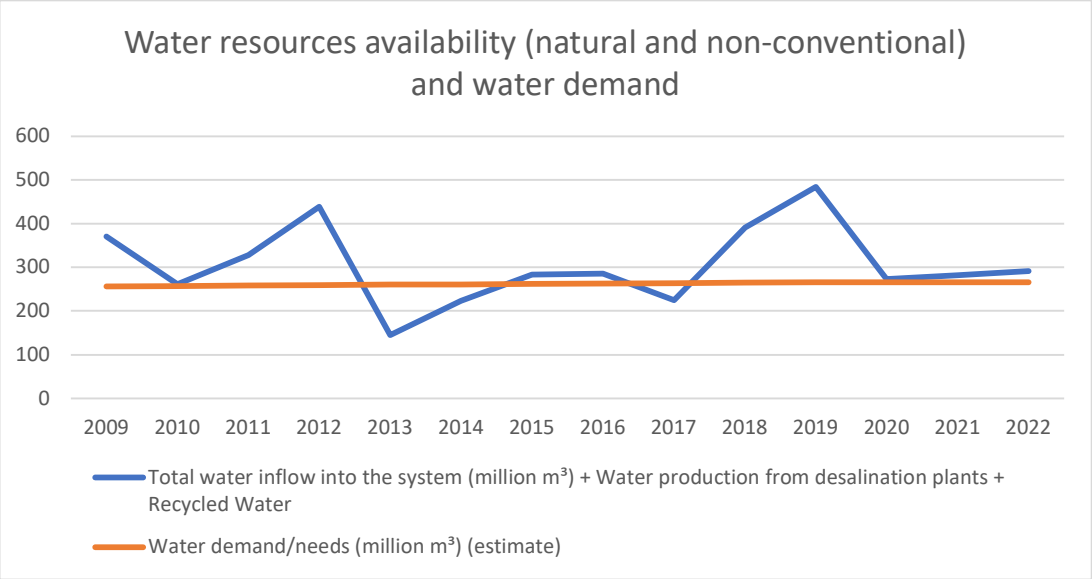
1. Summary of findings

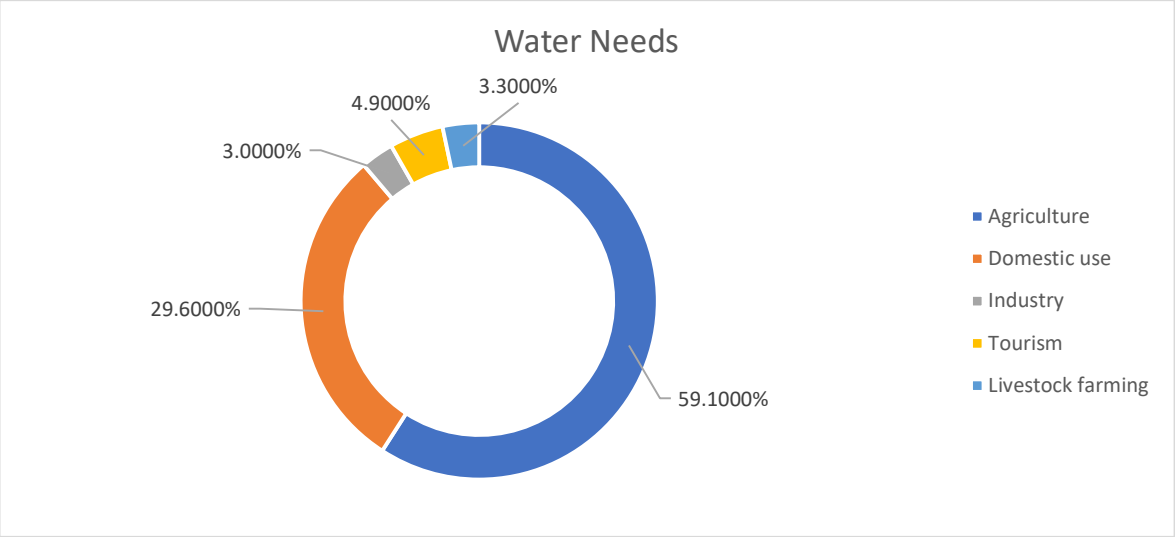
Water in Cyprus has been scarce since ancient times, and its management has consistently been a concern for all the governments of the Republic of Cyprus (RoC). The absence of lakes and rivers with continuous natural flow, along with the exclusive reliance on annual rainfall to meet the needs for domestic and irrigation water supply, combined with water scarcity, highlighted the need for action from an early stage.

