords including “potable water saving, saving, water saving, drinking water supply, potable water supply, fresh water supply, conservation water, household water saving, maintenance drinking water, maintenance potable water, drought, climate change” were used. First, the titles of the articles were reviewed, and then the abstract of the relevant articles were studied. Afterwards, the identified relevant articles, with the assistance of the research team, were studied several times and then their important points were extracted, and the variables related to reducing pressure on water resources were identified and categorized.

**Results and Discussion**

After applying the keywords, 276 articles were obtained from all 4 databases (Scopus 30, MBS 26, PubMed 107 and Web of Science 113). After considering the inclusion criteria, the number of selected articles was as follows: PubMed 14 articles, Web of Science 12 articles, Scopus 12 articles and EMBAS 12 articles. These articles were read by the authors during several review sessions. Finally, the following four themes were identified: the use of modern devices and equipment, the methods to reduce waste and prevent water loss, paying attention to culture and education and management and policy methods (Table 1).

**The Use of Modern Equipment**

some articles on desalination equipment to obtain a sufficient amount of water,<sup>18-22</sup> some on the use of intelligent equipment to provide feedback on water consumption, as well as the use of water pressure reducer before the meter, advanced irrigation technologies and control of water consumption in homes were mentioned.<sup>23-25</sup>

**The Methods to Reduce Waste and Prevent Water Loss**

These methods include methods such as water recycling, not using drinking water for agricultural purposes, washing clothes, cars, etc,<sup>18,19,21,25-32</sup> preventing water loss in the distribution system,<sup>19,33</sup> covering pools in homes,<sup>34</sup> building emergency water pipelines to solve the problems of water pipes in 24 hours,<sup>21</sup> providing water consumption feedback to the family<sup>25</sup>, and in general methods to prevent water wastage.<sup>35</sup>

**Culture and Education**

Some articles referred to teach the proper use of water, changing consumption by providing incentives and creating a culture in order to influence the knowledge, attitude and perception of people and, as a result, making changes in people’s behavior, creating social campaigns to conserve water and promoting a culture of saving.<sup>24,34,36-41</sup>

**Management and Policymaking Methods**

Some articles have suggested adapting water resources management practices to climatic conditions,<sup>19,27,31,42-47</sup> water demand management, setting pricing policies

**Table 1.** Search Results in EMBASE, SCOPUS, Web of Science and PubMed Databases in 2000-2020

Databases	PubMed	Web of Science	Scopus	Embase
Category	Sub-category	Sub-category	Sub-category	Sub-category
1. Use of advanced equipment	- Intelligent water control equipment - Desalination plants	-Water desalination	Construction of a desalination plant	- Intelligent feedback equipment water consumption, - High quality technologies to prevent water wastage
2. Reducing water waste	- Water recycling - Reducing waste in distribution systems, preventing waste such as covering swimming pools in residential houses	- Water recycling - Inspection of water distribution systems to reduce water leakage - Reducing water pressure at night	- Building a water emergency - Water recycling	- Feedback on water consumption to families - Social changes in life - Promoting water saving - Water recycling
3. Culture and education	- Educate people - Changing cultural beliefs - Changing the lifestyle of residents	Correcting water consumption behavior	Learning how to save water	- Changes in people's perceptions to enhance adaptive behavior - Increased sense of self-efficacy in people - Relating climate change to previous disasters that people have experienced - Teaching behaviors that are compatible with drought - Education of children and families through consultation, play and modeling
4. Management and policy making methods	- Collecting rainwater - Virtual water trade - Adapting water resources management to climate change - Pricing policies - Public information - General consultation - Investing in scientific research to increase drought resistance	- Collecting rainwater - Water use management - Reducing water demand policies at night -Optimal pricing policies - Paying attention to drought for future water supply plans - Water resources management	- Appropriate matching strategies - Virtual water trade	- Optimization of water consumption methods - Management of avoidance-emotional methods - Alternative management policies - Mandatory regulations for the use of modern equipment to prevent water loss - Management water demand reduction

to reduce demand,<sup>24,25,44,48-51</sup> enforcing rules to restrict water use to high-consumption subscribers,<sup>25,33,47,51,52</sup> applying incentive policies such as discounts to people who consume the most,<sup>20</sup> rainwater collection,<sup>53-63</sup> virtual water trade<sup>22,64,65</sup> and in general optimizing consumption methods.<sup>38</sup>

Apparently, any action at the household and community level reducing water consumption and controlling its consumption can reduce the pressure on water resources.

The findings of this study showed that some articles have referred to the use of modern devices and equipment, including DeNicola et al,<sup>18</sup> Kumar et al,<sup>20</sup> Tarawneh,<sup>19</sup> Frizenschaf et al,<sup>21</sup> Liu et al.<sup>22</sup> In their study, they referred to desalination equipment in the domestic and industrial sectors to reduce pressure on conventional water sources (surface water and groundwater aquifers) and as a way to access safe drinking water in drought.

In general, when desalination equipment is well designed, it can perform water purification operations and produce high quality water. Of course, these methods are very expensive and may not be cost-effective for many countries.<sup>66,67</sup> Therefore, its economic parameters must be considered.<sup>68</sup> On the other hand, this process can have adverse environmental effects, for example, the waste from this process may be toxic to marine organisms.<sup>69</sup>

In another study, Dawadi and Ahmad mentioned the construction of new homes with smart equipment for water consumption, landscaping with artificial turf, and the non-use of swimming pools in residential homes.<sup>34</sup> Liu et al stated that saving water consumption depends on providing feedback on the amount of consumption and the type of item being fed to the household such as the amount of water consumed in the wash over a one-month period. They emphasized that the information provided to families in the form of feedback should be easily understood by them.<sup>23</sup> Although the use of modern equipment, examples of which are mentioned has some advantages, it should be borne in mind that providing these methods requires spending money, so for developing countries with weakening economies it is necessary to examine the advantages and disadvantages of using these methods.

