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**water**  
**matters**

THE  
IMPORTANCE  
OF GOOD STATUS  
OF WATER  
BODIES

# GOOD PRACTICE GUIDE FOR THE SUSTAINABLE WATER MANAGEMENT IN AEGEAN ISLANDS

SANTORINI

IOS

LEROS

KALIMNOS

PSERIMOS

TELENDOS

INSTITUTE OF MARINE  
BIOLOGICAL RESOURCES  
AND INLAND WATER  
(I.M.B.R.I.W.)

HELLENIC CENTER  
FOR MARINE  
RESEARCH (H.C.M.R.)

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**Authors:** Skoulikidis Nikolaos, Andriopoulou Argyro, Dimitriou Elias, Koutsodimou Maria, Papadaki Christina, Lagogiannis Sergios, Tsianou Evgenia, Giakoumi Sofia, Kouvarda Theodora, Kester Moe Windy and Arnesen Tor.

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Dear reader,

It is with great pleasure that we present this handbook to you, aiming to highlight the importance of sound water resources management in our country's islands, as well as to create and foster a new water consciousness and water culture emphasizing on local solutions, conservation and informed citizen engagement in decision-making on collective interest.

Modern approaches, both at local and international level, underline the need for sustainable management of this finite common good, reduction of demand and consumption, ensure protection from pollution, exploitation of alternative water sources while at the same time stress the need for active participation of involved bodies in a collective and coordinated effort to sustainably manage the most valuable natural resource, aiming to meet the needs, of both, modern societies and ecosystems.

**Because... "Water Matters"!**

["Water Matters"](#) project team

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## CHAPTER 1

# Introduction

Introducing “**Water Matters**” as the slogan of this campaign, the [Institute of Marine Biological Resources and Inland Waters \(IMBRIW\)](#) of the [Hellenic Center for Marine Research \(HCMR\)](#) has undertaken the implementation of the Small Grant Project “Increase knowledge on the Importance of the Good status of Water Bodies”, within the framework of the [European Economic Area Financial Mechanism \(Iceland, Liechtenstein and Norway Grants\)](#).

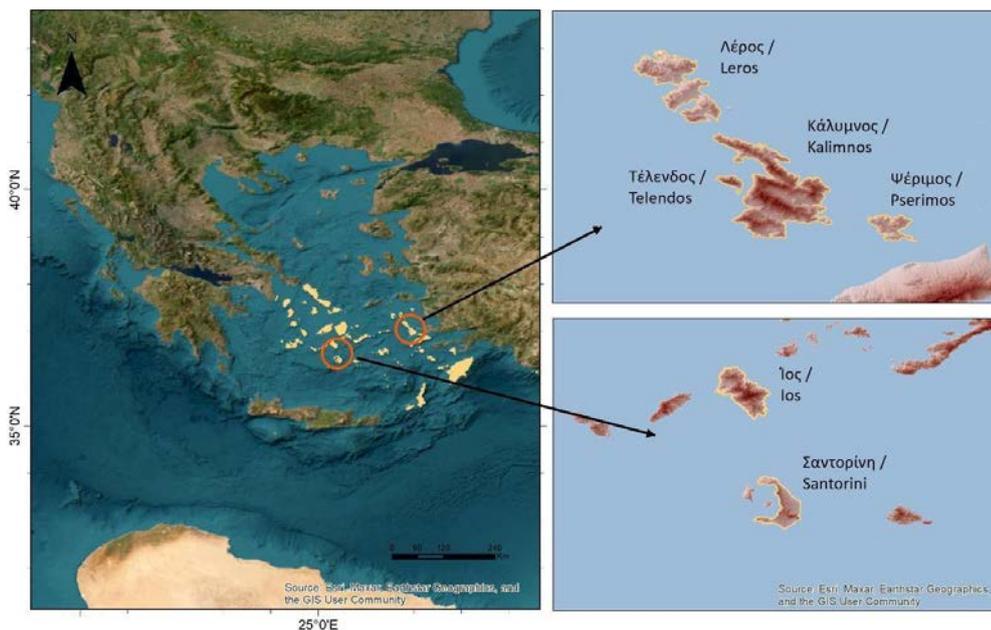
Overarching objective of this project is to run an **information and awareness campaign** on the islands of **Santorini, Ios, Leros, Kalymnos, Pserimos and Telendos** (Figure 1) targeting both students and the general public, in order to highlight the pressures water bodies are facing. The campaign will also aim at increasing the understanding on the value of water resources, with the main focus on the students’ population. (<https://water-matters.hcmr.gr>).

The project seeks to contribute to the **cooperation between public, private and social actors**, as well as primary and secondary education units in the study areas,

aiming to **cultivate knowledge** and involvement for an **integrated and sustainable water resources management**, as a prerequisite for conservation of resources and water resilience for the benefit of society.

Through diverse educational and informative actions on the islands, such as development of digital and printed material, educators training courses, experiential field actions with students, cultural actions and more, the project highlights the **need to improve the ecological status** of aquatic ecosystems, **through the reduction of the adverse effects of human pressures**.

Finally, in collaboration with scientists from the “Eastern Norway Research Institute” of the “Inland Norway University of Applied Sciences (ENRI)” who act as project partners, common practices for the sustainable use of water in the two countries are identified, while examples of Norway’s water body management from the past to the present are also presented.



**FIGURE 1**  
Study area of «Water Matters» campaign.

## CHAPTER 2

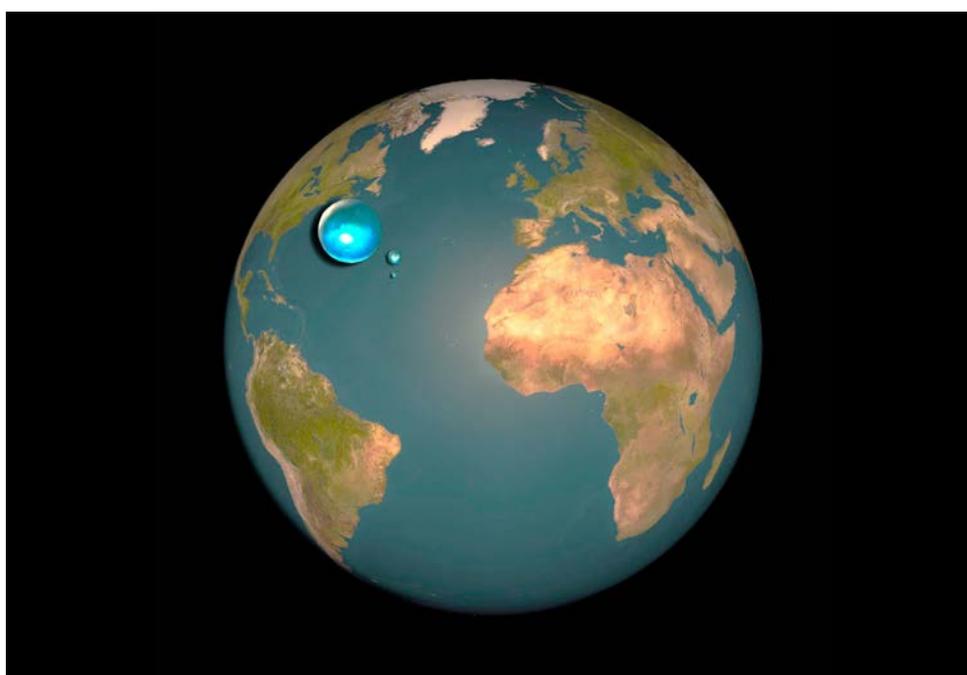
# Why “Water Matters”?

## 2.1 | A VALUABLE NATURAL RESOURCE THAT MATTERS!

Water is a unique and essential natural resource that constitutes an environmental and public good. It is necessary for all living beings and is a prerequisite for the presence of life on the planet. It cannot be replaced and or be produced in large quantities from other materials. Water is not a classic economic resource, but primarily an environmental good which however is related to important economic parameters, due to the needs of its proper management, processing, transport and distribution (Mediterranean SOS 2013).

For human societies, water is fundamental not only as a necessary condition for survival, but also for the support and development of agriculture, livestock, trade and any other production process and infrastructure. Establishment and growth of human communities in an area is determined by the precondition of access to water of sufficient quantity and satisfactory quality.

But water is not an inexhaustible resource: the total amount of water on Earth is estimated at about 1.36 billion cubic kilometers. Of this, 97.0% is salt water and 2.5% is freshwater but unavailable, as it is stored in solid form in the polar ice caps, in rocks very deep in the earth and in the atmosphere. If we were to subtract all freshwater that is not suitable for human use, contained in marshes, swamps, lakes and water bodies, from the total merely a 0.3-0.5% is left as available for use. **To put it into perspective, if the total reserves of freshwater were 100 liters, the amount available for consumption would be only 1½ teaspoons!** Therefore, freshwater is an extremely valuable and sensitive natural resource, characterized by insufficient availability. In Figure 2, the total amount of water, the amount of freshwater and the amount of readily accessible freshwater, compared to the size of Earth, are indicatively represented with proportional size “drops”.



**FIGURE 2**

Relative amounts of water reserves on Earth represented as three “drops”: total freshwater and saltwater reserves (large drop), freshwater reserves (middle drop) and accessible freshwater/flowing water reserves (tiny drop).

(Source: modified by Jack Cook , [Woods Hole Oceanographic institution](#))

## 2.2 | WHAT IS THE IMPORTANCE OF GOOD WATER QUALITY?

As a natural resource, freshwater is a common heritage that needs to be protected and managed in a way that each generation can meet its needs, while ensuring its delivery to the next, at the same or even improved status. The quality and quantity of water are decisive factors shaping the health of all living organisms.