Indicative of the importance of managing Cyprus' water resources is the fact that the available natural water resources per capita are, on average, only 390 m^3/per year, while the threshold for extreme water scarcity is set at 500 m^3/per year, and the threshold for water scarcity is set at 1,000 m^3/per year. At the same time, demand continues to rise due to non-climatic factors such as population growth, living standards, and tourism. For instance, during the period from 2019 to 2023, an increase of 14.8% in water demand for domestic use was recorded (+3.5% per year). Therefore, the need to enhance the available water supply through non-conventional sources became urgent, and in recent years, this has been achieved through the production of desalinated and recycled water.



Source: Audit Office of the Republic, based on data obtained from the Water Development Department, 2024.

The total annual water demand is distributed as follows:



Source: Audit Office of the Republic of Cyprus, based on data included in the Strategic Study for Water Management and Drought Mitigation, prepared by the Water Development Department in 2019, 2024.

Of the total arable agricultural land, only 24% can be irrigated, while the remaining 76% relies entirely on rainfall. Irrigation needs are largely covered (73%) by private boreholes, while the remaining 27% is irrigated by Government Water Works (GWWs).

The audit objective was to determine whether the RoC has adequately assessed the expected impacts of climate change on water resources and whether it has planned and implemented measures to address the anticipated risks, given that the overall management of water resources is vital for the RoC.

The audit questions (A - D), as well as the key findings, are briefly outlined below:

A. What have been the overall impacts of climate change on the water resources of Cyprus?

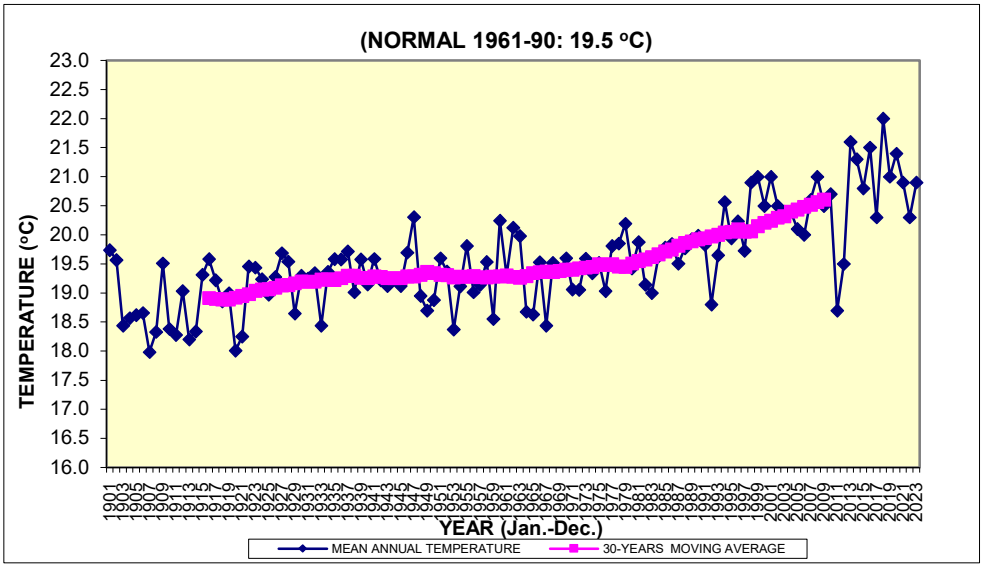
1. Impacts of climate change in the wider region of Cyprus (Eastern Mediterranean and Middle East - EMME)

