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# Investigate the TRNC Water Resources Management Strategies Using Possible Options

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**Abstract -** *Very good research has been done on the management of the TRNC's water resources, but none of them has compared all the options together. Therefore, the research of this study is done with a library study along with field research and finally it is concluded which strategies are most recommended. As mentioned, this research, unlike previous research, will not be on a specific management project. All possible options will consider for managing water resources in the TRNC, and all of these options will be collected, and a very important conclusion will be made. All possible options consider for managing water resources in the TRNC, and all of these options was with their recommendations and the most important was about: There is a need to periodically assess the water budget on a regional basis, for example, every 5 or 10 years, to provide a periodic update on demand and supply for proper water management in the domestic and agricultural sectors. There is a need to provide a periodic update on the groundwater extraction and yield capacity of all available aquifers including the extent of contamination or replenishment. There is a need to provide a periodic update on streamflow and dam storage including the extent to which these resources are affected by drought.*

***Key Words***: *Water Resources, Water Resources Management, Climate Change, Strategies, TRNC.*

## 1.INTRODUCTION

Among natural factors, climate plays a very important role in human activities. The assistance or non-assistance of the climate is more effective than other natural factors in the development of urban and rural areas. Indicates a lack of assistance from climatic factors; And the compactness of human communities in specific geographical areas indicates its moderation and assistance (1-3).

Types of climate and its annual or seasonal changes, in order to build and create their own types of living space, have required the creation of habitats in relation to the type of climate in which they live. The length and width of the doors and windows, the thickness of the walls, the shape and form of the building, the type of roof, the material, the height of the building and all, are in harmony with the natural environment and especially climatic factors (4-6).

The role of temperature in the sustainability and development of cities and residential areas has a significant effect. High temperatures require a special type of cities, villages and residential areas. The dispersion and extent of residential areas and even the area of such units is based on the type of temperature. Existence of windbreaks or porches, opposite windows, material type, which connects different elements of residential units, is due to the need for heat exchange between different components of the building. In contrast, homes that need more heat storage throughout the year require a different type of building, building coverage, and density (7-10).

Rainfall in different seasons of the year has different effects on the dispersal of human communities and their livelihoods. In areas with rainy and dry summers, groups of people circle around permanent water sources such as springs, rivers, or wells; And in other areas where there is rainfall throughout the year, such densities are more widespread and more diffuse. The type of housing in humid and dry climates is fundamentally different. The amount of rainfall has a direct relationship with the type of roof and their material in the building and the length and width of alleys and the natural slope of urban neighborhoods and even the formation of buildings. From another point of view, the amount of temperature and precipitation is related to the quality of asphalt and surface coverage of streets and alleys, and the amount of water penetration in the soil in terms of surface water disposal and the type of surface cover in relation to temperature should be studied take (11-13).

The water management problems are increased in recent century. For example, about Surface Flow, there are problems. About Turkey, it has a relatively high topography (about 1,000 m) and the altitude increases as you go to eastern Anatolia. In winter; Especially the eastern parts of Turkey receive the majority of precipitation in the form of snowfall; therefore, the principal rivers arising from these regions are classified as snow fed rivers. The peak flow in these rivers occurs in the spring. As snow cover is sensitive to temperature increases, the predicted temperature

increases are expected to shift the peak flow towards winter (14). The changes in flows in the 21st century according to scenario A2 of the ECHAM5 model simulation. For the first 30-year period, the ECHAM5 A2 simulation predicts an increase in runoff for almost every region of Turkey in both winter and spring seasons. This flow pattern starts to change in the second period. During this period, it is estimated that the runoff in Eastern Anatolia will increase in winter and decrease in spring. This is most likely an indication of early melting due to increased surface temperatures. In the same period; It is estimated that the surface runoff will increase in both seasons in the Western Black Sea Region, and increase in the Aegean and Southeastern Anatolia in the spring. It is expected that there will be less runoff in the Mediterranean Region in the 2041-2070 period compared to the current period. The change pattern in the last period is largely similar to the changes in the second period (15- 19).