In Greece and globally, there is a significant increase of pressures exerted on water bodies as a result of increasing anthropogenic needs and climate change, leading to the deterioration of its condition. The most significant pressures are exerted through changes in land use, overexploitation of water resources, organic and chemical pollution/contamination and as a result of incorrect and poor management practices. Nitrification, pollution

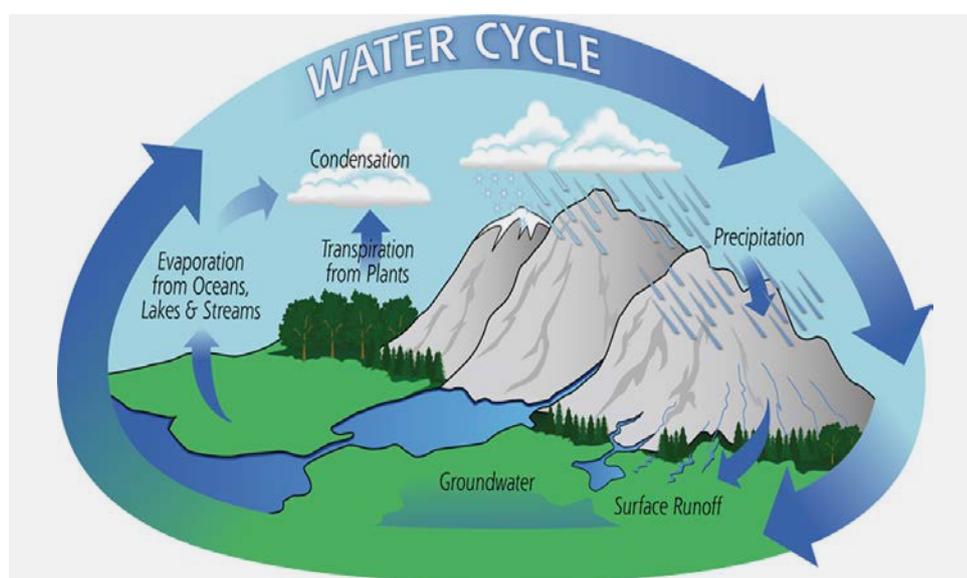
with organic and inorganic micropollutants, eutrophication and the reduction of biodiversity have negative effects on the quality of water, resulting in the degradation of aquifers, surface waters and aquatic ecosystems which may even lead to the migration and disappearance of populations and species.

Alleviation of pressures can be done gradually through a sustainable, integrated and interdisciplinary approach to water management issues at watershed level, while at the same time implementing actions to inform the public and raise awareness of water users, cultivating environmental ethics and expanding collective consciousness on issues concerning quality, quantity and ultimately the importance of the good status of water bodies as a whole.

## 2.3 | THE WATER CYCLE

The water cycle describes the continuous recycling and movement of Earth's water in the atmosphere, surface and underground. As shown schematically in Figure 3, a part of the total amount of water that precipitates on earth's surface as rain or snow, flows superficially towards the sea. Another part of it, evaporates and returns to the atmosphere. Finally, a third part flows into the ground (infiltration and percolation), in soils and porous rocks that have the ability to store it.

Over time, the groundwater resources, mainly the ones located in central areas far from the coasts, end up being saturated up to 100% with freshwater. In this way, a freshwater reservoir is created and occupies all the available space until it comes in contact with an impermeable layer, which prevents it from moving to a greater depth and delimits it.



**FIGURE 3**

The water cycle

(source: <https://gpm.nasa.gov/education/water-cycle>)

## 2.4 | WATER BALANCE

The water balance of an area (e.g. watershed) is the simplified mathematical expression of the water cycle. Knowledge of the water balance is a prerequisite for the rational and sustainable management of water, which is based on the availability of water resources. Specifically, on a daily, monthly or yearly basis, the equation for a watershed is:

$$P = Q + E + \Delta S$$

where,  $P$  is precipitation,  $Q$  is surface runoff,  $E$  evapotranspiration<sup>1</sup> and  $\Delta S$  is water stored in soil or rock.

This equation tells us that, when precipitation ( $P$ ) begins, a percentage of water reaches the ground and gets stored in it (infiltration) until it gets saturated, while the rest of the water is led through surface runoff ( $Q$ ) to streams and rivers and ultimately to final recipients: lakes and sea.

In addition, a quantity of water that reaches the ground penetrates (percolates) towards the deeper soil layers and rocks ( $\Delta S$ ) and gets stored, depending on the type of geological formations that prevail in the area. Therefore, in addition to the surface runoff of water (in rivers and lakes), storage of a quantity of water occurs in the aquifer (groundwater). At the same time, there are "losses" ( $E$ ) through evaporation of water from surface water bodies and from the ground, to a depth that usually does not exceed 1 m, along with "losses" from transpiration of vegetation. The phenomenon of transpiration and evaporation is more intense during the warm periods of the year. In mountainous areas, snowfall occurs in addition to precipitation, which provides valuable water resources at the end of spring and the beginning of summer, a period in which precipitation has already decreased significantly.

<sup>1</sup> Evapotranspiration is the sum of evaporation and transpiration, where evaporation is defined as the transition of water molecules from the liquid (or even solid) phase to the gaseous phase, while transpiration refers to the evaporation that takes place through the stomata of plant leaves.

## CHAPTER 3

# Water issues on the islands

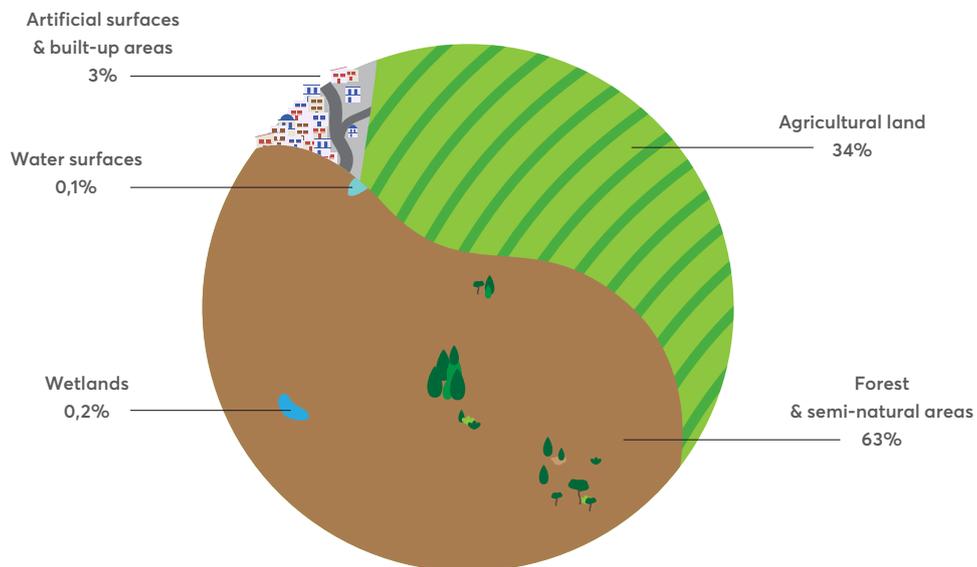
### 3.1 | INTRODUCTION

Aegean islands are characterized by a number of distinct features, the most significant of which are a small land surface surrounded by the sea, high temperatures, intense sunlight and strong winds causing higher rates of evaporation. In addition, their mountainous relief favors rapid surface runoff, a fact that limits both the possibility of creating permanent flowing rivers and recharging groundwater reserves. So, despite the fact that islands are literally "inside" the water element, they face shortages of freshwater with significant consequences for the daily lives of permanent residents and visitors, especially

during periods of increased tourism and overtourism.

The River Basin District (RBD) of the Aegean Islands includes the island complexes of Cyclades, North Aegean Islands and Dodecanese with a total population of 522,763 (5% of the country's total). Most of the Aegean Islands RBD is covered by forest and semi-natural<sup>2</sup> areas, while a significant part is agricultural land<sup>3</sup> (Figure 4). Concerning the remaining land uses, artificial surfaces and built-up areas occupy a limited extent while the percentages that correspond to wetlands and water surfaces are very small.

**FIGURE 4**  
Land use distribution in the RBD of the Aegean Islands (source: YPEN 2017)



<sup>2</sup> According to CORINE land cover categories, urban and semi-natural areas include «combinations of shrubby and/or herbaceous vegetation» and «areas with sparse or no vegetation».

<sup>3</sup> Includes "heterogeneous areas" and "pastures and meadows"

## 3.2 | HYDROLOGICAL CHARACTERISTICS OF THE ISLANDS

### 3.2.1 Rainfall

Figure 5 shows the distribution of rainfall in Greece according to data from the last 70 years (Varlas et al. 2022). According to the National Observatory of Athens (NOA) in most of the Cyclades, parts of Crete (Lendas, Toplou Monastery) as well as in some of the Dodecanese (Kasos, Nisyros) a warm semi-arid steppe climate prevails. The islands of South Aegean (namely, Cyclades and Dodecanese) experience the lowest average annual rainfall rates in Greece, less than 400 mm. The beginning of the wet season occurs in October, later than in other regions of the country (Bank of Greece 2011).

### 3.2.2 Surface Water

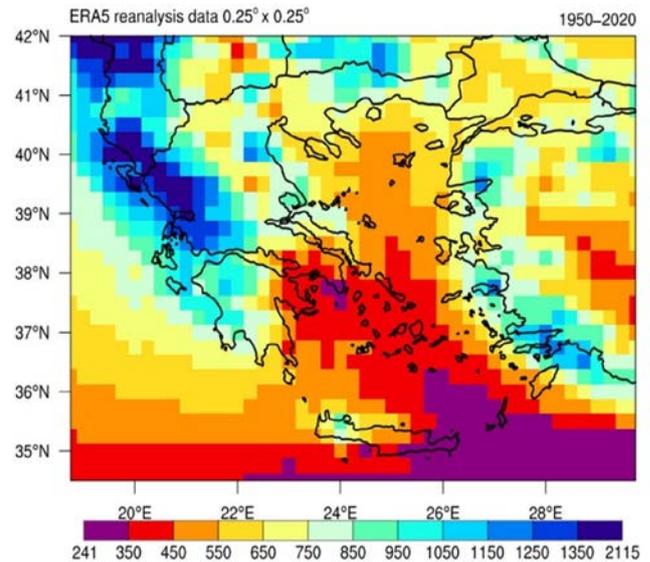
In the islands of the Aegean Sea the presence of surface water bodies is sparse, as a consequence of the limited rainfall rates and the small extent of river catchments.

Conversely, rivers of ephemeral or intermittent flow represent the main hydrological type in the Aegean islands (Figure 6). Perennial rivers exist mainly on large islands such as Lesbos, Rhodes, Naxos and Crete, although spring-fed perennial streams can also be found in smaller islands (e.g. Andros, Samos, Ikaria).

