International Conference

ADAPTtoCLIMATE

Nicosia 27-28/3/2014

Water supply management in Cyprus under climate uncertainty

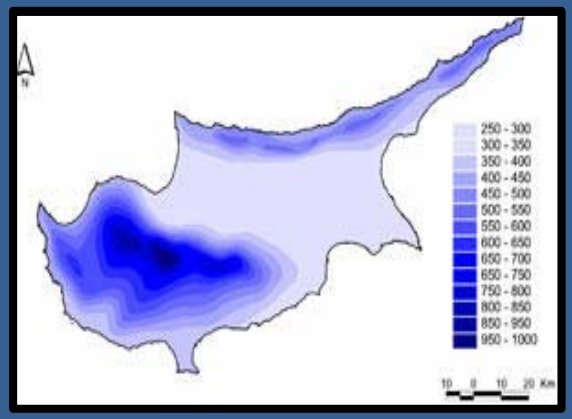
Panagiotis Thrasivoulou, Kyriacos Patsalosavvis, Dr. Antigoni Zafirakou

Civil Engineering Department, Aristotle University Thessaloniki

Water supply management in Cyprus under climate uncertainty

Impacts of Climate Change

Local climatic conditions



Water sufficiency measures

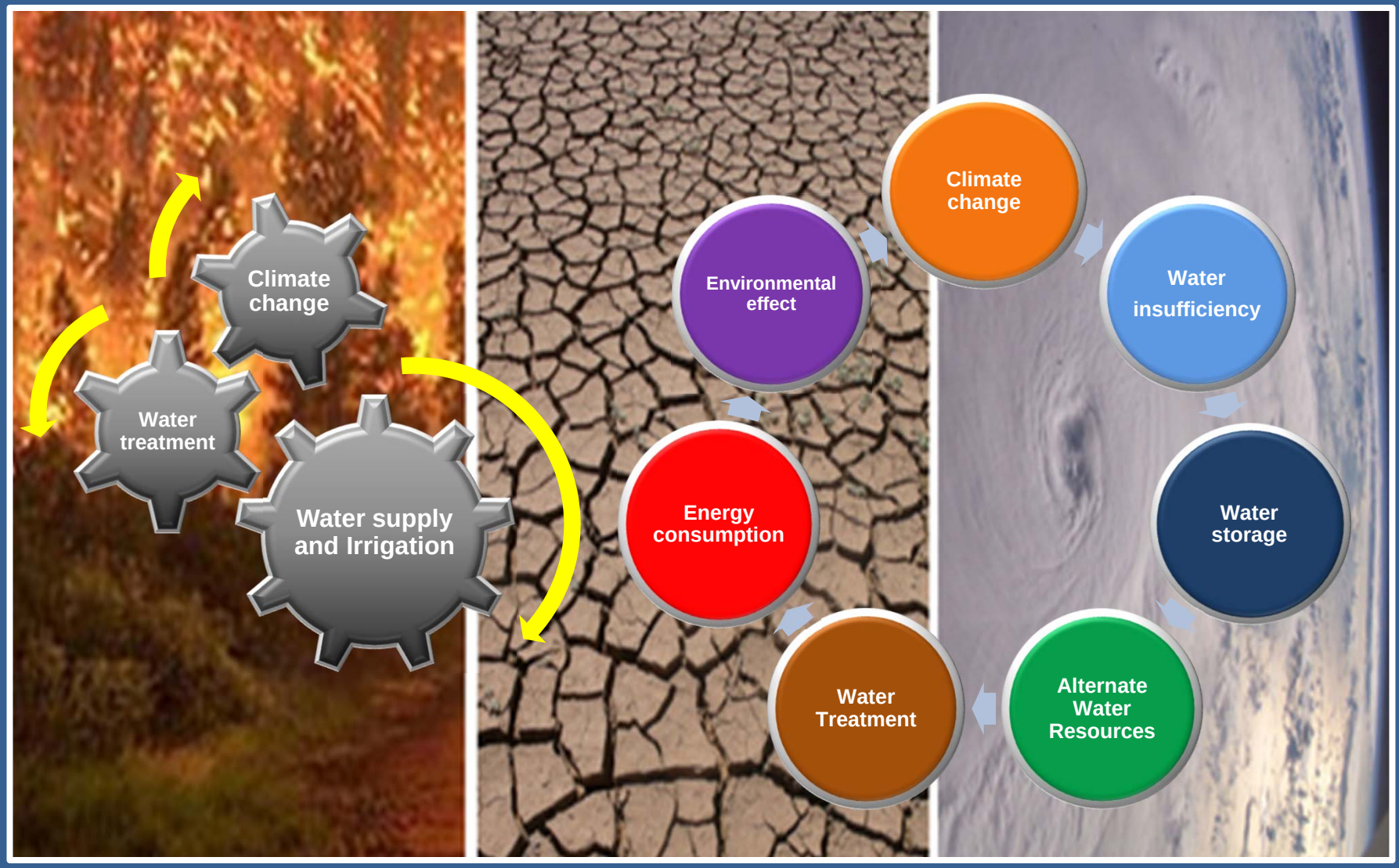
Water production impacts

Environmentally friendly technologies

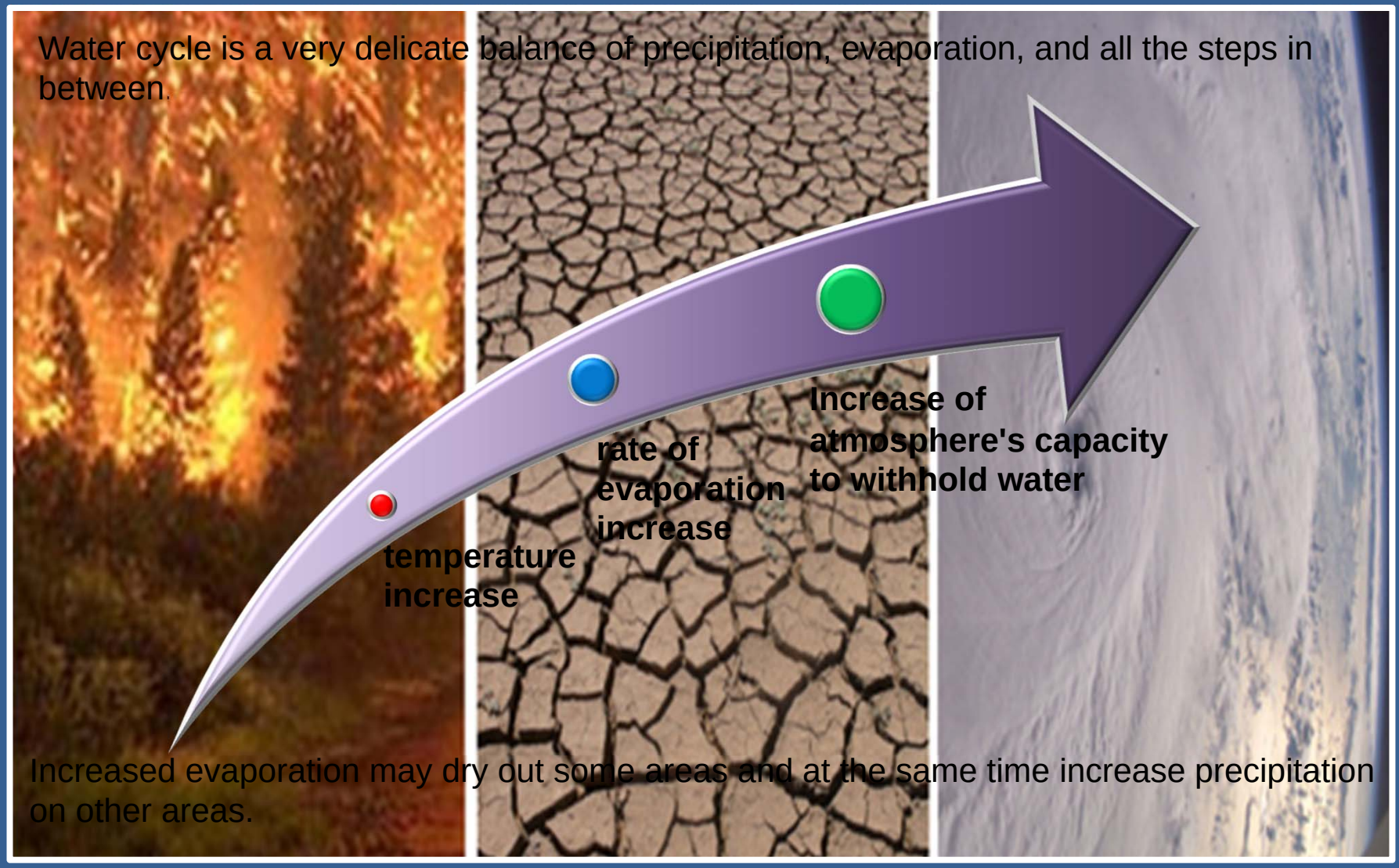
Impacts of Climate Change

- The impacts of climate change are being noticed primarily and more intensively on water resources
- We depend on a reliable, clean supply of drinking water to sustain our health and at the same time we need water for agriculture, recreation and manufacturing.
- Climate change in combination with improving life quality is increasing water demand ,while water resources are shrinking.