All simulations indicate significant reductions in winter and spring runoff in western Turkey. In addition, according to these simulations, there is a significant decrease in spring runoff in eastern Turkey. ECHAM5 and HadCM3 A2 simulations for the same region show greater increases in winter runoff; in contrast, CCSM3 simulations do not show large changes in winter runoff. The reason for the large changes in the surface runoff during the summer months is the very low flow rates in the summer months. Even small changes result in large percentages (20,21).

As mentioned, this research, unlike previous research, will not be on a specific management project. All possible options will consider for managing water resources in the TRNC, and all of these options will be collected, and a very important conclusion will be made.

## 3. Methodology

As mentioned, this research will use library studies as well as field research to extract existing options for water resources management in the TRNC, and then a total strategies with their recommendations will be prepared.

### 3.1 Study Area

Northern Cyprus (Turkish: Kuzey Kıbrıs), officially the Turkish Republic of Northern Cyprus (TRNC; Turkish: Kuzey Kıbrıs Türk Cumhuriyeti, KKTC), is a de facto state that comprises the northeastern portion of the island of Cyprus. Northern Cyprus extends from the tip of the Karpass Peninsula in the northeast to Morphou Bay, Cape Kormakitis and its westernmost point, the Kokkina exclave in the west. Its southernmost point is the village of Louroujina. A buffer zone under the control of the United Nations stretches between Northern Cyprus and the rest of the island and divides Nicosia, the island's largest city and capital of both sides. Figure 1 shows Northern Cyprus and its water transferring.


**Fig -1**: Northern Cyprus and its water transferring

### 3.2. Methodology and Data

All the information used in this article is obtained from library articles and studies, which are about 50 articles. Also, all strategies are extracted from these articles and the emphasis on them is determined.

## 4. Results

Infrastructure helps to solve the water crisis in various ways, some of which are mentioned below.

Water shortage solutions

There are many ways to help reduce water scarcity, including increasing agricultural productivity, investing in green and gray infrastructure, and reusing wastewater [22-24].

Increase agricultural efficiency

Previously, a lot of water was wasted during the agricultural process, but with changes including the use of seeds that require less irrigation and an improved and accurate irrigation system, water consumption can be reduced [25-28].

Green and gray infrastructure investment

The results of research and the World Bank show that gray infrastructure such as pipes and treatment plants and green infrastructure, wetlands and healthy watersheds can work together to provide water quality. Investing in new technology can broadly improve the day-to-day management of water needs in communities and businesses [29-31].

Solutions to the water crisis with the help of technology

Steam density

Researchers in the Americas used solar distillates to purify water. Water is evaporated using solar energy and steam condenses on a surface to collect clean water. Current technology is providing solutions to this old method that improves its performance and efficiency [32].

Water from the desert air

In large parts of the world, the problem is not water pollution, but its absence. According to the United Nations, more than 2.1 billion people live in arid areas, which make up 41.3% of the total land area, and this figure is expected to increase with desertification due to climate change. To reduce water scarcity in these areas, systems such as fog condensers have been developed, but require large reservoirs, energy sources, or complex installations [33-36].

Fresh water from the sea

Despite living by the great oceans, a large part of the world's population does not have access to drinking water. However, desalination of seawater is still a limited option. Large factories that use polymer membrane filtration systems are expensive and inefficient due to their high energy consumption. New materials science can also provide an alternative solution to existing sweeteners [37, 38].

Water purifier with straw

The United Nations estimates that of the 2.2 billion people who do not have access to safe water in their homes, more than 1.6 billion will have to travel long distances to collect water. Nearly 600 million people also drink from wells, streams, lakes or other sources that are a source of dangerous microbes. Every year, 829,000 people die from diarrhea caused by microbiological contamination of water [39-42].

In 2005, the Swiss company introduced a simple but innovative system (plastic pipe 22 cm long and 3 cm in diameter) that was used as a soft drink and was effective in eliminating water pollution. Each sample could purify up to 4,000 liters of water for one person in three years [43].

Water Purifier Book

Undoubtedly one of the most important, simplest and most practical systems for water purification is provided by Folia Water; A book whose pages kill water microbes. This design is also known as a "drinkable book". Each book provides aseptic water for four years. The company aims to provide access to clean water for one billion people at a cost of less than a cent a day [44].