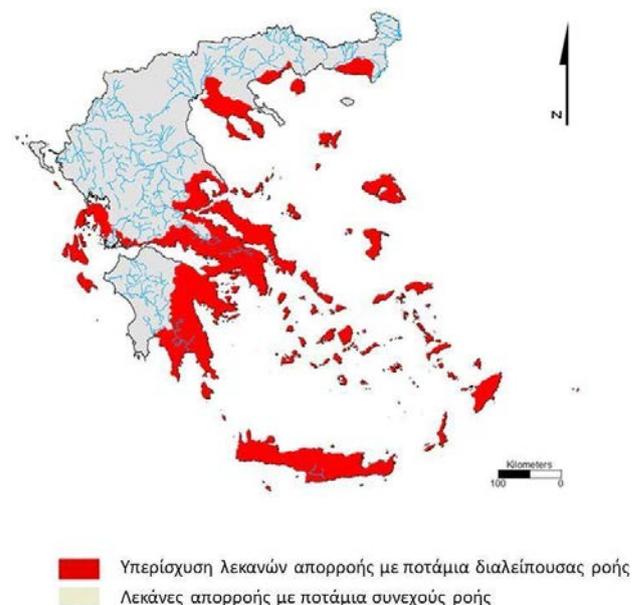
Pursuant to the EU Water Framework Directive 2000/60, 81 surface water bodies have been identified in the Aegean islands, which correspond to approximately 6% of the country's total water bodies (Figure 7). In most cases, they are of good ecological status, mainly due to their low population density (see Chapter 4.4.1).

There are no natural lakes in the Aegean islands, however standing water bodies are mainly found in the form of wetlands and lagoons. Among them, the most common type are coastal marshes, which are formed either where a stream of perennial or temporal flow outflows or are fed from groundwater.

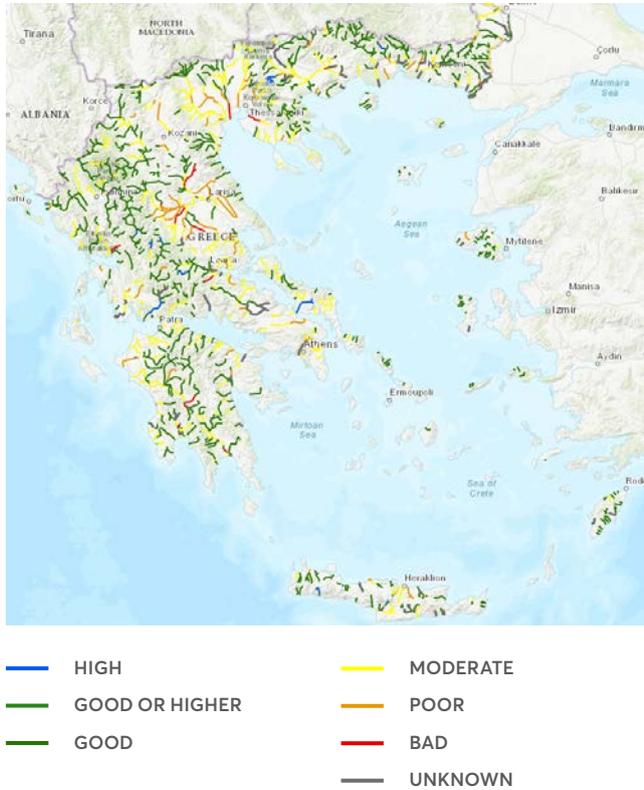
**FIGURE 5**  
Rainfall distribution in Greece (Varlas et al., 2022)



**FIGURE 6**  
Catchments with permanent rivers (grey color) and catchments dominated by intermittent rivers (red color). The latter occupy most of the Aegean islands (Skoulidakis et al., 2017)



**FIGURE 7**  
Surface water bodies of Greece and their ecological status, concerning the period 2012-2015. (source: HCMR)

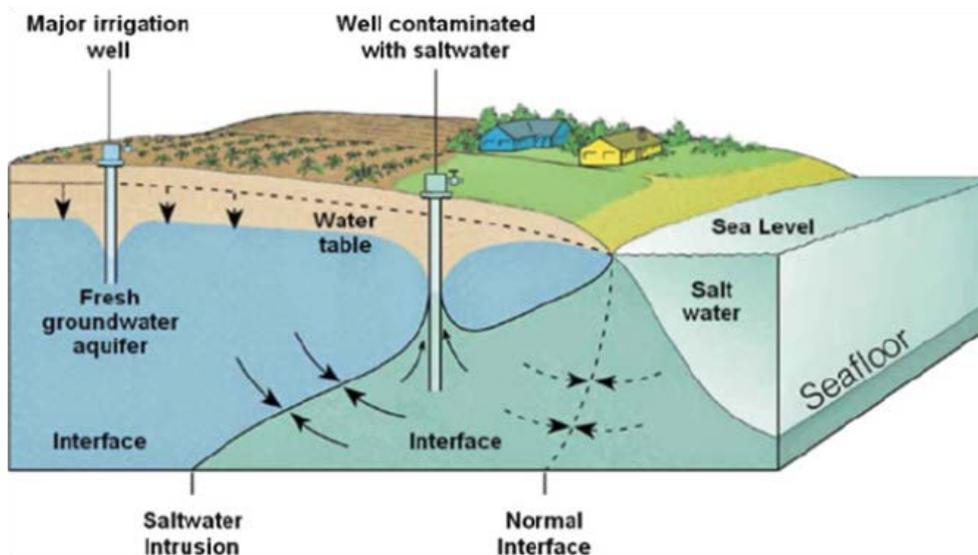


### 3.2.3 Groundwater bodies

In most of the Aegean islands, groundwater bodies have a predominant occurrence over surface water. Recharge of groundwater bodies occurs primarily through infiltration of rainfall into the soil, indirectly through rivers and streams that run along groundwater bodies in addition to lateral feeds, from neighboring groundwater bodies (Ministry of Environment and Energy, 2023).

The distinctive characteristics concerning the Aegean islands, is the existence of small and mainly karstic aquifers, which develop in carbonate deposits (marbles, dolomites, limestones, crystalline limestones). Likewise, the porous alluvial and neogene aquifers on most islands have also a limited extent, due to relatively small spatial development of the alluvial and neogene formations. In aquifers that develop in porous formations, salinization may occur due to their overexploitation, especially when combined with low rainfall and the challenges of inadequate groundwater recharge (Ministry of Environment and Energy, 2023) (Figure 8).

**FIGURE 8**  
The phenomenon of groundwater salinization, as a result of over-pumping. (source: Abd-Elaty et al. 2018)



CHAPTER 4

# Water management in Greek islands

## 4.1 | WATER MANAGEMENT IN THE ISLANDS

At a country level, the total water reserves exceed the amount currently allocated for various uses. However, the actual amount of available freshwater in different geographical areas may be significantly restricted. As the available amount of freshwater decreases over time, important areas such as the Aegean islands, are or tend to become water-deficient and in several cases the collective needs for water are covered by water transport projects with significantly increased costs (Ministry of Economy and Trade 2008).

On islands, and especially on small dry ones, current practices to ensure water supply are not fully sustainable and efficient, especially during summer months, when needs increase significantly due to tourism (Koutris et al., 2019). As a result, the islands are often confronted with the problem of water scarcity<sup>4</sup> in a much more severe way, than in continental Greece.

Concerning water supply, a key challenge is the large losses due to leakage from the distribution network, ranging from 30-80% as a result of aged materials and insufficient maintenance. In some cases, municipalities make irrational use such as using drinking water to clean streets, squares and equipment, irrigating at inappropriate times, not implementing saving measures in municipal buildings, etc. (Mediterranean SOS 2013).

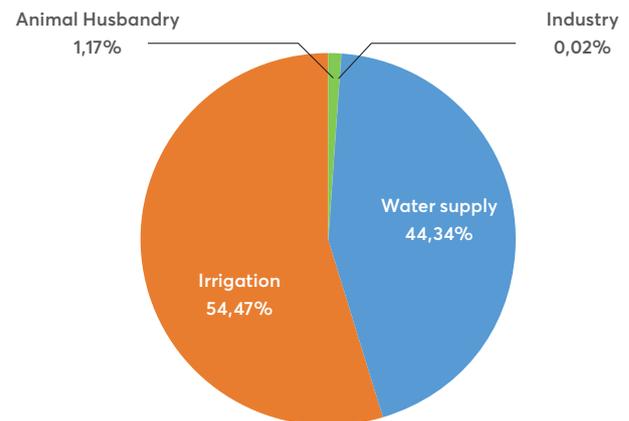
In recent years, the problem of water supply on Aegean Islands has significantly worsened due to the ever-increasing touristic development, which has led to the transforma-

tion of the islands' economies from agricultural/livestock to service economies (hotels, tourism, etc.) increasing dramatically the demand for water.

### 4.1.1 Water demand in the RBD of the Aegean Islands

The total annual water demand for all uses in the **RBD of the Aegean Islands**<sup>5</sup> is estimated at 204.5x10<sup>6</sup> m<sup>3</sup> and concerns almost in their entirety irrigation and water supply (Table 1), which respectively constitute 54.5% and 44.3% of the total (Figure 9). The water demand for

**FIGURE 9**  
Water demand for all uses (in percentages) for the RBD of the Aegean Islands



Water supply (10 <sup>6</sup> m <sup>3</sup> )	Irrigation (10 <sup>6</sup> m <sup>3</sup> )	Animal Husbandry (10 <sup>6</sup> m <sup>3</sup> )	Industry (10 <sup>6</sup> m <sup>3</sup> )
90,66	111,36	2,39	0,05

**TABLE 1**  
Annual water demand in the RBD of the Aegean Islands for each water use (source YPEN 2017)

<sup>4</sup> Water scarcity is the lack of freshwater resources to adequately meet water demand.

<sup>5</sup> It includes the islands of the North and South Aegean Regions. The Administrative Unit of the North Aegean Region includes the islands: Limnos, Ag. Eustratios, Lesvos, Chios, Samos, Ikaria, Fournoi, Oinousses, Psara, Andipsara, Thymena, Paas and Ag. Minas. The Administrative Unit of the South Aegean Region includes the Cyclades and the Dodecanese. In the River Basin Management Plan, the islands of the North Aegean Region are referred to as the islands of the Eastern Aegean.

animal husbandry constitutes a very small percentage (1.2%) while the demand for industrial use is minimal (Ministry of Environment and Energy 2017).