- The region is warming nearly twice as fast as the global average.
- Rate of temperature increase (1981–2019):
    - EMME: 0.45°C/decade
    - Global average: 0.27°C/decade"

2. Impacts of climate change in Cyprus:

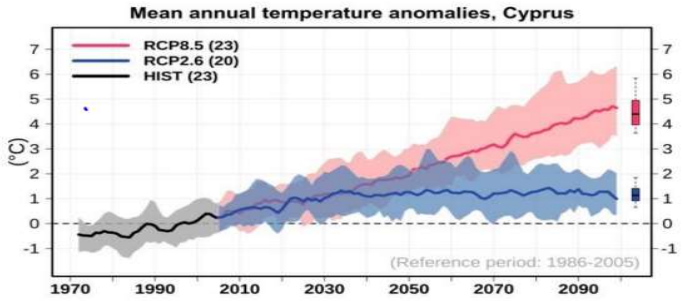
- Significant increase in temperature in the last 100 years, which in Nicosia and Limassol amounted to 1.8°C and 2.9°C, respectively, while the recorded increase in the global mean temperature (1906–2005) is estimated at 0.74°C.

Mean annual temperature (°C) in Nicosia (1901–2023)



Source: Department of Meteorology, 2024.

Predictions for anomalies in the average annual temperature in Cyprus.



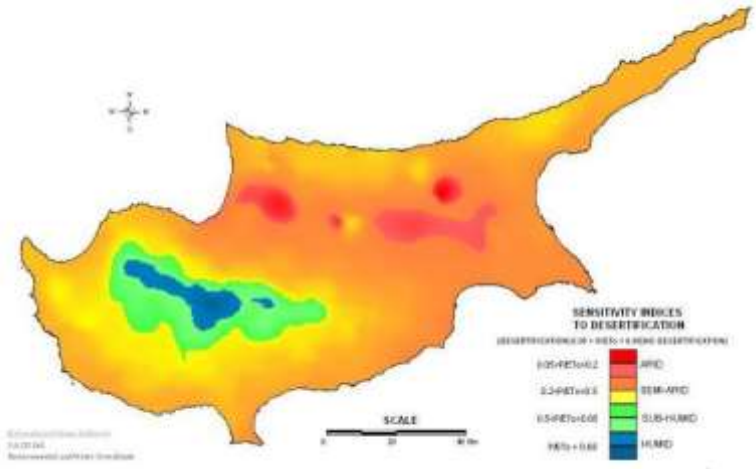
Source: Cyprus Eighth National Communication and Fifth Biennial Report – under the United Nations Framework Convention on Climate Change, Department of Environment, 2023.

- Increase in extreme temperature records:

- Heatwaves: +8 to 12 days/decade
- Summer days: +up to 8 days/decade
- Tropical nights: +up to 13 nights/decade
- Increase in days with ≥ 40°C
- Decrease in days with ≤ 0°C

- Increase in the frequency and intensity of droughts. 91% of Cyprus is characterized as critical or sensitive to climate changes.