Impacts of Climate Change

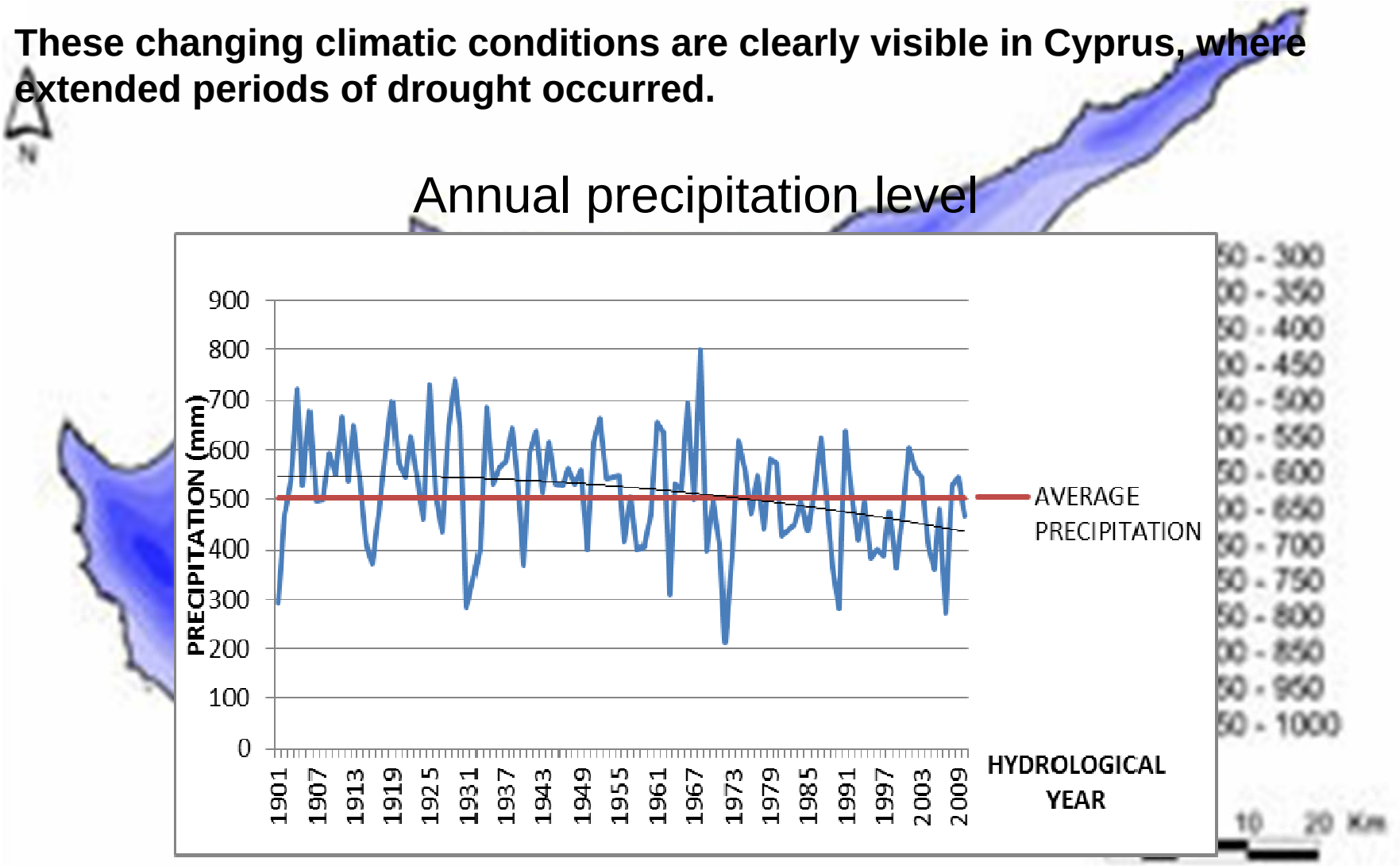


Impacts of Climate Change



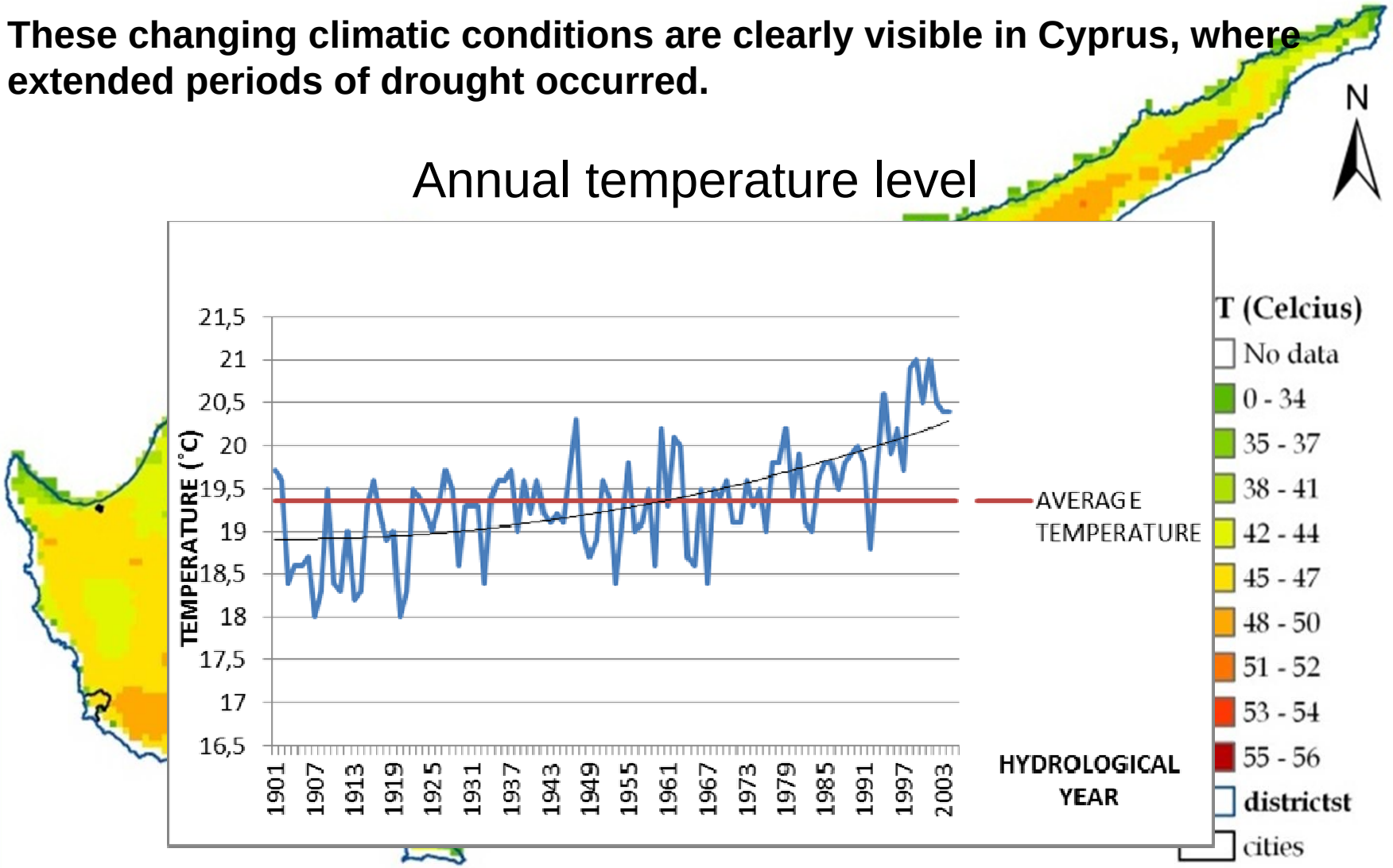
Local climatic conditions

These changing climatic conditions are clearly visible in Cyprus, where extended periods of drought occurred.



Local climatic conditions

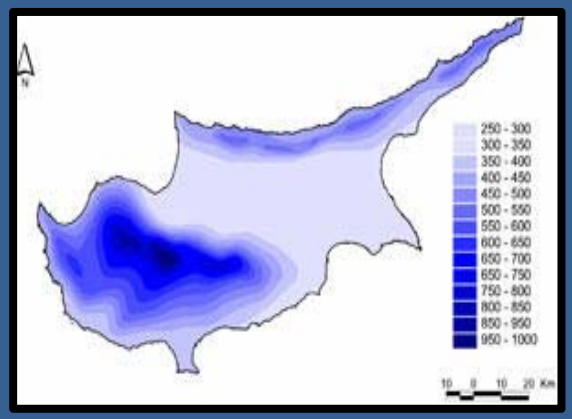
These changing climatic conditions are clearly visible in Cyprus, where extended periods of drought occurred.



Water supply management in Cyprus under climate uncertainty

Impacts of Climate Change

Local climatic conditions



Water sufficiency measures

Dam construction

Southern Conveyor project

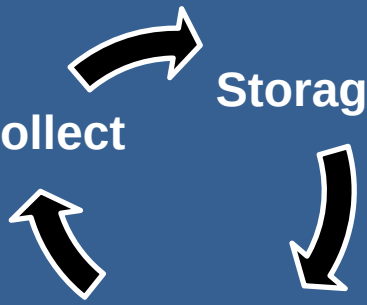
Desalination project

Water sufficiency measures

Dam construction

Climatic conditions → **Droughts** → **Water shortage**

Ways had to be found to



water

At the beginning of the 20th century the construction of dams began.

With the establishment of the Republic of Cyprus in 1960 for the first time, a unified Water Department operated.

Although many dams had been constructed, water shortage continued to concern most areas of the island.

The reason was that water shortage was treated as a local rather than a general problem.