#### 4.1.2 Meeting water demand in the RBD of the Aegean Islands

In the RBD of the Aegean Islands altogether, approximately 112 million cubic meters ( $112 \times 10^6 \text{ m}^3$ ) of groundwater are pumped annually for water supply, irrigation, animal husbandry and industrial uses (Ministry of Environment and Energy 2023). Correspondingly, withdrawals from surface water bodies (rivers, lakes and reservoirs) reach  $19 \times 10^6 \text{ m}^3$  per year, a quantity corresponding to approximately 15% of total water abstractions from surface and groundwater bodies combined. Comparing the figures concerning annual water withdrawals from the surface and groundwater reserves to the annual water demand (Table 1), it is evident that the RBD of the Aegean Islands face water scarcity.

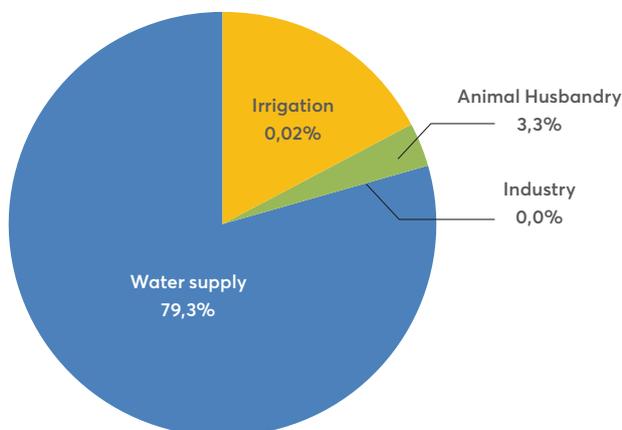
As far as surface water sources (including springs) are concerned, abstractions are intended almost entirely for potable water supply and, secondarily, for irrigation and animal husbandry (Figure 10). On the contrary, abstractions from groundwater (Figure 11) are done primarily for irrigation purposes (75.4%) and secondarily for potable use (23.6%). In the islands of the Eastern Aegean and the Cyclades complex, withdrawals from groundwater are done mainly for irrigation and secondarily for water

supply, in contrast to the Dodecanese complex, where this relationship is reversed. Finally, animal husbandry and industry together, make up for only a small fraction of the abstractions on groundwater reserves (Ministry of Agriculture 2017). Boreholes for the exploitation of groundwater have been drilled both by public authorities or governmental bodies (Prefectures, Municipalities, and Communities) and by individuals to cover their private water needs (drinking, irrigation, etc.).

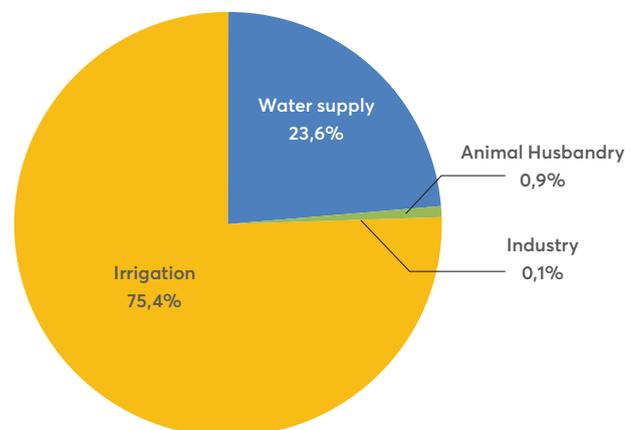
It is estimated that desalination plants in the Aegean islands cover up to 10% of the water needs. Desalination requires significant amounts of energy and involves high operational costs of the units. It is also related with adverse environmental impacts, since the uncontrolled disposal of brine and toxic substances, can cause damage in marine ecosystems and organisms (Roberts et al. 2010, Gomes et al. 2023). It is noted that desalination is increasingly being used to produce freshwater, as the islands' aquifers are depleted and new desalination units are being built.

Finally, water transfers cover up to 1% of water needs (Figure 12) and concern islands mainly of the Cyclades and the Dodecanese complexes (Ministry of Environment and Energy 2017). Yet, water transport is related to three critical problems: firstly, the cost per cubic meter of water is enormous, secondly the environmental footprint of shipping water is significant and thirdly sea transport does not provide a permanent solution to the water scarcity issue faced by the Aegean islands (Karvounis 2017).

**FIGURE 10**  
Allocation of water abstractions from surface water bodies in different uses, in the RBD of the Aegean Islands (Ministry of Environment and Energy 2017)



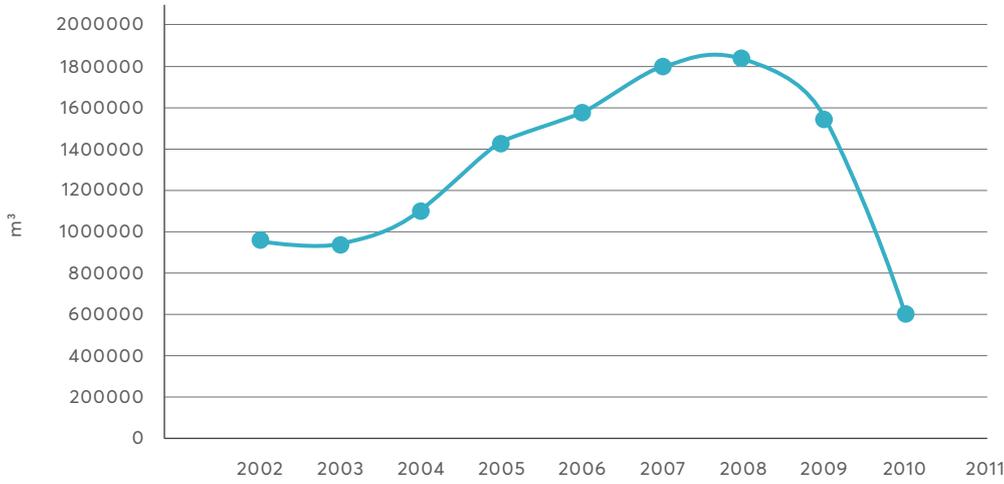
**FIGURE 11**  
Allocation of water abstractions from groundwater bodies in different uses, in the RBD of the Aegean Islands (Ministry of Environment and Energy 2017)



**FIGURE 12**

Water transport in the Aegean islands in the period 2002-2010.

The total volume of water transported to the islands during this period was 10,808,903 m<sup>3</sup> (Karvounis 2017)



**FIGURE 13**

Portable seawater desalination unit in Oia. Commission funded by EEA Grants 2009-2014.



## CHAPTER 5

# Current challenges

### 5.1 | CLIMATE CHANGE

On a global scale, islands are at the forefront of climate change vulnerability. With less than 1% of greenhouse emissions, island communities contribute the least to climate change, yet it is foreseen that they will be the most affected by it (IPCC 2018). According to climate models, in the coming decades the largest percentage of decreased precipitation during winter months (over 18% according to a fairly pessimistic climate scenario) will occur in the South Aegean (Bank of Greece 2011).

### 5.2 | POLLUTION/ CONTAMINATION AND SALINIZATION

Freshwater quantity and quality are under threat both by direct human pressures, such as the use of agrochemicals in agriculture, urban sewage and over-pumping of groundwater primarily to meet increased touristic needs and by climate change impacts, such as decline of rainfall rates and the rise of sea level that can cause or exacerbate the salinization of groundwater bodies.

A recent report with the results of the groundwater monitoring program for Greece, operated by the Hellenic Survey of Geology and Mineral Exploration, highlighted that con-

cerning the islands of the South Aegean the degradation of groundwater quality is mainly related to over-pumping. At the same time, in the bigger islands of the Dodecanese (Rhodes, Kos) the groundwater systems are maintained in a good qualitative and quantitative status. Increased concentrations of metals (Ni, Pb, As, Fe and Mn) in Syros, Sifnos, Tinos, Ikaria, Kasos and Patmos islands are mainly attributed to geological formations. Regarding the islands of the North Aegean are concerned, groundwaters do not exceed nitrate quality standards and have a good status of drinking water, with a few exceptions. Yet documented issues are related to agricultural activities, over-pumping especially during the summer months and geogenic contamination of groundwater.

### 5.3 | DESERTIFICATION

Desertification is the degradation of land, in arid, semi-arid and sub humid regions, as a result of various factors, including climate change and human activities (UN Definition 1994). Desertification causes a progressive loss of soil fertility, through the destruction of its structure and composition, which does not allow sufficient agricultural production or vegetation development with a wide variety of plant species. The loss of soil threatens biodiversity, while it does not allow sufficient amounts of water from

#### George Maskalidis:

*"We don't even have soil for regeneration to take place. And the moisture that comes, let's say in the evening, cannot be easily absorbed and go down to enrich the aquifers, because there is no vegetation to help penetrate this water into the soil through the root system, so most of it flows on the surface and creates erosion problems, but much more it does not enrich the aquifers, it*

*flows and ends up in the sea. Even if grazing stops, there is no soil for new trees to grow since all the soil is washed away. When the mother rock comes out, on the surface, we will have lost all hope."*

—

#### Audio Stories about Water

Episode 3

<https://water-scarcity.gr/>

rainfall to percolate and thus it impairs the replenishment of groundwater reserves.

Factors that cause the phenomenon of desertification are related to: climate (drought and heavy rainfall), physiography (high slopes), geology (impermeable formations), soil (erosion), hydrology (flash floods) as well as anthropogenic activities and pressures (water overexploitation, overgrazing, fires) (Ministry of Environment and Energy 2016A).

Aegean islands are identified as high-risk areas in terms of desertification. In fact, according to the National Action Plan to Combat Desertification (2001), the islands of the Central Aegean, characterized by a dry climate, intense erosion, strong touristic development and abandonment of agricultural land, have been selected as pilot areas to test the suitability of the measures against desertification.

#### 5.4 | SUSTAINABLE MANAGEMENT AND DEVELOPMENT

Islands are not autonomous units as they are financially dependent on the Greek state and the EU (e.g. Common Agricultural Policy, subsidies). Yet, at the same time, they have a higher degree of autonomy from the mainland, offering possibilities that can accelerate the implementation of innovative processes (Koutris et al., 2019). As islands host energy, water and wastewater utilities locally, the integrated management of these infrastructures can create interesting examples and produce cumulative results. Thus, innovative investments such as smart grids, energy storage, circular water and waste management can have a far greater impact on the islands.

The Public Water Supply and Sewerage Companies (PWS&SC), although operating according to the rules of the private economy, due to their public benefit nature and the ambiguities of their institutional framework, are balancing between the private and public sectors. As a result they are not flexible enough to operate quickly and effectively. On the other hand, the experience related to the problems arising from private water management in other countries (e.g. the lack of investment in infrastructure, tariff increases, environmental risks, degradation of water quality) has convinced communities and policy makers that the public sector excels in delivering quality services to citizens and promoting of the human right to water (Mediterranean SOS, 2013) (Figure 14).