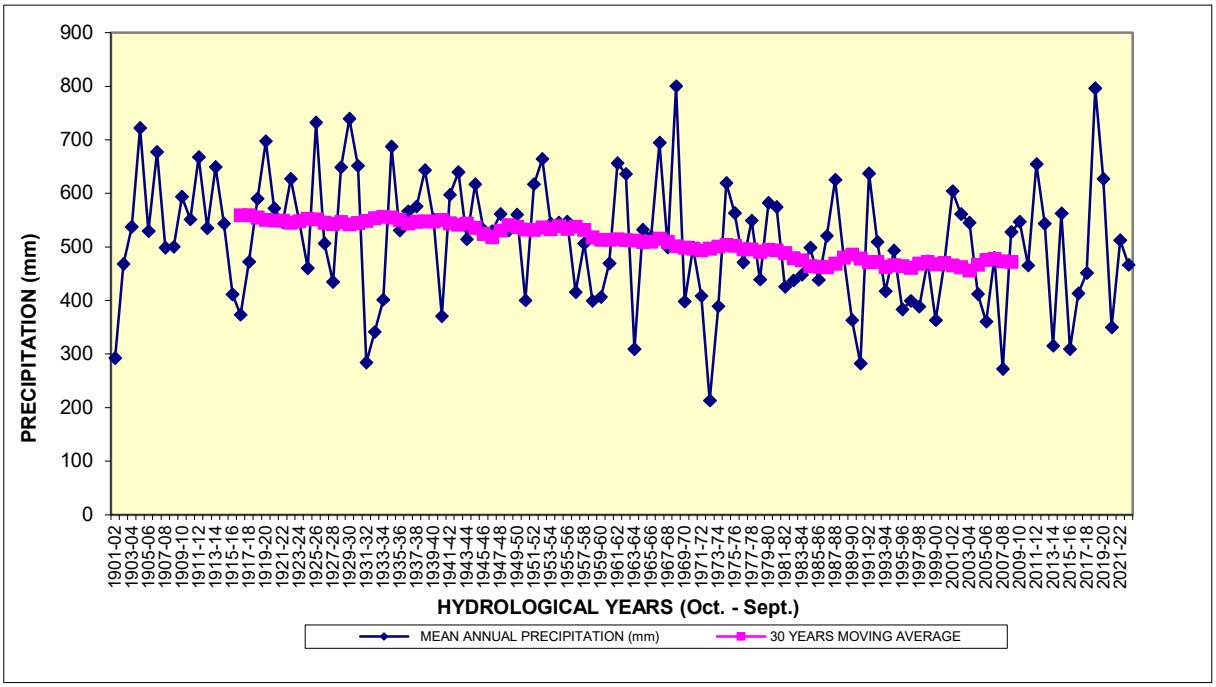
Environmentally sensitive areas to desertification.



Source: National Action Plan for Combating Desertification, Department of Environment and I.A.CO Environmental and Water Consultants Ltd, 2008.

- Decrease in the average annual rainfall (hydrological year Oct-Sep) and high rainfall variability:
  - Years with high rainfall: 800mm (1968–69), 796mm (2018–19)
  - Years with low rainfall: 213mm (1972–73), 272mm (2007–08)

Cyprus: Mean Annual Precipitation (mm) (1901–02) – (2022–23) (Normal 1961–90: 503 mm)



Source: Department of Meteorology, 2024.

- Increase in evapotranspiration: During the period 1971–2000, it is estimated that 86% of the rainfall returned to the atmosphere through evapotranspiration. In additions, in the Troodos River Basin areas, evapotranspiration shows an increasing trend of approximately 0.3–0.7 mm/year.

3. Impacts of climate change on the water resources of Cyprus:

The impacts of climate change on water resources are summarised below:

- Insufficiency of natural water resources:
    - During the years 2010, 2013–17, 2020–22, an insufficiency of natural water resources to meet demand was recorded.
    - During the years 2013, 2014, and 2017, water demand was not fully met even with the use of the produced desalinated and recycled water.
- Depletion & Salinization of Aquifers:
    - Over-extraction in 14 out of 22 Groundwater Bodies (GB)
    - Salinisation (seawater intrusion) in seven out of 22 GB
    - Coastal aquifers are particularly vulnerable.