Wastewater recycling

Wastewater treatment plants, homes, and industrial wastewater can effectively reduce our dependence on freshwater resources. At present, treatment and reuse leaders are emerging. Oman is one of the countries with the highest water pressure, treating 100% of its collected wastewater and reusing 78%. In the GCC countries, 84% of wastewater is collected and treated at safe levels, but only 44% is reused [45].

On the other hand, the sunlight source can also be used to remove microbiological contamination from dirty water using ultraviolet (UV) rays. Disinfection of solar water using sun exposure in suitable containers is a popular method recommended by the World Health Organization. However, UV makes up only 4% of the energy in sunlight, and Stanford University researchers did this using visible light [46].

The United Nations estimates that half of the world's population will live in areas of high water stress by 2030, and the effects of water scarcity could include increasing global tensions, reduced access to clean water, food shortages, energy and slowing economic growth.

"Over the next 30 years, more than one billion people will be displaced by water scarcity," said Steve Kililla, an Australian entrepreneur and founder of the Institute for Economics and Peace [47-50].

It is clear that water scarcity is on the verge of becoming a global water crisis, and if we do not continue to do so, our lives will be affected. Now is the time for countries, businesses and communities to pay attention to their water needs and use and to plan for the future.

the most important The TRNC's water management principles was about: There is a need to periodically assess the water budget on a regional basis, for example, every 5 or 10 years, to provide a periodic update on demand and supply for proper water management in the domestic and agricultural sectors. There is a need to provide a periodic update on the groundwater extraction and yield capacity of all available aquifers including the extent of contamination or replenishment. There is a need to provide a periodic update on streamflow and dam storage including the extent to which these resources are affected by drought.

## 5.Discussion

As mentioned, this research, unlike previous research, is not be on a specific management project. All possible options

consider for managing water resources in the TRNC, and all of these options was with their recommendations and the most important was about: • There is a need to periodically assess the water budget on a regional basis, for example, every 5 or 10 years, to provide a periodic update on demand and supply for proper water management in the domestic and agricultural sectors.

• There is a need to provide a periodic update on the groundwater extraction and yield capacity of all available aquifers including the extent of contamination or replenishment.
• There is a need to provide a periodic update on streamflow and dam storage including the extent to which these resources are affected by drought.
It is suggested that in future research, a questionnaire be prepared and from these cases, from experts.

## REFERENCES

[1] Dong, X., Jiang, L., Zeng, S., Guo, R., & Zeng, Y. (2020). Vulnerability of urban water infrastructures to climate change at city level. Resources, Conservation and Recycling, 161, 104918.

[2] Ananda, J. (2014). Institutional reforms to enhance urban water infrastructure with climate change uncertainty. Economic Papers: A journal of applied economics and policy, 33(2), 123-136.

[3] Ruth, M., Bernier, C., Jollands, N., & Golubiewski, N. (2007). Adaptation of urban water supply infrastructure to impacts from climate and socioeconomic changes: the case of Hamilton, New Zealand. Water Resources Management, 21(6), 1031-1045.

[4] Sahin, O., Siems, R., Richards, R. G., Helfer, F., & Stewart, R. A. (2017). Examining the potential for energy-positive bulk-water infrastructure to provide long-term urban water security: A systems approach. Journal of Cleaner Production, 143, 557-566.

[5] Mikovits, C., Rauch, W., & Kleidorfer, M. (2014). Dynamics in urban development, population growth and their influences on urban water infrastructure. Procedia Engineering, 70, 1147-1156.

[6] De Graaf, R., & Van Der Brugge, R. (2010). Transforming water infrastructure by linking water management and urban renewal in Rotterdam. Technological Forecasting and Social Change, 77(8), 1282-1291.

[7] Hailegeorgis, T. T., & Alfredsen, K. (2017). Analyses of extreme precipitation and runoff events including uncertainties and reliability in design and management of urban water infrastructure. Journal of Hydrology, 544, 290-305.

[8] Noi, L. V. T., & Nitivattananon, V. (2015). Assessment of vulnerabilities to climate change for urban water and wastewater infrastructure management: Case study in Dong Nai river basin, Vietnam. Environmental Development, 16, 119-137.

[9] Savic, D., Bicik, J., Morley, M. S., Duncan, A., Kapelan, Z., Djordjevic, S., & Keedwell, E. (2013). Intelligent urban water infrastructure management.