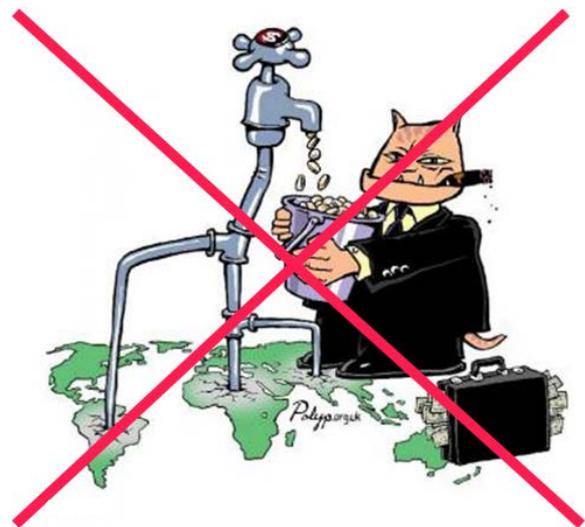
A framework for the sustainable exploitation and use of water should necessarily take into account a combi-

nation of parameters, such as natural conditions (e.g. drought, global climate change), water uses and their impacts (irrigation, urban uses, sewage control, etc.), the sources of supply (surface, groundwater, desalination) as well as the social and demographic conditions, such as population growth, urbanization, industrialization and so on (Karavitis et al., 2012).

It is obvious that the development of a long-lasting, robust and sustainable integrated water policy must be inextricably linked to environmental protection along with the maintenance of cultural values for each island separately, grounded on its characteristics and particularities. A long-term sustainable management plan on water resources must be based on the concept of sufficiency, accompanied by an action plan against desertification and follow a long-term sustainable development strategy. Such strategy should avoid focusing on income from tourism alone and be rather based on local agricultural, livestock and fishery products as well as their standardization.

FIGURE 14

Water is a social good and should not be subject to financial speculation.



## CHAPTER 6

# Good Practice Guide

### 6.1 | WATER CONSERVATION

Suggested practical tips and guidance for water saving in everyday life and at work are presented on the website of the project "Water Matters" (<https://water-matters.hcmr.gr/en/water-saving-tips>). In this chapter we present these water-saving tips and sustainable management practices in islands, at both individual and collective level.

#### 6.1.1 Water saving tips at home and at work

Among numerous, some effective good practices for saving domestic water that have been tested in many parts of the world, and in Greece alike, are the following:

- Water saving devices (e.g. low-consumption aerated taps, water flow reduction nozzles for taps and showerheads, double flush toilets), or other smart systems (Figure 15). Low-consumption faucets and showers that mix air with water, giving the sense of a stronger flow, thus saving water by 40-50% without loss of comfort for the user.
- Rainwater harvesting from rooftops to storage tanks, which can be used for watering plants, washing outdoor areas, use in toilets, etc.
- Crops/Plants that are resistant to drought and adapted to the arid conditions of the islands. Such crops/plants require less water and are more likely to thrive in such conditions.
- Drip irrigation, which supplies water directly to the roots of the plants, minimizing losses. This method is an extremely effective and economical way to water plants.
- Choose to water your garden early in the morning when the temperature and wind speed are at their lowest possible. This reduces water loss through evaporation.

#### 6.1.2 Water saving tips from Municipalities

Water saving measures that can be implemented by municipalities or citizens through programs conducted by the PWS&SCs may include (Mesogeios SOS 2013):

- Mandatory installation of water saving equipment in new homes and in homes that are being renovated.
- The use of rainwater for irrigation or other secondary uses, by promoting the mandatory construction of rainwater tanks/cisterns.
- The provision of financial incentives, either as direct or indirect subsidy, for the installation of water-saving equipment in old houses with (a) a subsidy for the replacement of water supply systems in old houses (b) subsidizing rainwater tank installation in old and new homes in priority areas.
- Use of a labeling scheme for water efficiency products (like shower heads taps, toilets)

**FIGURE 15**  
Faucet with an integrated sink



- The strengthening of information and public awareness campaigns from PWS&SCs with free distribution to every household of a "saving water kit", which indicatively may include low-flow nozzles for taps, a water-saving shower head, a dye to detect leaks from toilets, silicone insulating cord and other related instructions.
- Awareness campaigns aiming to educate local communities for the promotion and implementation of water saving practices (e.g. "Water Matters" project, <https://water-matters.hcmr.gr/>) (Figure 16).

FIGURE 16

Water matters' campaign ambassadors present 10 tips to save water in our daily life



### 6.1.3 Water saving tips in hotels/ guesthouses

In islands that face the risk of water scarcity while at the same time host a large number of visitors, water conservation particularly in hotels and guesthouses, is of utmost importance. Some effective practices are the following: energy storage, circular water and waste management can have a far greater impact on the islands.

- Set up a water management plan, that on one hand will identify and determine the actual water consumption and on the other will outline water-saving goals and plan ways to achieve them.

- Raising awareness among customers, for example informing them about the importance of reusing sheets and towels and avoid changing them on a daily basis. In this way, the volume of laundry and ultimately the use of the washing machines are reduced (see also infographics in <https://water-matters.hcmr.gr>) (Figure 17)
- Use water saving devices, like low-flow aerated taps, water-efficient showerheads and dual flush toilet tanks.
- Frequent maintenance of the pool to prevent leaks and cover when not in use, to prevent water evaporation.

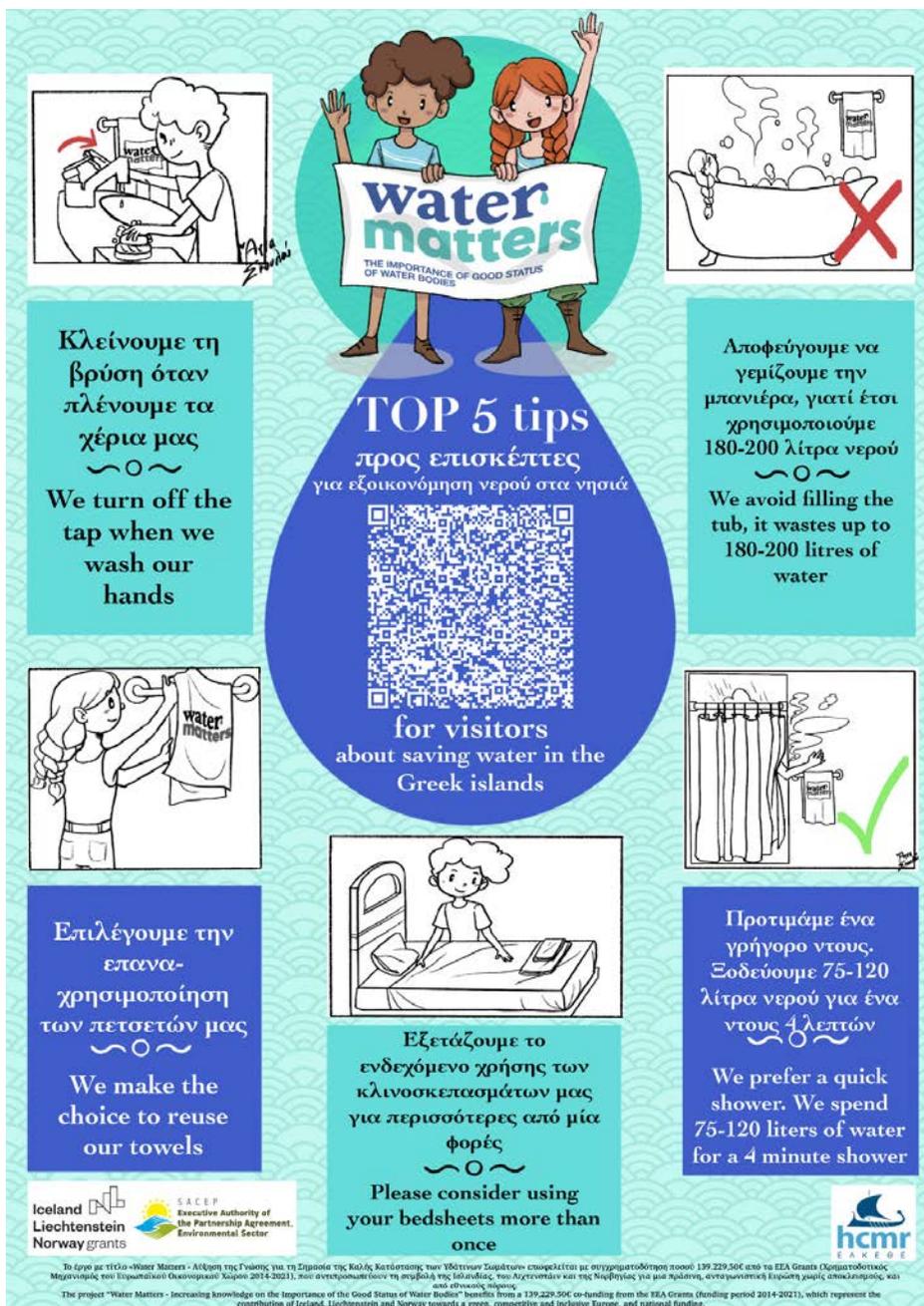
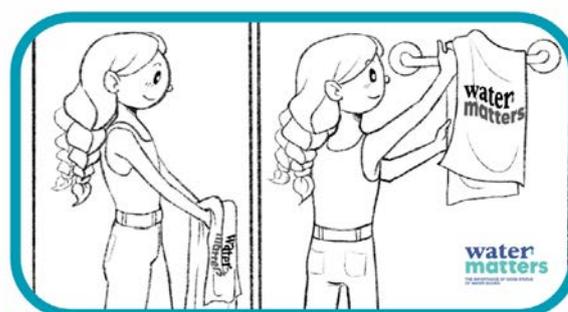


FIGURE 17  
5 tips for visitors about saving water in the Greek islands

- Collect grey water and reuse it for gardening or toilet flushing.
- Place cards and signs in the rooms asking guests to save water. (Figure 18)
- Conduct regular checks for leaks to prevent/avoid water losses.
- Certain cleaning products such as shampoos, soaps and lotions can cause an increase of pollutants in the used water. It is recommended to switch to natural and organic care products, as well as to biodegradable or recyclable packaging for a more holistic approach.