- Impacts on river flows and the infiltration of water into GB.
- Water loss and qualitative degradation of GB.
- Increase in evapotranspiration: eutrophication, water pollution.
- Biodiversity: reduction in freshwater, destruction of ecosystems, spread of invasive species.
- Reduced agricultural productivity due to:
    - Droughts
    - Extreme weather events
    - Land degradation

B. What are the expected impacts of climate change on the water resources of Cyprus?

1. Reduction in water availability:

- Quantity and quality deterioration of the already scarce water resources (2021-2050 as compared to 2000-2010).
- Continuation of the declining trend in groundwater levels due to reduced rainfall and increased evaporation.
- Reduction in groundwater recharge due to changes in the effective precipitation and the duration of the recharge period.

Predicted anomalies in average annual precipitation in Cyprus.

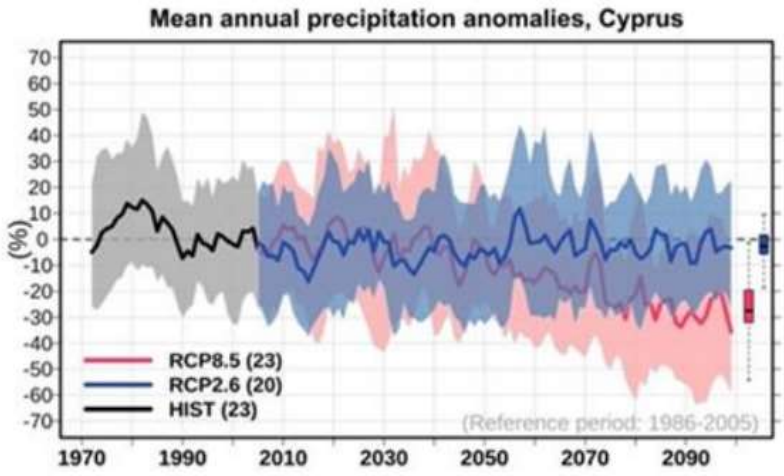


Figure 6.14. Projections of mean annual precipitation anomalies for Cyprus based on the CORDEX-CORE ensemble (see Zittis et al., 2022).

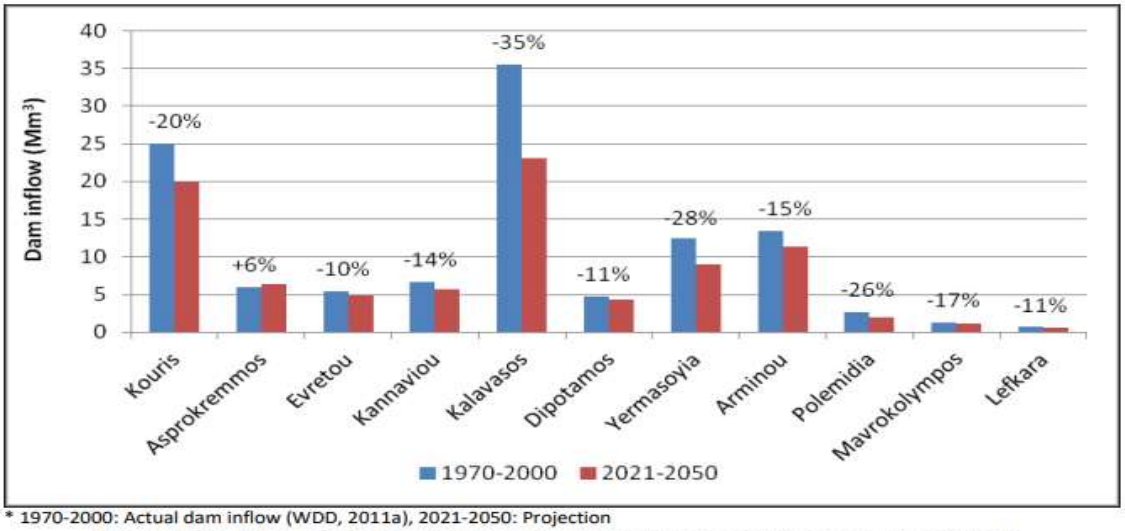
RCP 2.6[1], RCP 8.5[2]

Source: Cyprus Eighth National Communication and Fifth Biennial Report – under the United Nations Framework Convention on Climate Change, Department of Environment, 2023.