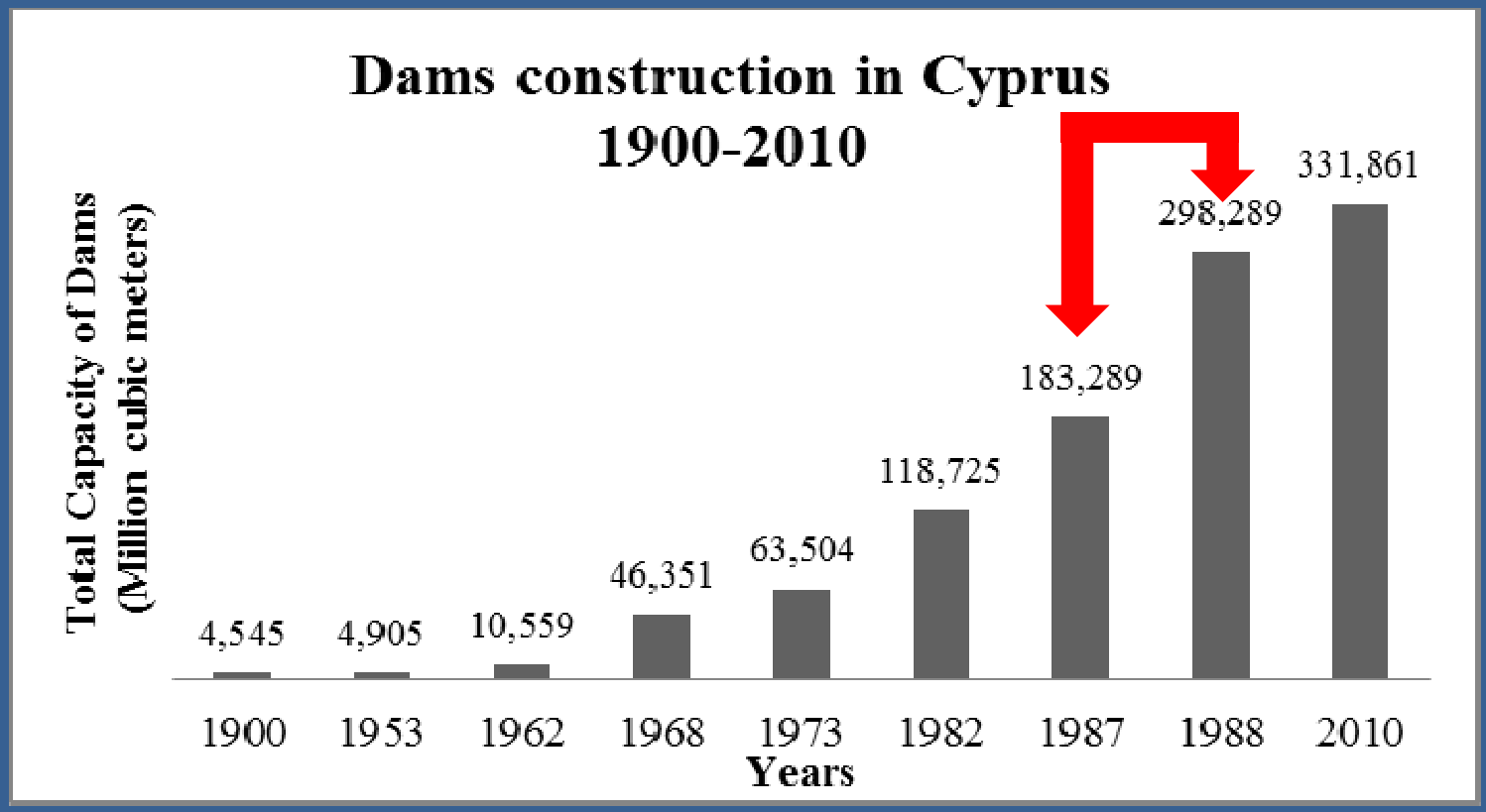
The newly formed water department set two goals:

1) **The urgent need for water conservation by the consumers**

2) **The immediate construction of new dams to meet water demand**

Water sufficiency measures

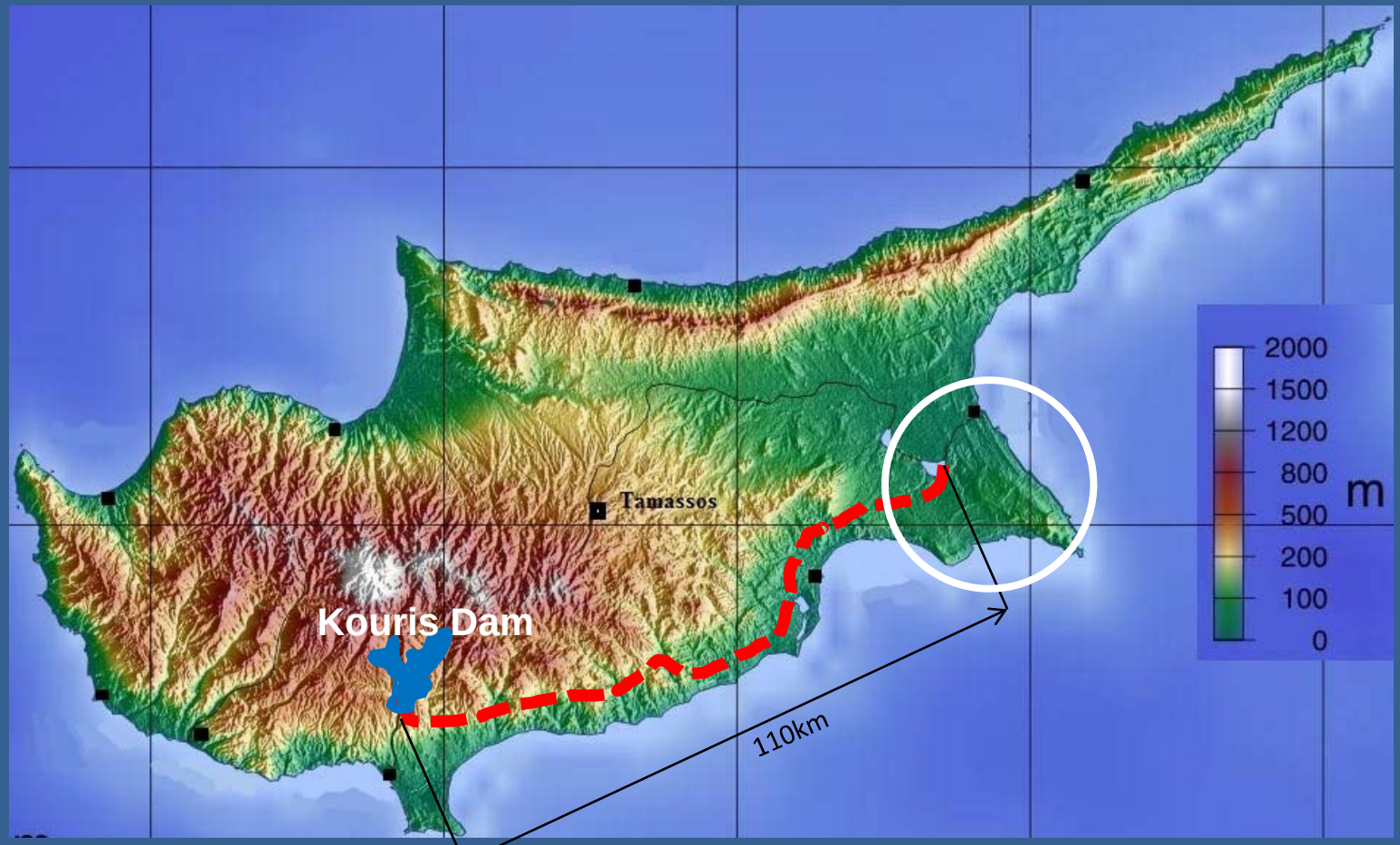
Dam construction



The most remarkable dam project was the construction of *Kouris* dam at the late 80's with a capacity of 115 million m^3, as a part of the "Southern Conveyor Project".

Water sufficiency measures

Southern Conveyor project



When "Southern Conveyor Pipeline" started operating, water supply in Cyprus changed radically. Since then Northern, Northeastern and Central areas were supplied with water mainly from Kouris dam.

Water sufficiency measures

Desalination project

In 1996 it was noticed that inflows to dams were decreasing radically due to reduced rainfall combined with high temperatures while water demand was firmly increasing.

Consequently water supply demand couldn't be ensured by surface water, forcing officials to take immediate alternative measures.

The favored solution was the construction of a desalination plant. The current plant was constructed at Dhekelia and started operating in 1997.

Dhekelia desalination plant designed to supply the central and southeastern part of the island with water.