[10] McDonald, R. I., Weber, K., Padowski, J., Flörke, M., Schneider, C., Green, P. A., ... & Montgomery, M. (2014). Water on an urban planet: Urbanization and the reach of urban water infrastructure. Global environmental change, 27, 96-105.

[11] Flörke, M., Schneider, C., & McDonald, R. I. (2018). Water competition between cities and agriculture driven by climate change and urban growth. Nature Sustainability, 1(1), 51-58.

[12] Hughes, G., Chinowsky, P., & Strzepek, K. (2010). The costs of adaptation to climate change for water infrastructure in OECD countries. Utilities Policy, 18(3), 142-153.

[13] Harris-Lovett, S., Lienert, J., & Sedlak, D. L. (2018). Towards a new paradigm of urban water infrastructure: identifying goals and strategies to support multi-benefit municipal wastewater treatment. Water, 10(9), 1127.

[14] Yilmaz, K. K., & Yazicigil, H. (2011). Potential impacts of climate change on Turkish water resources: a review. Climate change and its effects on water resources, 105-114.

[15] Fujihara, Y., Tanaka, K., Watanabe, T., Nagano, T., & Kojiri, T. (2008). Assessing the impacts of climate change on the water resources of the Seyhan River Basin in Turkey: Use of dynamically downscaled data for hydrologic simulations. Journal of Hydrology, 353(1-2), 33-48.

[16] Şen, Z. (2019). Climate change expectations in the upper Tigris River basin, Turkey. Theoretical and Applied Climatology, 137(1), 1569-1585.

[17] Aktaş, Ö. (2014). Impacts of climate change on water resources in Turkey. Environmental Engineering & Management Journal (EEMJ), 13(4).

[18] Aras, E. (2018). Effects of multiple dam projects on river ecology and climate change: Çoruh River Basin, Turkey. Advances in environmental research, 7(2), 121-138.

[19] Gorguner, M., Kavvas, M. L., & Ishida, K. (2019). Assessing the impacts of future climate change on the hydroclimatology of the Gediz Basin in Turkey by using dynamically downscaled CMIP5 projections. Science of the Total Environment, 648, 481-499.

[20] Baloch, M. A., Ames, D. P., & Tanik, A. (2015). Hydrologic impacts of climate and land-use change on Namnam Stream in Koycegiz Watershed, Turkey. International Journal of Environmental Science and Technology, 12(5), 1481-1494.

[21] Selek, B., & Tuncok, I. K. (2014). Effects of climate change on surface water management of Seyhan basin, Turkey. Environmental and Ecological Statistics, 21(3), 391-409.

[22] Bryant, R. E., & Mason, M. (2017). Water technology and sustainability in north Cyprus: Climate change the Turkey-north Cyprus water pipeline. Peace Research Institute Oslo Cyprus Centre.

[23] Gökcekuş, H., Iravanian, A., Türker, U., Oğuz, G., Sözen, S., & Orhon, D. (2018). Massive freshwater transport: a new dimension for integrated water-wastewater management in North Cyprus. Desalination and Water Treatment, 132, 215-225.

[24] Park, E. J. (2020). Strategy of Water Distribution for Sustainable Community: Who Owns Water in Divided Cyprus?. Sustainability, 12(21), 8978.

[25] ASCE/UNESCO Task Committee. (1998). Sustainability Criteria for Water Resource Systems. American Society of Civil Engineers, Reston, Virginia.

[26] Beek, E. V., & Arriens, W. L. (2014). Water security: putting the concept into practice (No. 20). Global Water Partnership.

[27] Elkiran, G., & Ergil, M. (2006). The assessment of a water budget of North Cyprus. Building and Environment, 41(12), 1671-1677.

[28] Elkirana, G., Dahirub, A., & Gokcekusa, H. (2019). Water resources management and trend of water use in North Cyprus. Desalination and Water Treatment, 177, 264-274.

[29] Lee, H. (2007). Intergovernmental Panel on Climate Change.

[30] National Research Council. (2001). Compensating for wetland losses under the Clean Water Act. National Academies Press.

[31] Orr, S., Pittock, J., Chapagain, A., & Dumaresq, D. (2012). Dams on the Mekong River: Lost fish protein and the implications for land and water resources. Global Environmental Change, 22(4), 925-932.