FIGURE 18

Tent card to inform guest to save water



*To help us reduce water and energy consumption as well as detergent wastewater, please consider reusing your towels*

THANK YOU FOR HELPING US CONSERVE WATER

## 6.2 | WATER HARVESTING

### 6.2.1 Rainwater harvesting

Rainwater harvesting is a water management technique that has been practiced for more than 4000 years. Today, it is increasingly gaining ground as a modern and simple water-saving technology (Londra et al., 2015). Rainwater harvesting can bolster water supplies and help meet urban and rural needs, adding flexibility and robustness to a system, while avoiding more costly investments.

Untreated rainwater can be used for non-potable uses such as toilet flushing, laundry, other domestic uses and garden watering. Drinking rainwater is also common in several countries (e.g. Spain, Australia). The most common method is rain harvesting from home roofs, however, given that rainwater in Greece is polluted (Skoulikidis 2018), a full chemical and microbiological analysis is required (Sazakli et al., 2007), along with purification when possible (Koutris et al., 2019).

Several studies (Pala et al. 2012) have shown that rainwater harvesting can be a viable alternative source for domestic water uses, with savings ranging from 12% to 100% of total demand, depending on the specific environmental conditions and the technical characteristics of each system (e.g. tank size).

In the Aegean islands, Global Water Partnership Mediterranean (GWPMed) applied relevant program in 2008 which is underway in 31 islands of the Cyclades and Dodecanese. In Folegandros island there are 2,500 cisterns and storm tanks and is perhaps a unique exam-

ple of an uninterrupted continuation of this tradition in the Cyclades, unlike most other islands in which rainwater harvesting disappeared when they acquired a water supply network. Altogether, rainwater harvesting is currently reemerging and it is regarded as a viable practice in combination with modern technologies (GWPMed).

### 6.2.2 Fog and dew harvesting

Collecting water vapor directly from fog or generally from atmospheric moisture, is a technique that has been applied for several years in arid countries. Water vapor collection systems are divided into passive (e.g. harp type) (Figure 19, left) and active (using an energy source to cool the collection surface) (Figure 19, right). Their application has recently started as a pilot in Greece, especially in the islands, aiming to provide drinking water to the communities. Islands, especially in their higher altitude parts, are suitable for the application of this technique due to the upward movement of air currents laden with water vapor which come from the sea, and subsequently cooling and condensation due to the altitude difference (Skoulikidis et al., 2020). This technology can produce 5.3 to 13.4 liters of water per day per square meter surface area of moisture collector. The exact yield of these systems depends on the time of year and location (Bertule et al., 2018). In order to use this water for drinking purpose it must first be purified, similar to the case of rainwater.

In Tinos under the framework of Hydrousa project solar-powered units were installed to recover drinking water



**FIGURE 19**  
Left: Experimental passive water vapor collection system from the harp-type atmosphere in Samothraki (HYDRO-E Program, Photo: Nikos Skoulidakis).

Right: Water vapor collection system using solar energy in Folegandros (Zero drop program, GWPMed)

from water vapor (<https://www.hydrousa.org/hydro5/>). Also, in the Zero drop program of GWPMed, a system with atmospheric condensers was installed in Folegandros that converts air humidity into water using solar energy. 30 liters of drinking water per day are thus produced. Finally, the Municipality of Nisyros, as part of the EIT Community Water Scarcity 2022-2023 project, will install a system that will produce fresh water from atmospheric moisture using solar energy.

Although dew can be collected simply from the roofs of houses, today there are more sophisticated systems that use special absorbent materials placed close to the ground in frames of varying geometry and arrangement (Figure 20). In Corsica and on an island in Croatia, collection systems were installed on horizontal surfaces measuring 30 m<sup>2</sup>, made of special material. In Croatia the average yield was almost 4 liters per dew day, while in Corsica an average of 3.6 liters per dew day was collected (Muselli et al., 2002, Beysens et al., 2007).

### 6.2.3 Artificial aquifer recharge

Artificial recharge is the introduction of additional amounts of water into aquifers using excess natural or treated water. Artificial recharge, reduces losses from evaporation and surface runoff, increases the level of groundwater, prevents

**FIGURE 20**  
Inclined fog collector (top) (Khamdevi & Matius 2023) and funnel-shaped dew collector (bottom) (Beysens et al., 2013)



salinization of groundwater reserves and improves their quality, while at the same time ensures groundwater supply to rivers (baseflow).

Overall, there are two categories of artificial recharge, passive and active. In passive recharge, surface water is released over large, usually flat, areas in which the geological strata are permeable. On these surfaces, water has enough residence time to infiltrate into the aquifer system. Active recharge is the process of injecting water into the aquifer, through boreholes or wells.

Artificial enrichment has been used internationally for about 200 years, but applications in Greece are minimal and mostly experimental (Vachaviolos-Kapranos 2016). However, the Regional Climate Change Adaptation Plan for the South Aegean Region includes relevant applications.

#### 6.2.4 Small dams (Micro-dams)

Small-height dry stone masonry dams on small and ephemeral streams were a traditional water management practice that has been lost in time. However, they perform multiple functions for the environment and humans, as they collect small amounts of water for irrigation purposes, reduce flood risk and soil erosion, combat desertification, recharge aquifers while at the same time are hotspots of biodiversity (<https://el.boulouki.org/>), especially in combination with revegetation /reforestation and restoration of crop terraces.

Nowadays, site prioritization for micro-dams is based on geomorphological, geological and hydrogeological criteria, usually treated in Geographical Information Systems (GIS). Micro-dams are typically built in mountainous or semi-mountainous areas, using local raw materials. (Figure 21).

Over the last 20 years, micro-dams were built with great success in the Aperathou area of Naxos (Glezos 1993, Glezos 1994). Since 1988, 98 micro-dams between 0.50-3.50 m high, 1 to 10 m wide and holding a few hundred cubic meters each, have been constructed. The outcome was very satisfactory, since after their construction water began to appear in all dried wells and springs revived (Vahaviolos-Kapranos 2016).

#### 6.2.5 Desalination using renewable energy sources

Among the renewable forms of energy used to produce drinking water from desalination plants, wind and solar energy are the most commonly applied. Given the high wind potential of the Aegean islands, operation of wind-powered desalination plants can be expanded. Also, solar radiation is abundant in both the Dodecanese and the Cyclades com-

plexes and can reach up to 1950 kWh/m<sup>2</sup> and 1800 kWh/m<sup>2</sup> respectively. Therefore, installation of solar powered desalination plants would be a fitting method for these areas.

Since 2010, desalination units based on renewable energy sources have been applied in the islands of Kimolos, Heraklia, Symi and Strongyli, and in Tinos in the framework of Hydroussa project (Figure 22). The most innovative operating unit is the floating desalination unit in Heraklia, with an installation cost of 1,500,000 euros in 2010 (Karvounis 2017). It operates on a combination of a 30 kW wind turbine and photovoltaic panels, having a capacity of 80 m<sup>3</sup>/day. Another innovative solution is applied in Oinousses island, using solar, wind and wave energy for desalination (MUSICA program <https://dafninetw.org/portfolio/musica/>).

Likewise, the Municipality of Nisyros is piloting solar desalination within the framework of the EIT Community Water project Scarcity 2022-2023, with SunAir Fountain technology, of the [Agua de Sol company](#) (France). Similar technology was applied in the Municipality of Tinos in collaboration with the Italian company Planet, as part of the Hydroussa research project.

FIGURE 21

Micro-dams in Paros island

(SOURCE: [www.water-scarcity.gr](http://www.water-scarcity.gr), [www.parianostypos.gr](http://www.parianostypos.gr))





**FIGURE 22**  
Low-cost solar driven desalination system in Tinos  
(Source: [www.hydrousa.org](http://www.hydrousa.org))

### 6.3 | REUSE -RECYCLE OF WASTEWATER AND «GREYWATER»

Greywater is water originating from domestic use with the exception of toilet water, such as water from the bathtub, sink, washing machines and dishwashers. It is estimated to make up 50-80% of domestic wastewater. Greywater can, after appropriate and small-scale treatment, be reused for selected domestic use (e.g. toilet flushing), urban uses (e.g. construction) and irrigation. It is considered an important alternative source, as over 50% of water used for domestic use is not necessarily potable.

Greece has a long tradition of reusing urban wastewater for the purpose of irrigation and fertilizing fields,

dating back to the prehistoric era (Minoan civilization, 5000 years ago) and extending over the ancient Greek and Roman periods (Koutsoyiannis et al., 2008, Angelakis et al., 2023). However, in recent times the reuse of treated wastewater is minimal and according to data from 2005 it ranges only from 0.07%-0.09%, while the predicted percentage for 2025 reaches only 0.75% (EDEA 2009). Contrastingly, in other Mediterranean countries, such as Jordan and Israel, the reuse of treated wastewater for irrigation purposes reaches 90% and 85%, respectively (Capodaglio 2021).

### 6.4 | INNOVATIVE SOLUTIONS

This chapter presents applications of modern technologies implemented for the management, protection and conservation of water resources.

#### 6.4.1. Hydroinformatics

Sustainable management of water resources, requires a significant amount of hydrological and ecological data, the collection of which is a costly and time-consuming task. However, in the last decades, technological innovations in remote sensing, unmanned aerial systems and au-

tomatic water monitoring through sensors provided the possibility of obtaining high quality, reliable and relatively low-cost hydrological and water quality data that can be used to assess the ecological water status (Dimitriou 2021).

#### 6.4.2. Automatic Monitoring Stations

Another innovative method is automatic telematics monitoring with sensors that can provide near real-time measurements such as water level/flow, water turbidity along with measurements on physicochemical parameters (e.g. water

temperature, pH, electrical conductivity, dissolved oxygen).

Networks of automatic monitoring stations are expanding worldwide and provide useful near real-time information on flood, drought and water pollution phenomena. These systems record on hourly or half-hourly basis critical water parameters, such as water level/flow, water temperature, and electrical conductivity related to salinization and dissolved oxygen. These data are telemetrically transmitted to a central computer and presented to users with data visualization platforms. The collected information appears in a dashboard format (Figures 23, 24). Furthermore, these systems have the possibility of automatically sending notifications to the competent authorities, when critical safety limits (thresholds) in the measured parameters are exceeded. In this way, there can be an early warning in cases of flood, drought or water pollution, which allows immediate intervention and thus reduction of the effects of these phenomena.