However drought period continued creating further insufficiency issue forcing officials to design a new desalination plant.

The construction of the new plant began in 1999 and started its operation in 2001 at Larnaca.

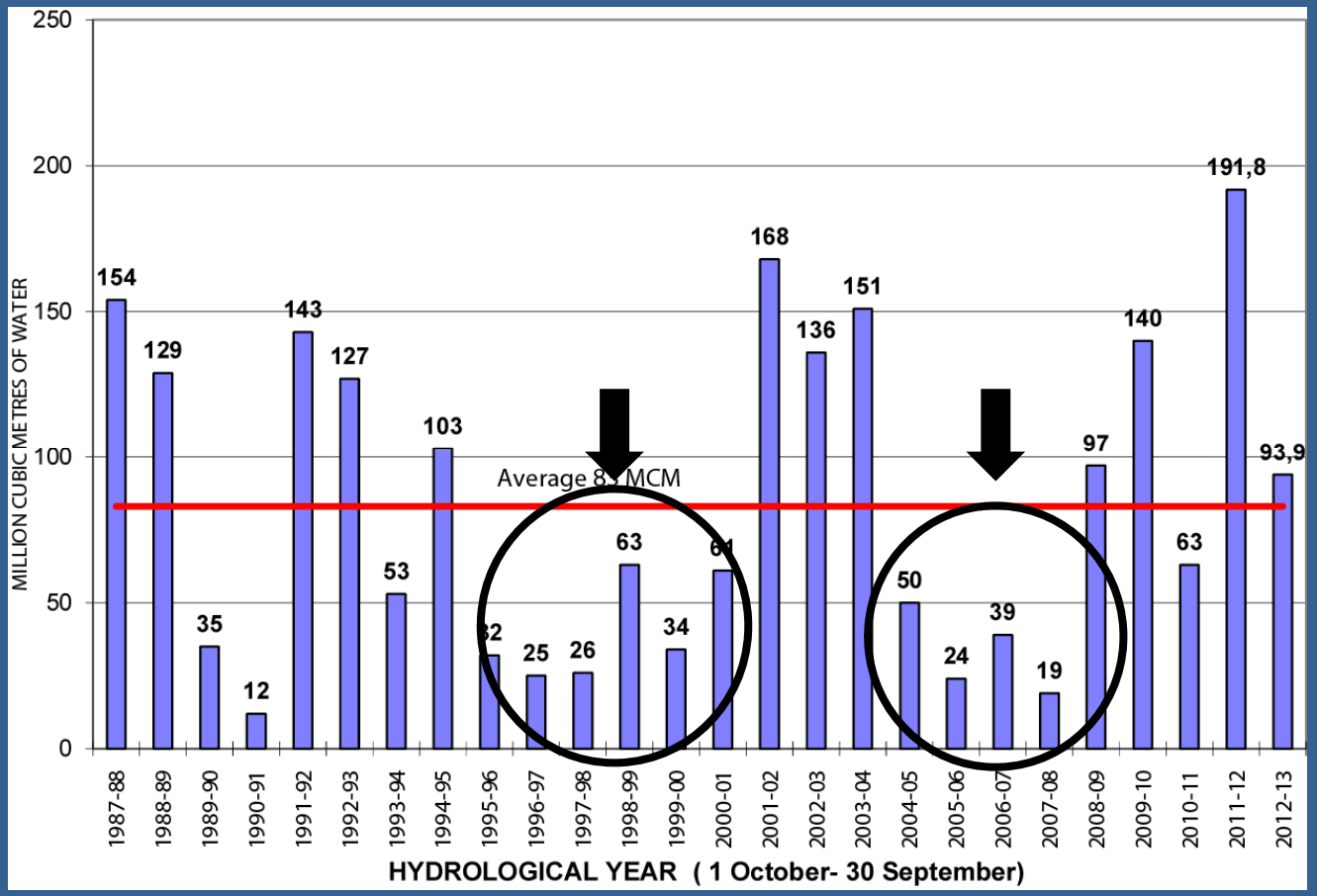
Water sufficiency measures

Desalination project

At 2008, although the two plants were operating, and the only district which was provided water exclusively from *Kourris* dam was Limassol, the dam almost dried out.