[32] Strazzabosco, A. (2020). Asian Water Development Outlook 2020:: Advancing Water Security across Asia and the Pacific.

[33] TAC, G. (2000). Integrated Water Resources Management., TAC Background Paper No. 4. Global Water Partnership Technical Advisory Committee, Stockholm.

[34] Winemiller, K. O., McIntyre, P. B., Castello, L., Fluet-Chouinard, E., Giarrizzo, T., Nam, S., & Sáenz, L. (2016). Balancing hydropower and biodiversity in the Amazon, Congo, and Mekong. Science, 351(6269), 128-129.

[35] Bayazıt, Y. (2021). The effect of hydroelectric power plants on the carbon emission: An example of Gokcekaya dam, Turkey. Renewable Energy, 170, 181-187.

[36] Aras, E. (2018). Effects of multiple dam projects on river ecology and climate change: Çoruh River Basin, Turkey. Advances in environmental research, 7(2), 121-138.

[37] Bilgili, M., Bilirgen, H., Ozbek, A., Ekinci, F., & Demirdelen, T. (2018). The role of hydropower installations for sustainable energy development in Turkey and the world. Renewable Energy, 126, 755-764.

[38] Kaygusuz, K., Guney, M. S., & Kaygusuz, O. (2019). Renewable energy for rural development in Turkey. Journal of Engineering Research and Applied Science, 8(1), 1109-1118.

[39] Zhang, X., Li, H. Y., Deng, Z. D., Ringler, C., Gao, Y., Hejazi, M. I., & Leung, L. R. (2018). Impacts of climate change, policy and Water-Energy-Food nexus on hydropower development. Renewable Energy, 116, 827-834.

[40] Bulut, U., & Sakalli, A. (2021). Impacts of climate change and distribution of precipitation on hydroelectric power generation in Turkey. In IOP Conference Series: Materials Science and Engineering (Vol. 1032, No. 1, p. 012043). IOP Publishing.

[41] Sayan, R. C. (2019). Exploring place-based approaches and energy justice: Ecology, social movements, and hydropower in Turkey. Energy Research & Social Science, 57, 101234.

[42] Koç, C. (2018). A study on operation problems of hydropower plants integrated with irrigation schemes operated in Turkey. International Journal of Green Energy, 15(2), 129-135.

[43] Yilan, G., Kadirgan, M. N., & Çiftçioğlu, G. A. (2020). Analysis of electricity generation options for sustainable energy decision making: The case of Turkey. Renewable Energy, 146, 519-529.

[44] Bayram, H., & Öztürk, A. B. (2021). Global climate change, desertification, and its consequences in Turkey and the Middle East. In Climate Change and Global Public Health (pp. 445-458). Humana, Cham.

[45] Ozcan, M. (2018). The role of renewables in increasing Turkey's self-sufficiency in electrical energy. Renewable and Sustainable Energy Reviews, 82, 2629-2639.

[46] Adamo, N., Al-Ansari, N., Sissakian, V., Laue, J., & Knutsson, S. (2018). The future of the Tigris and Euphrates water resources in view of climate change. Journal of Earth Sciences and Geotechnical Engineering, 8(3), 59-74.

[47] Kılıç, E., Puig, R., Zengin, G., Zengin, C. A., & Fullana-i-Palmer, P. (2018). Corporate carbon footprint for country Climate Change mitigation: A case study of a tannery in Turkey. Science of the total environment, 635, 60-69.

[48] Erat, S., Telli, A., Ozkendir, O. M., & Demir, B. (2021). Turkey's energy transition from fossil-based to renewable up to 2030: milestones, challenges and opportunities. Clean Technologies and Environmental Policy, 23(2), 401-412.

[49] Kucukali, S., Al Bayatı, O., & Maraş, H. H. (2021). Finding the most suitable existing irrigation dams for small hydropower development in Turkey: A GIS-Fuzzy logic tool. Renewable Energy, 172, 633-650.

[50] Ergüner, Y., Kumar, J., Hoffman, F. M., Dalfes, H. N., & Hargrove, W. W. (2019). Mapping ecoregions under climate change: a case study from the biological 'crossroads' of three continents, Turkey. Landscape Ecology, 34(1), 35-50.