- Impacts on river flows and, subsequently, on the quantity and quality of surface water entering dams and reservoirs.
- Projected reduction in river runoff in the Troodos area (14% to 30% for a 6% to 15% decrease in rainfall).
- Expected decrease in the average annual inflow to dams by 23% (2021-2050 as compared to 1971-2000), despite the smaller estimated reduction in rainfall (5%).

[1] RCP2.6 represents a low greenhouse gas emissions scenario characterized by significant climate change mitigation actions, providing a 67% probability of limiting the increase in GMST to below 2°C by 2100.
[2] RCP8.5 is a high greenhouse gas emissions scenario characterized by the absence of climate change mitigation policies, resulting in a continuous and sustained increase in atmospheric greenhouse gas concentrations. It entails a probability exceeding 50% of GMST rising above 4°C by 2100.

Change in inflow to Cyprus' main dams for the period 1970–2050.



* 1970-2000: Actual dam inflow (WDD, 2011a), 2021-2050: Projection

Figure 6.42. Change in inflow to the main dams of Cyprus for the period 1970-2050

Source: Cyprus Eighth National Communication and Fifth Biennial Report under the United Nations Framework Convention on Climate Change, Department of Environment, 2023.

- Expected decrease in the base flow of rivers and potential risk of reduction or elimination of spring flows, rendering the mountainous communities, which rely on them for satisfying their domestic water supply needs, particularly vulnerable.

- Potential increase in sediment runoff to small dams, resulting in a reduction of their effective volume and consequently increased maintenance costs.

- Potential increase in irrigation water demand due to increased evapotranspiration and/or reduced effective rainfall.

- Further decrease in crop yields due to a combination of high temperatures and reduced water availability. This is also influenced by the fact that, during periods of limited water availability, reductions are imposed on irrigation water supply.

2. Deterioration of water quality:

- Deterioration of the quality of surface water (moderate to high) and GB (high to very high), due to reduced rainfall, increased drought periods, heavy rainfall events, rising water temperatures, sea-level rise, and low runoff. Water bodies that are already in poor quality condition are even more vulnerable to the impacts of climate change.

3. Increase in the frequency and severity of drought events:

- Increase in the frequency and duration of drought periods.
- Increased impacts of drought on the agricultural sector due to reduced soil moisture.
- Greater vulnerability of crops such as the tomatoes, the vineyards, and the olive trees due to their growth cycle being in summer.
- Significant impact of rainfall deficits on winter crops such as potatoes, barley and wheat.
- Extended drought periods also affect other sectors of the economy.

4. Impacts on infrastructure:

- Risk of physical damage and operational disruption of infrastructure (desalination plants and wastewater treatment plants) located in coastal areas, due to heavy rainfall and rising sea levels.
- Impacts from the need for increased desalinated water production on Cyprus's energy balance.
- Increase in the required operational and maintenance costs of infrastructure due to rising sea levels and the potential need for new investments.
- Vulnerability of infrastructure to damages resulting from floods (urban and coastal) and landslides.
- Need for the government to take protective measures against floods (coastal protection works, fishing shelters, dams, sustainable urban drainage systems).

The lack of sufficient data to assess the effectiveness of existing measures and the need for additional measures requires further research for a more detailed evaluation of the vulnerability of infrastructure to climate change.

C. To what extent has the RoC identified and assessed climate change risks to water resources?

References to the risks that climate change is expected to pose to the water resources of Cyprus are identified in the following:

- **Water Policy Report (2011):**

- ✓ It mentions some risks (e.g., impact on evaporation) but without an extensive discussion of the impacts of climate change.
- **x** It needs to be updated/revised with more recent data and a clear reference to the risks and impacts of climate change.