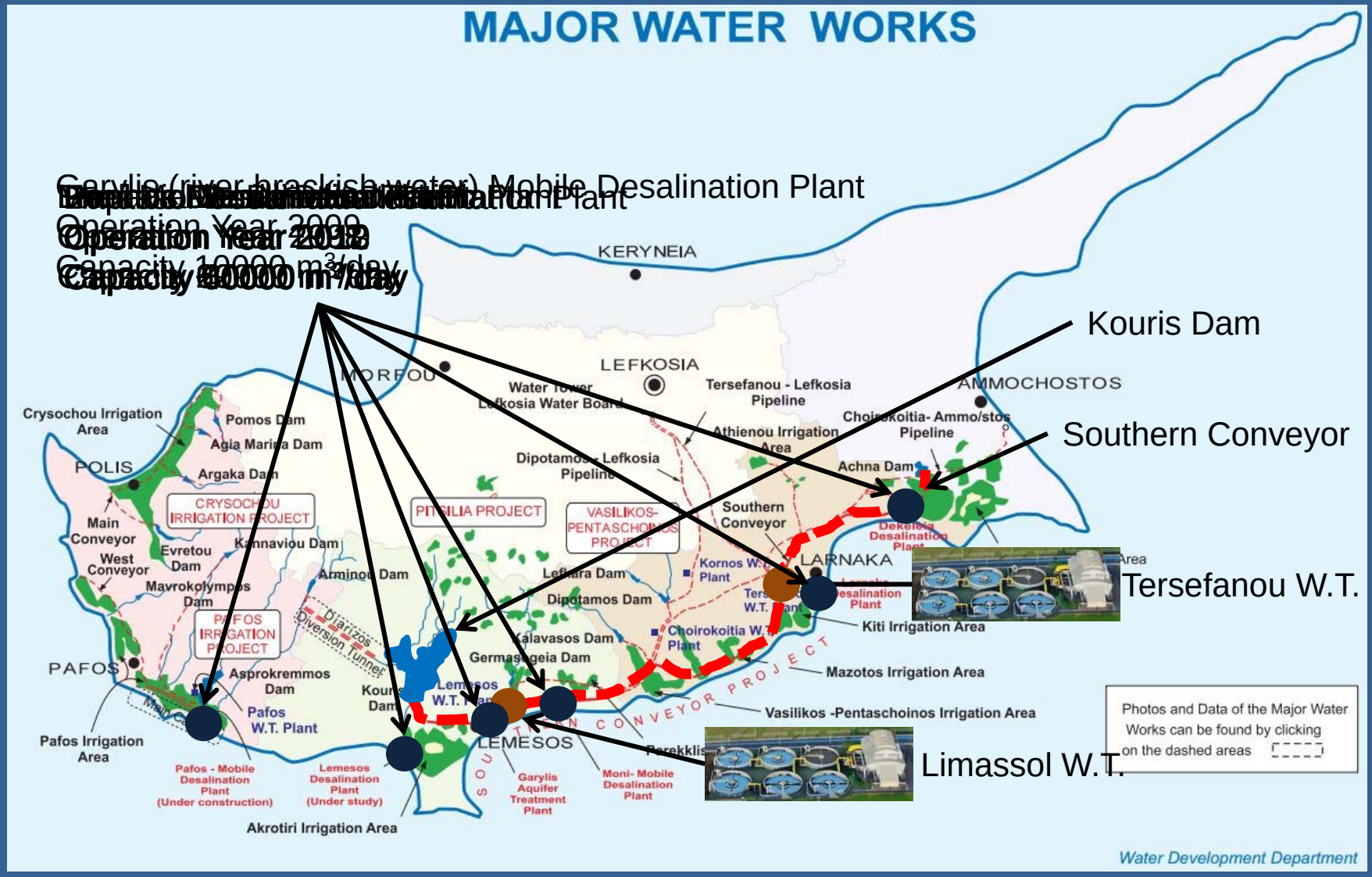
Water sufficiency measures

Desalination project



➡ Extended periods of drought

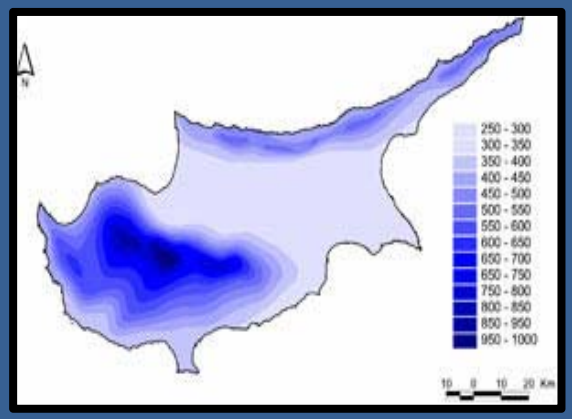
Water sufficiency measures



Water supply management in Cyprus under climate uncertainty

Impacts of Climate Change

Local climatic conditions



Water sufficiency measures

Water production impacts

Dams impact

Desalination impact

Water production impacts

Dams impact

Dams were constructed at almost every large river resulting to:

- **Degradation of ecosystems by river flow reduction**
- **Erosion of the costal zone by river sediment entrapment by dams**

Most dams impact hadn't been examined properly because the obligation of Environmental Impact Reports wasn't introduced until 1991.

Despite the effects created by dam construction, dams ensured sufficiency of drinking water to residents.

Water production impacts

Desalination impact

Operating method used by all desalination plants in Cyprus is Reverse Osmosis.

Desalination is an energy intensive process. Reverse osmosis was chosen due to its low energy requirements; also it was considered the best solution of its time.

Water production impacts

Desalination impact

Desalination energy demand impact

Energy represent s 60% of direct operation cost

Plant	Capacity (m^3/ημ)	Production (m^3/ώρα)	Electric energy demand (kWhr/m^3)	Total energy usage (kWhr)	Fossil fuel usage (kg/kWhr)	Total fossil fuel usage (kg/hr)	CO_2 Emission (kg CO_2 / kg fossil fuel)	Emission CO_2 (kg/hr)	Annual CO_2 emission (tons/year)	Energy (GWh)	Total production EAC (GWh)	Percentage of total production EAC (%)
Dhekelia	60.000	2500	5,3	13250	0,29	3843	3.165	12163	106548	116,1	4996	2,3
Larnaca	62.000	2583	4,4	11367	0,29	3296	3.165	10432	91384	99,6	4996	1,99
Paphos	40.000	1667	4,5	7500	0,29	2175	3.165	6884	60304	65,7	4996	1,3
Limassol	40.000	1667	5,34	8900	0,29	2581	3.165	8169	71560	78,0	4996	1,7
Vasiliko	60.000	2500	5,3	13250	0,29	3843	3.165	12163	106548	116,1	4996	2,3
total	262.000	10.917		54.267		15.738		49.811	**436.344**	475,5		**9,59**
Brackish water desalination												
Garylis	10.000	417	4,3	1792	0,29	520	3.165	1646	14419	15,7	4996	0,3

€

Economic impacts due to emission restriction

Exceeded GHG emission limit – ETS penalty fee

Water production impacts

Desalination impact

Impacts on marine ecosystem

Impact generated by seawater pumping

Seawater absorption increases marine organisms mortality.

Impact generated by brine discharge

Saline discharge after the desalination process, contains approximately 50% more salt for the same water volume.

Brine discharge impact is limited to a relatively short radius (200 - 300 m), where significant changes are noticed only around the discharge point.

Water production impacts

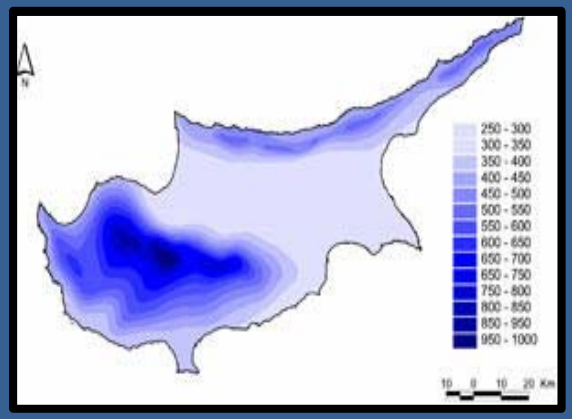
Desalination impact

Desalination Plant	Capacity (m^3/day)	Land Usage	Aquifers	Brine & Marine Ecosystem	Noise	Energy Usage	CO_2 Emission (tons/year)	Water Supply	Other Effects	Economic Impact
Dekelia	60.000	1	1	3	1	5	5	2	3	5
Larnaca	62.000	2	1	2	1	5	5	2	2	5
Paphos	40.000	3	3	2	2	4	4	2	2	4
Episkopi	40.000	1	3	2	1	4	4	2	2	4
Vasilikos	60.000	1	1	2	1	4	4	2	2	5
Brackish Garylli	10.000	4	3	1	4	2	3	4	1	5
Moni mobile	20.000	2	2	1	1	3	3	1	1	4
Paphos mobile	20.000	3	3	1	2	3	3	1	1	4
Vasilikos mobile	20.000	1	1	1	1	3	3	1	1	4
(Very Important=5, Significant=4, Moderate=3, Relatively Significant=2, Insignificant=1)										