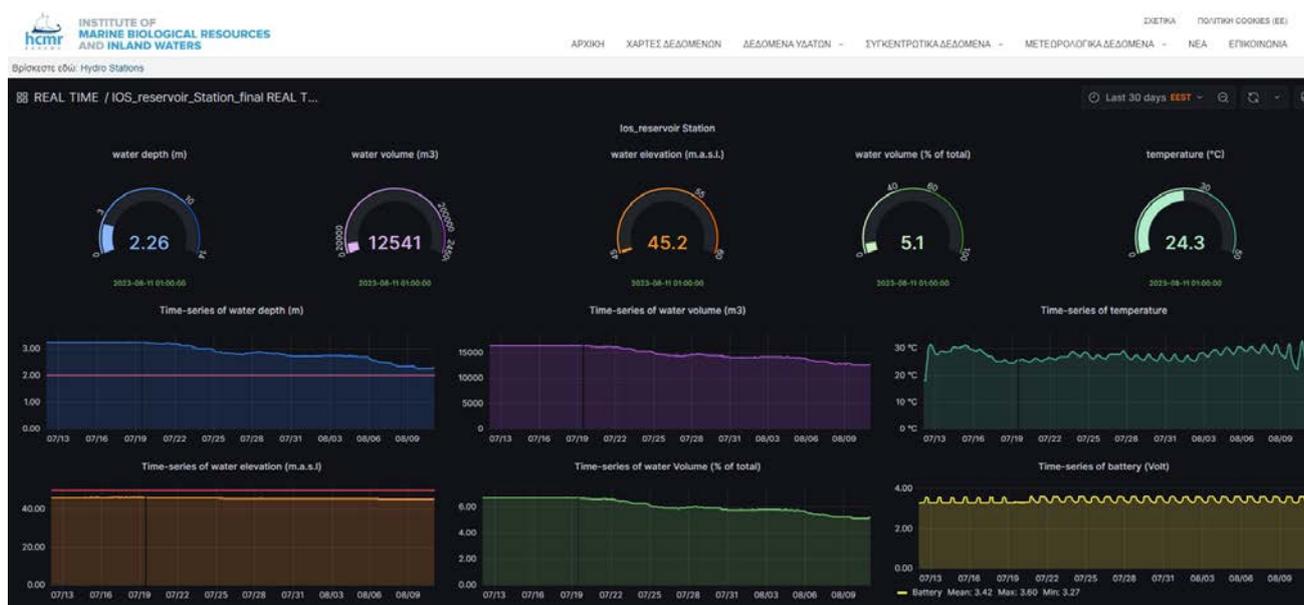
Examples of networks of automatic water monitoring stations operating in Greece are the network of HCMR (<https://hydro-stations.hcmr.gr/>) which currently consists of more than 60 automatic stations in rivers and lakes of the country, the National infrastructure HiMioFots

(<https://www.himiofots.gr/>) which includes automatic stations and operational models at sea and inland waters, as well as a series of smaller networks operated by Universities, Research Institutes and other Public bodies (Municipalities, etc.)

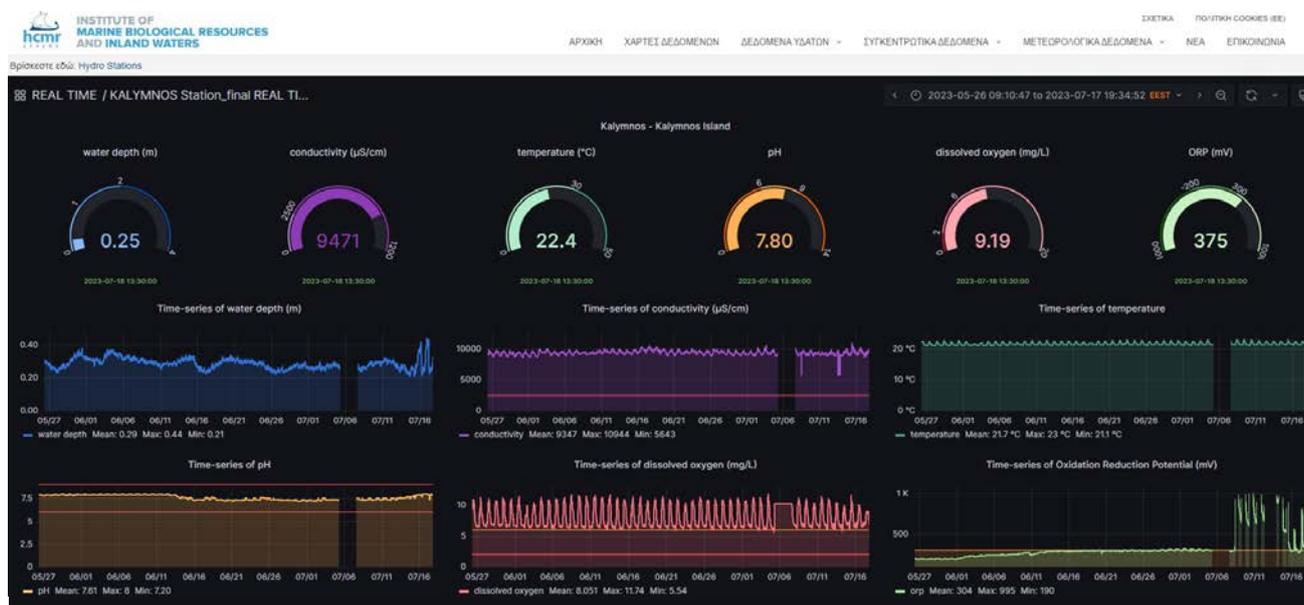
Within the framework of the Water Matters project, the Department of Inland Waters of HCMR has installed and operates two automatic water monitoring stations, one in Ios (June 2023) and one in Kalymnos (May 2023). The first station, was installed in Mylopotas Reservoir and monitors water level and water temperature on an hourly basis. (<https://hydro-stations.hcmr.gr/station/ios-reservoir/realtime/>). At the same time, the water volume of the reservoir is calculated and presented in the same dashboard (Figure 23). The second station was installed in a small pond in Vathy harbor of Kalymnos (<https://hydro-stations.hcmr.gr/station/kalymnos/realtime/>), monitoring water level on an hourly basis, along with the basic physicochemical characteristics: water temperature, electrical conductivity, dissolved oxygen, pH, redox potential (Figure 24). The data of these two stations are openly accessible to all and shared via the website <https://hydro-stations.hcmr.gr/>.

FIGURE 23

Monitoring dashboard of the automatic station operating in Mylopotas reservoir, in Ios Island.



**FIGURE 24**  
Monitoring dashboard of the automatic station operating in Vathi, in Kalymnos Island.



**FIGURE 25**  
Label of the automatic station operating in Vathi, in Kalymnos Island.



## CHAPTER 7

# Study Areas

The “Water Matters” information and awareness campaign, planned and implemented a series of actions in the 6 islands (study-areas) of the South Aegean region, during a period spanning from January 2023 to February 2024. The project team conducted a multitude of webinars, workshops, experiential field actions including measurements and samplings, activities with students in their school environment, cultural actions highlighting the value of water in folklore and more than 20 interviews with residents in the study-areas.

The team had the opportunity to interact with people from the island communities of Santorini, Ios, Leros, Kalymnos, Telendos and Pserimos. Locals were informed on the current water situation of their island and got to discuss, but also share, their concerns on the adequacy of water resources in their land. These on-site interactions offered a platform for exchange of common concerns from the residents of the six islands that participated in the awareness campaign, related to the quality and availability of water reserves.

By and large, all six islands cover most of their water needs mainly through desalination plants and ground-water abstractions. Therefore, the high conductivity of their drinking water, which results in its salty taste and has also negative consequences in the functioning of the household appliances (e.g. washing machines, dishwashers, coffee machines, etc.) was highlighted as a common problem. Serious concerns were also underlined regarding under-reporting on drinking water quality, dams, that are under-functioning or not functioning at all, while at the same time the need to reuse or reconstruct old private cisterns was noted. In addition, proposals from the islands’ residents, for water efficiency in domestic use and everyday life were gathered and documented by the project team (see BOX 1). These proposals are also presented on the project website <https://water-matters.hcmr.gr/>.

In subsequent chapters, the distinctive features of each study area are presented in detail, along with the challenges each island faces, in terms of the adequacy and quality of its water resources and related solutions are being proposed.

### BOX 1 | Water-saving tips and sustainable water management proposals from island residents

*“Inspections on the quality of both drinking water and water for general use, by the competent bodies” (Kalymnos resident)*

*“Rainwater harvesting projects, to save the water in the inhabited areas of Kalymnos that currently runs off and is lost in the sea” (Kalymnos resident)*

*“Posting posters on water coolers/dispensers that will promote awareness messages for saving water” (Kalymnos resident)*

*“Installation of water kiosks in schools of the island” (Kalymnos resident)*

*“Raising students awareness on good practices for water use, by placing informational signs in the school premises” (Leros resident)*

*“Engaging residents and students for the correct use and conservation of water” (Leros resident)*

*“Reuse or build new cisterns in households, as was done in the past” (Kalymnos resident)*

*“Use the water from the dehumidifier to water plants” (Kalymnos resident)*

*“Use of outdoor showers to utilize grey water” (Leros resident)*

*“Promote greywater systems, especially in new constructions” (Leros resident)*

*“Pool water at the end of the touristic season should not be discharged into the drains, but to be collected for treatment” (Leros resident)*

## 7.1 | SANTORINI

### 7.1.1 Main features

Santorini is an island in the Aegean Sea that belongs administratively to the South Aegean region and is the southernmost member of Cyclades island complex. With an area of 76.2 Km<sup>2</sup> and 15,457 permanent residents (2021 census), it has the highest population density (204 inhabitants/Km<sup>2</sup>) among the islands examined. At the same time, it is one of the most popular travel destinations on a global scale.

Santorini was shaped in its current form after a series of volcanic eruptions, with the largest being the Minoan eruption, dating back to about 3,600 years ago (Karsens et al. 2023). The International Geological Heritage Committee (IUGS-IGC) has included the [volcanic caldera of Santorini](#) as one of the 100 World Geological Heritage Sites (IUGS 2023).