Some articles have suggested ways to reduce water waste including Stec and Kordana stated that recycling gray water and using rainwater for non-drinking purposes can be a valuable alternative source for conserving water resources.<sup>32</sup> Also, DeNicola et al emphasized on wastewater recycling and water reuse,<sup>18</sup> and Hurlimann et al suggested using recycled water to irrigate gardens, washing clothes, and flushing toilets.<sup>29,30</sup>

Garnier et al point to the soundness of distribution systems to prevent water loss, reuse, and local collection of rainwater.<sup>33</sup> In another study, Dawadi and Ahmad, to reduce water use, pointed to significant changes in people's consumption and lifestyle, such as covering swimming pools in residential homes and providing incentives for people to consume less water.<sup>34</sup> Dolnicar and Schäfer also

highlighted the importance of water recycling and states that the use of fresh water is more suitable for eating and drinking, and in contrast, recycled water is more suitable for irrigation, car washing, and home washing. According to their study, it is necessary to bridge the gap of public knowledge to address their concerns in various ways.<sup>52</sup> Furthermore, Kumar and Ahmad highlighted the importance of water reuse in industry and agriculture.<sup>20</sup> Frizenschaf et al also emphasized the greater use of recycled water for non-drinking purposes. Among the ways to use water efficiently in drought, the researchers considered limiting water consumption, establishing rapid assessment and monitoring teams as water emergencies for accidents related to damage to drinking water supply pipelines, and limiting water abstraction from rivers.<sup>21</sup>

Khodarahimi et al also emphasized the following options: do not consume drinking water for matters other than drinking or eating, reduce the frequency of bathing, general education to develop optimal methods of water use and prevent bad habits in water consumption, water quotas and warning people to reduce water consumption.<sup>25</sup>

Leusbrock et al stated that reducing demand through conservation methods could save 23% to 25% of water consumption, and cited water recycling as a way to reduce pressure on water resources.<sup>47</sup> Suzuki also introduces the use of discounts in water prices as a motivating factor for promoting the correct water consumption pattern.<sup>24</sup> Also, Tarawneh points to the reconstruction of water distribution systems to reduce water waste and the implementation of rainwater collection techniques for greater access to safe water.<sup>19</sup>

In general, the findings of the present study showed that paying attention to water recycling and strategies to prevent water wastage can all reduce the pressure on water resources.

In terms of culture and education, articles such as Ferguson et al pointed to the importance of changing urban water supply systems to an integrated water system, and pointed to the role of culture and its importance in achieving this goal.<sup>36</sup> Dawadi and Ahmad noted the role of educating individuals in changing water consumption habits and lifestyles in reducing water consumption.<sup>34</sup> Dolnicar and Schäfer suggest that to reduce the gap in public knowledge about water recycling and its use in non-drinking water it is necessary to act through education in schools, public information campaigns and give advice to the people in the areas where the equipment is available.<sup>52</sup> Khodarahimi et al stated that providing education to families and children can prevent water loss.<sup>25</sup> Deng et al emphasized culture and education to conserve drinking water resources.<sup>41</sup>

Nevertheless, regarding the management and policy, options such as rainwater collection, virtual water trade, adaptation of water resources management to climate change, information and public consultation, optimization of water consumption methods, the use of alternative management policy for consumption water in rural areas,

mandatory regulations for the use of modern equipment that can prevent water loss, water use restrictions, reduced water demand, reduced water pressure at night, paying attention to the frequency and possibility of drought for future water supply plans, water resources management plan, pricing policies, were all among the items that overlapped in the above groups; hence, in this study, only the rest of the articles are mentioned, in the following.

Bangash et al pointed to the active management of drinking water supply basins and paying attention to preventive measures to conserve water resources.<sup>42</sup> Mashhadi Ali et al highlighted the management of water use restrictions.<sup>31</sup> Sağlam pointed to the impact of pricing policies and states that, if prices are properly regulated, there will be virtually no shortage in the next century.<sup>50</sup> Staben et al stated that it is necessary to formulate an appropriate adaptation strategy that takes into account the conditions of climate change and other influential factors such as growing demand for water and its impact on the supply system.<sup>51</sup>

### Conclusions

Any use of purified water other than eating and drinking puts pressure on freshwater sources and therefore all water consumption behaviors need to be well managed. To reduce the pressure on water resources in drought in the world, it is necessary to pay attention to the following four components according to the level of economic development of each country or region, culture and laws of each country: the use of new equipment, reduction of water loss, paying attention to culture and education, and management and policy methods. Due to the multi-disciplinary nature of drinking water resources management, policymakers in this area need to adopt an integrated, multi-sectoral and comprehensive approach to identify, prioritize and implement options to reduce pressure on water resources. These programs need to be included in crisis management and disaster risk reduction programs. Moreover, legal and executive guarantees should be considered for its proper implementation. Educating the community and creating a culture to improve the drinking water consumption pattern and change the unacceptable behaviors, to improve the consumption pattern of the community, should be an integral part of these programs. In addition, recycling of drinking water and use of gray water are methods that can prevent water wastage and reduce the pressure on resources. It is suggested to increase the use of this approach with innovative methods by considering the conditions of each region.

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### Authors' Contributions

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**Data curation:** All of the authors.

**Formal analysis:** All of the authors.

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### Competing Interests

The authors declare that they have no conflict of interest.

### Ethical Approval

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

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