Water supply management in Cyprus under climate uncertainty

Impacts of Climate Change

Local climatic conditions

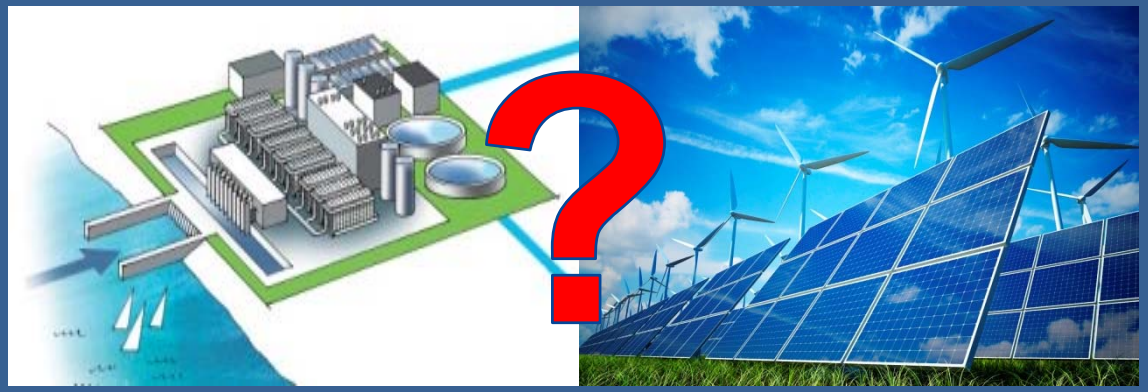


Water sufficiency measures

Water production impacts

Environmentally friendly technologies

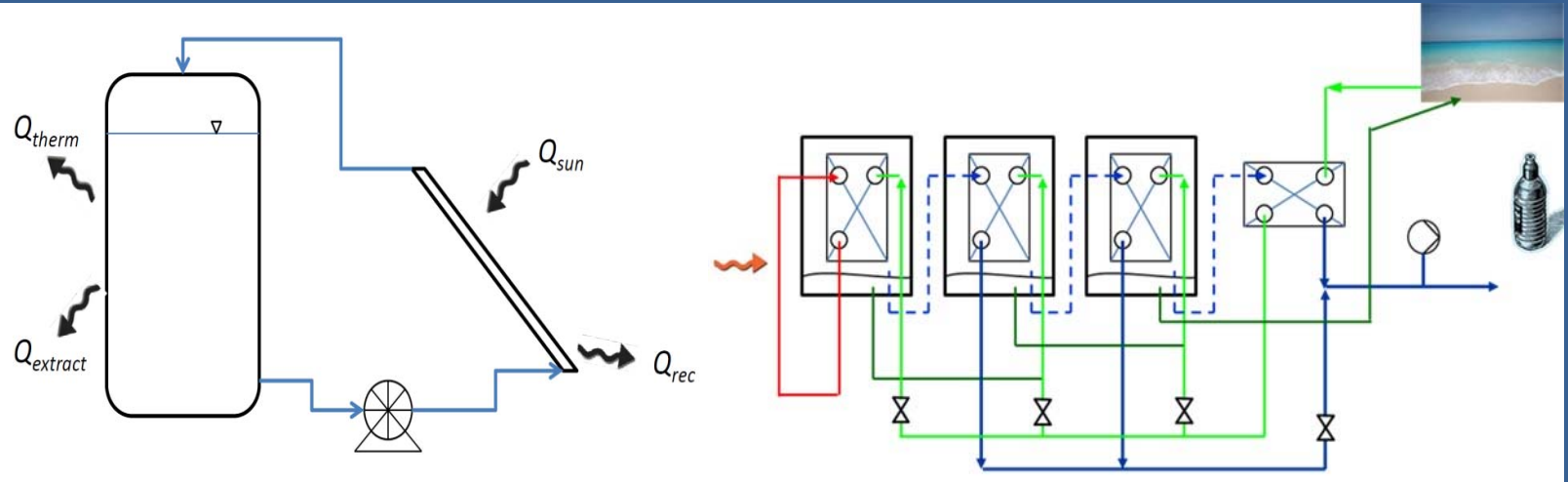
Environmentally friendly technologies



Solar Energy, could be considered, due to the high solar dynamic of Cyprus even for part of the facilities' energy requirements. Panels could be installed on the roof top of the structures, which cover a large space.

Environmentally friendly technologies

A promising proposal is the construction of an experimental desalination plant at *Pentakomo* which uses **Solar Thermal Energy** for the desalination process and at the same time generates electricity.



The technological solution that is proposed is **Multiple Effect Distillation Method** (MED), which requires low energy self-covered through heat source.

This particular process is environmentally friendly due to its **low energy need**; however it does not reduce the saline discharge to the sea.

Environmentally friendly technologies

A plausible **solution to the saline rejection** is examined by the Chemical Engineering department of the National Technical University of Athens, at an experimental facility placed in *Tinos* Island, Greece.

This particular plant **reprocess the saline** instead of rejecting it to the sea.

vaporization crystallization drying

65%

pure water

35%

pure salt

A different desalination method is used in Israel, a country with similar hydrogeological and climatic characteristics with Cyprus.

Reverse osmosis is applied without the use of chemicals, but rather **biofilters** that purify the water. It is a viable, economic solution that does not effect the environment with chemical rejection into the sea or the ground.

Environmentally friendly technologies

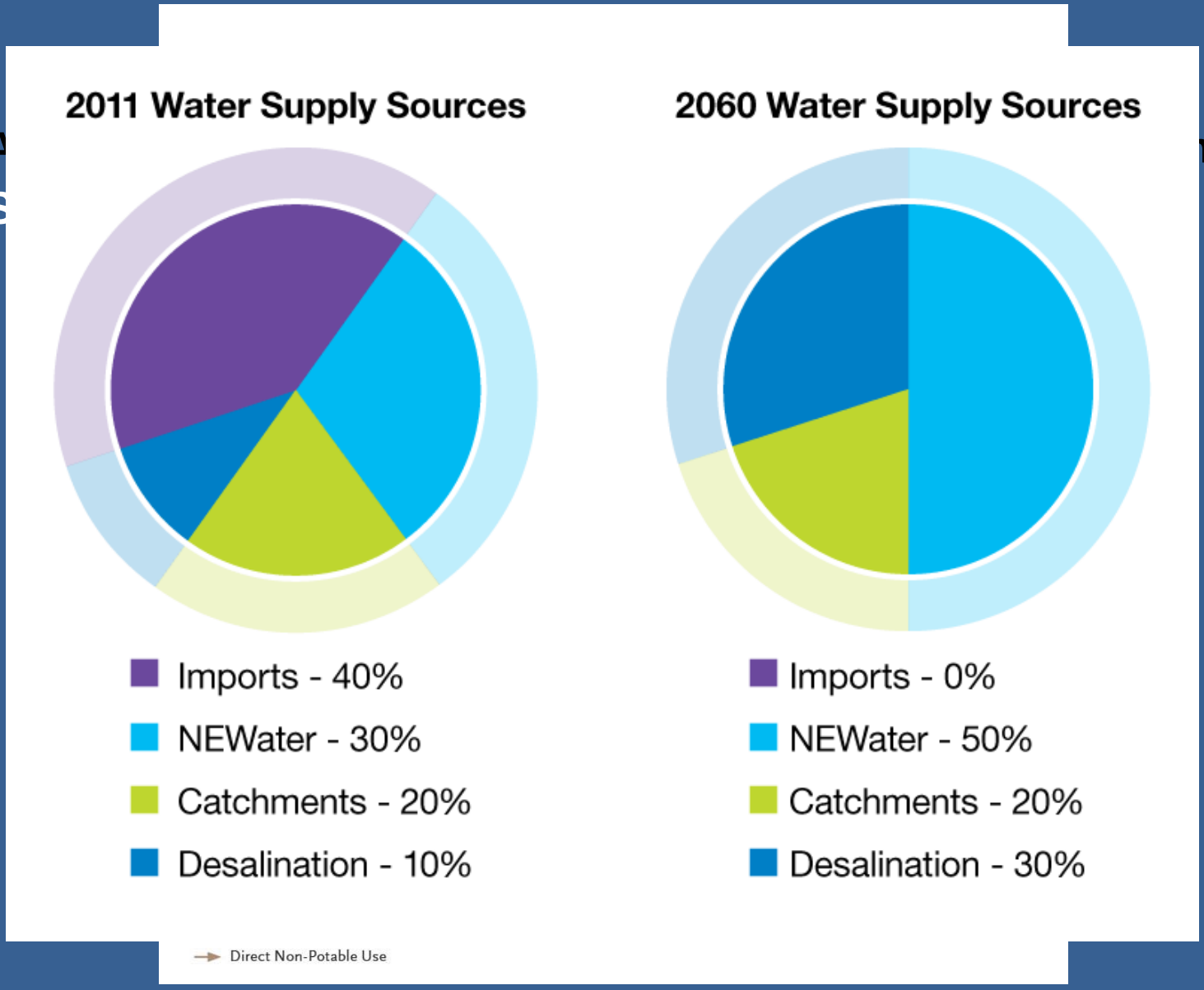
Researchers at the West of England University of Bristol have developed a mobile water treatment system for surface water, capable of providing low cost, clean drinking water directly at the source.