- **Climate Change Risk Assessment Report for Cyprus (2016)**

  - ✓ It identified and assessed specific risks to water resources, determining the impact and likelihood of their occurrence.
  - ✓ It focused on areas such as irrigation water supply, the natural environment (drought, productivity loss) and the provision of drinking water.
  - ✓ It recorded risks such as deficits in irrigation water supply, increased water supply costs (due to desalination), and reduced available water quantities for irrigation.
  - **x** It is now considered outdated and needs to be updated due to the long period of time elapsed since its preparation.

- **Revised Drought Management Plan (2016)**

  - **x** It mentions the expected climate changes and their impact on water resources, but without reference to their likelihood of occurrence or the magnitude of their impact.

- **National Strategy for Climate Change Adaptation (2017)**

  - ✓ It identified the impacts of climate change on water resources (availability, quality).
  - ✓ It generally mentions risks but without specifying or assessing their impact and likelihood of occurrence.
  - **x** It is outdated and is already undergoing a process of revision and updating.

- **Strategic Study for Water Management and Drought Response (2019)**

  - **x** It identified the impacts (availability, quality) but did not mention specific risks or assess the potential impact and the likelihood of the occurrence of those risks.
  - **x** It was not subjected to an environmental impact assessment (EIA).

- **National Energy and Climate Plan (2020)**

  - **x** It did not include extensive references to the consequences of climate change on water resources nor did it identify risks with an assessment of their impact and likelihood to occur.
  - **x** It only mentioned the consequences of drought and reduced rainfall.

- **x** The non submission of the final updated National Plan, caused the European Commission to initiate an infringement procedure againgst Cyprus.

- **Eighth National Communication and Fifth Biennial Report of Cyprus under the United Nations Framework Convention on Climate Change (2023)**

  - ✓ It assessed the future vulnerability of water resources to climate change (sensitivity, exposure, adaptive capacity).
  - ✓ It showed very high sensitivity and exposure of water availability to climate change.
  - ✓ It estimated moderate to high sensitivity of surface water and high to very high sensitivity of groundwater to pollution.
  - ✓ It predicted very high future exposure of Cyprus to droughts.
  - ✓ It evaluated Cyprus' adaptive capacity in various sectors (domestic and irrigation water supply, water quality, drought) as limited to very high, depending on the case.

- **Third Cyprus River Basin Management Plan or Water Management Plan (2023)**

  - ✓ It recognizes the need for sustainable use of water and the implementation of measures, taking into account the impacts of climate change.
  - **x** No specific reference to risks or the assessment of their impact and the likelihood of their occurrence.

D. To what extent has the RoC taken actions to manage climate risks to water resources through climate change adaptation actions?

Due to the long-standing problem of water scarcity faced by Cyprus, significant measures have been taken, since the establishment of the Republic, to address the problem. However, these measures were not originally intended to address the risks posed by impending threats of climate change, but merely to address existing problems caused by water scarcity. Therefore, as a clear identification of measures implemented to address climate change per se is impossible, we set below all the measures that have been implemented and contribute to adaptation to climate change.

- **Water Development Infrastructure:**

  - ✓ Construction of dams (108 in total, with a capacity of 332 million m^3) for domestic and irrigation water supply.
  - ✓ Construction of five desalination plants (with a total capacity of 235,000 m^3/per day) to eliminate the dependency on rainfall of the domestic water supply. The unit in Paphos was recently destroyed and is currently under restoration.

- ✓ Implementation and operation of works for the utilization of recycled water from wastewater treatment plants.
- ✓ Construction of a new water treatment plant in Choirokoitia and replacement of the Choirokoitia–Famagusta pipeline.
- **x** The project for connecting the Vasilikos desalination plant to the domestic water supply network is under construction, with delays. As a result, the desalinated water produced is being directed to the Southern Pipeline System, leading to the need for re-refining.

Source: Water Development Department, 2021.

- **Water Pricing Policy:**

x Without disregarding the fact that water is a basic necessity and access must be ensured for all, pricing policy is recognized as an effective tool for controlling demand for water and, consequently, for its sustainable management. The existing pricing policy for domestic water supply presents inequalities among consumers in different regions, as there are significant discrepancies in the fees imposed by Local Water Authorities.

- x Regarding irrigation, the low recovery of the cost of water supplied does not contribute to promoting crops that align with the new climatic conditions in Cyprus (World Bank report 2018, Audit Office of the RoC report 2016).
- x The provisions of the relevant regulations for the pricing of water abstracted from boreholes have not yet been fully implemented.
- x The effectiveness of the existing pricing policy as an adaptation measure has not been evaluated.

- **Dam and Reservoir Management:**

  - x Fragmented management (Ministry of Agriculture, Rural Development and Environment (ARDE) and Ministry of Interior).
  - x Lack of interconnection between major GWWs, limiting flexibility.
  - x No measures have been implemented to reduce water evaporation from dams and reservoirs, which, according to the latest estimates, stands at 8% of their storage capacity.
  - ✓ Successful application of pilot solutions to limit evaporation (floating membranes), which, however, have not been widely implemented.
  - x Exceeding the approved water abstraction limits from dams (Southern Conveyor System and Paphos GWW) set by the relevant drought indicators.
  - x Delays in the decisions of the Council of Ministers regarding water allocation for irrigation purposes.

- **Desalination Plants:**

  - ✓ Critical contribution to meeting domestic water supply needs, especially during drought periods (up to 81% of consumption).
  - x Increased production costs due to energy dependency on conventional fuels and rising energy costs.
  - x Significant discrepancies in production cost between plants.
  - x Operation of certain plants with reduced production or in standby mode.
  - x Incomplete implementation of the Drought Management Plan (DMP) for determining the operation and standby mode of plants.
  - x Need for technologies to improve efficiency and reduce costs, as well as investment in renewable energy sources.
  - x Need for rapid activation of mobile desalination plants in emergency situations (e.g., plant destruction).

- **Tertiary Wastewater Treatment:**

- ✓ Utilization of recycled water for irrigation (since 1998).
- **x** Maximum production capacity of 53.9 million m^3 annually, however in 2023, 28.2 million m^3 were produced (52.3%).
- **x** A large portion of the recycled water remains unused or is discarded.

- **European Commission infringement letters concerning water resources:**

  - **x** The European Commission sent a letter of formal notice to Cyprus on 19.04.2023 for the non-implementation of the European Court's decision, concerning the inadequate application of Directive 91/271/EEC which sets rules for the collection, treatment, and disposal of urban wastewater.
  - **x** The European Commission sent a letter of formal notice to Cyprus on 14.11.2024 for failing to periodically review the water permits it issues in line with the Water Framework Directive (WFD). In Cyprus, the national legislation does not impose any kind of periodic review, as required by the WFD.

  Cyprus is urged to take immediate measures to comply with the above, in order to avoid further sanctions.

General Conclusions/Comments

- The RoC has taken significant adaptive measures for the management of water resources through the construction of infrastructure (dams, desalination plants, wastewater treatment plants).
- The use of desalination has become critical, compensating for the impacts of reduced rainfall and guaranteeing the adequacy of water supply for domestic use, irrespectively of weather conditions.
- Weaknesses were identified in the integrated management of water resources (fragmentation, lack of interconnection).
- The pricing policy, as a tool for encouraging the sustainable use of water resources, is not used effectively.
- Delays have been observed in the implementation of strategies and plans and these are not fully utilized for the optimal functioning of infrastructure.
- It is recognized that there is a need to improve efficiency, reduce costs, and utilize renewable energy sources in desalination plants.
- There is room for improvement in the use of recycled water.