This technology is at an early stage, with the experimental facilities producing only 2 m^3/12 days of drinking water, but it is estimated that in the near future the production of an actual size facility could reach 2 m^3/day.

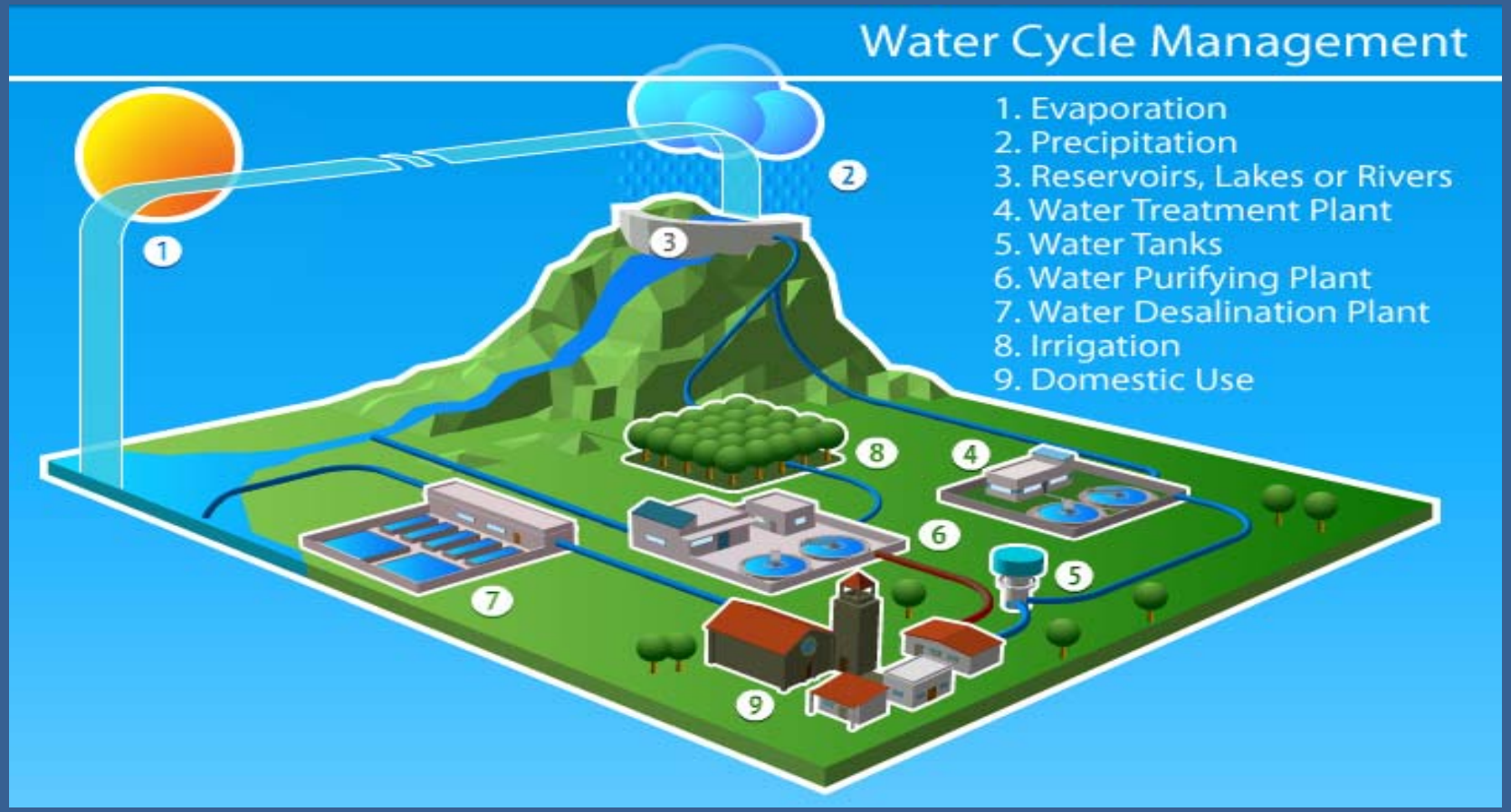
UWE researchers developed a disinfectant that kills the bacteria in the water without causing corrosion to the filtration system, in contrast to common disinfectants like Cl_2 that causes corrosion to the filtration membranes after some time.

In Cyprus, this technology could be applied in old dams that are out of service and provide drinking water to remote villages.

Environmentally friendly technologies



Environmentally friendly technologies



Different methods and techniques can coexist and provide the desired solution, in countries like Cyprus that are surrounded by water and can not depend on cross-border water resources.

Conclusions

1) Water saving policy is essential in order to manage water resources properly, especially in countries like Cyprus that are facing extended dry periods.

2) It is essential not to create further vulnerabilities harming the environment in the effort to treat the current ones.

3) Water supply managers should be well aware of the impact of climate change on water resources, when planning for urban water supply systems, or agricultural works.

4) The research for new alternative solutions about environmentally friendly technologies should never stop.

Thank you for your attention!

Panagiotis Thrasivoulou
Kyriacos Patsalosavvis
Dr. Antigoni Zafirakou