It is a semi-mountainous island with its highest peak being Profitis Ilias (565 m), which is located in the southwestern part of the island. The average annual rainfall is notably low, only 327 mm (data 1962-2002, YPAN 2005), which results in very limited surface runoff. Moreover, infiltration is low and the presence of aquifers is limited, on one hand due to the low permeability and carrying capacity of the recent deposits, even though they cover almost half of the area of the island, and on the other due to the small carrying capacity of limestones (YPAN 2005c). Increased stress on the available groundwater reserves is also a consequence of reduced infiltration along the streams, since most of them have been cemented and turned into roads (YPAN 2005c). Thus, groundwater reserves of the island are not sufficient to cover the water needs. On top of that, they have been degraded due to over-pumping while at the same time the degradation of water quality from the intrusion of the seawater (YPAN 2005c) has an impact on the cultivated lands as well (Spilanis 2017).

There are three groundwater bodies in Santorini, as shown in Figure 26. These are "Kamari Fira Emporio A" (EL1400871) with an area of 54.6 Km<sup>2</sup>, "Kamari Fira Emporio B" (EL1400872) with an area of 17.8 Km<sup>2</sup> and "Kamari - Fira - Emporio C" (EL1400873) with an area of 3.5 Km<sup>2</sup>. According to the assessment and analysis from the Management Plans of the Aegean Islands RBD, one groundwater body (EL1400871) is classified as having good status concerning both quality and quantity,

while the other two (EL1400872, EL1400873) show a poor chemical quality and quantitative condition (Ministry of Environment and Energy, 2023).

No aquatic ecosystems are recorded on the island (apart from a small number of springs), as streams in the island are ephemeral and cease to flow on a regular basis. Although water resources of Santorini are almost non-existent and its aquifers have been impacted from salinization, the island's morphology, microclimate and soil composition, favor the cultivation of dry crops.

### 7.1.2 Challenges and Suggestions

Historically, Santorini's water needs were met by rainwater tanks, wells and springs. At present, water resources in Santorini are insufficient to meet human and environmental demands. The water budget deficit is intensified by "overtourism" and the resulting uncontrolled development of tourism infrastructures, swimming pools and Jacuzzis.

Drinking water scarcity is a major problem that is almost entirely covered by desalination plants and large quantities of transported bottled water (Spilanis 2017). Central desalination units operating on the island produce 7,000 m<sup>3</sup>/day of drinking water while there are also four small autonomous units, with a capacity of 6 m<sup>3</sup>/day each. Supplementary, 3,000 m<sup>3</sup>/day will soon be added from new units. On that account, Santorini ranks first in Greece concerning the production of drinking water from desalination, which the municipal water service

**FIGURE 26**  
The three groundwater bodies of Santorini.

EL1400872   EL1400872   EL1400873



manages profitably with a production cost of 1.5 euros/m<sup>3</sup> and a selling price of 2.5 euros/m<sup>3</sup>. Operating boreholes are used to supply brackish water to some settlements connected to the distribution network, while water trucks transfer water to settlements/residences that are not connected to the network. According to the municipal water service website, the water quality from treatment facilities and water wells is regularly checked for parameters such as odor, taste, turbidity, color, pH, conductivity and microorganisms. However the website only presents results of a single water quality analysis per Municipal District, whereas sampling and analysis dates are not reported.

Notable Santorini has the largest percentage of agricultural land (59.4%) among the islands examined in the Water Matters project. Nevertheless, the uncontrolled expansion of the touristic infrastructure has an impact on vineyards (Figure 27) a land-based crop that has been cultivated uninterrupted since ancient times and is known to produce excellent wine quality.

The use of rainwater harvesting systems (Koutsoyianis et al. 2008) to meet water needs (Enriquez et al. 2017, Preka et al. 2017), as well as a comprehensive economic analysis of the efficiency of all available options for water uses, could contribute to the future management of the island's water resources, given the increasing water consumption trend, resulting from excessive touristic development (new accommodations, swimming pools). However, the fact that the residents of Santorini have the financial capability to afford high water costs, seems to make the increasing dependency on desalination to cover future water needs, unavoidable. It is finally recommended that the municipal water service should present to the residents, the results of the water quality analyses performed in the Municipal Apartments of the island, on a regular basis.

FIGURE 27

The vineyards of Santorini (Photos: Nikos Skoulikidis, Sofia Giakoumi)



## 7.2 | IOS

### 7.2.1 Main features

Ios is part of the Cyclades island complex and administratively belongs to the South Aegean region. With an area of 108.7 Km<sup>2</sup> and a population of 2.299 permanent residents (census 2021) it is a rather sparsely populated island (population density 20 inhabitants/Km<sup>2</sup>). Ios is semi-mountainous, with limited agricultural land (5.6%) and its highest peak being Megalo Vouni (710 m), located in its central part. The total annual rainfall on the island reaches up to 405 mm (YPAN 2005d).

Geologically, the island is occupied by metamorphic igneous rocks (schists, gneiss, amphibolites, quartzites) in its greater extent (80%) while, the remaining 20% is covered by permeable formations, mainly of the carbonate type (marbles, limestones, dolomites) and alluvial deposits. Due to the nature of these formations, infiltration is low. Shallow unconfined aquifers are formed within the alluvial deposits, especially when these deposits overlie the metamorphic bedrock.

In Ios, only one groundwater body is identified, the "Chora" system (EL 1400830). With an area of 108.3 km<sup>2</sup> it is considered to extend over the entirety of the island. According to the assessment and analysis from the Management Plans of RBD of Aegean Islands, it is classified as of good chemical and quantitative status (EGY 2023). Water supply for the island is provided by a combination of desalinated water and 7 boreholes. Finally, five typical coastal wetlands can be found in Ios, with the older ones located in Ag. Theodoti and Magganari, with an area of 56,8 m<sup>2</sup> and 25,6 m<sup>2</sup> respectively.

### 7.2.2 Challenges and Suggestions

Water reserves of Ios are under threat from agricultural and livestock activities, municipal sewage and wastes. Furthermore, the lack of data on the ecological status of the coastal wetlands of Ios is regarded as the main risk for the loss of biodiversity and the ecosystems themselves. It is also suggested to upgrade/ replace the water distribution networks for water supply and irrigation alike, to reduce losses.

To meet the needs of potable water and irrigation, the Mylopotas reservoir was constructed in 1995, with an active capacity of 215,000 m<sup>3</sup>. However, during the field trips (May 2023, February 2024) of the "Water Matters" project team the water level of the reservoir was found to be very low, due to the dry preceding period. During this trip HCMR, covering all costs involved, has installed an automatic water level monitoring station in the reservoir (Figure 28). From the water level recordings, the volume of water in the reservoir is automatically calculated and displayed in real-time. The station's data is openly accessible to all and shared via the website <https://hydro-stations.hcmr.gr/>.

Complementary to the island's water resources, a desalination unit with a capacity of 20.3 m<sup>3</sup>/day has been built near the Mylopotas reservoir. Three more desalination plants using reverse osmosis technology, are planned to be constructed in the same area, with a total capacity of 1,080 m<sup>3</sup>/day. Finally the plan of small

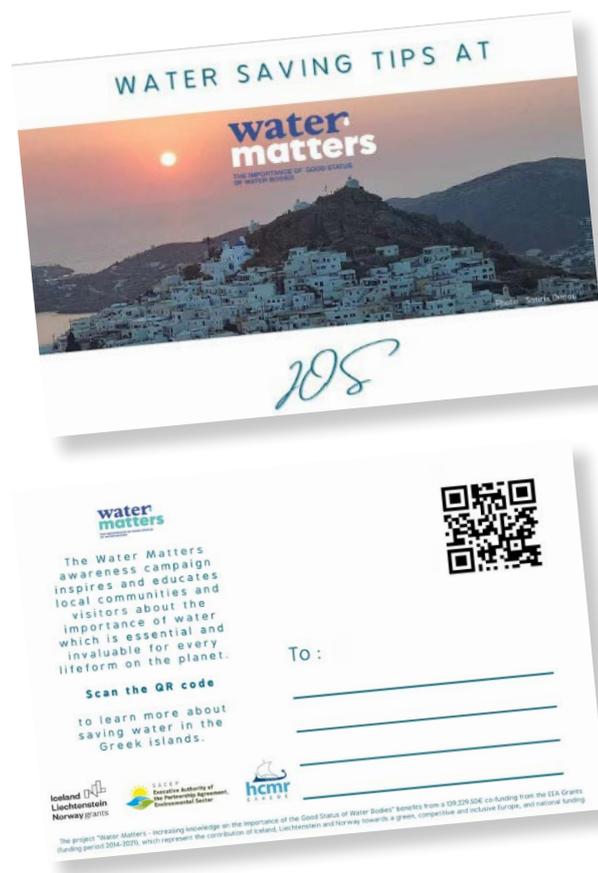
FIGURE 28

The Mylopotas reservoir in Ios and the installed automatic water level monitoring station of HCMR (Photographs: Nikos Skoulikidis)



dams construction in the Gialia watershed is expected to significantly enhance the recharge of the groundwater aquifer. In the study of YPAN (2005d), ancillary measures are proposed for the sensible exploitation of alluvial aquifers, coupled with the protection of groundwater from salinization through the development of a long-term monitoring network of groundwater level and quality.

Furthermore, the "Water Matters" project team considers necessary to install rainwater harvesting systems in houses, construct more small dams for the purpose of recharging groundwater, inform the public and raise awareness on residents and visitors concerning water saving and water reuse (greywater) and lastly strengthen alternative methods of cultivation with less water requirements (dry farming), with an emphasis on reducing water consumption and enhancing the efficient use (e.g. drip irrigation), especially during the summer months when water demand is high.



### Problems and suggestions for saving water from residents of los island

- The water of the swimming pools after the end of the tourist period it shouldn't be discharge but it should be collected for treatment, so that it can be reused again.
- Promote the use of outdoor showers for collection of grey water
- Reduction of swimming pools as they "consume" large amount of water
- Collection of rain in traditional cisterns
- Strengthening the culture of integration with grey water tanks in new constructions (houses, hotels, etc.)
- The Tap water does not taste nice
- Promotion of the construction of micro dams in the island
- Promotion of water awareness campaigns for cultivating a new water consciousness
- Placing pots near the sink so that water from washing can be used for pottering the plants
- Recommendations for saving water should be made In the hotel units,
- If water will disappear what will we do?

## 7.3 | LEROS

### 7.3.1 Main features

Leros is an island of the Dodecanese group that administratively belongs to the South Aegean Region. It has a population of 7,992 permanent residents (census 2021) and an area of 54.4 Km<sup>2</sup> (population density 147 inhabitants/Km<sup>2</sup>). Leros has the highest percentage of artificial surfaces and built-up areas (15%), among the six study areas.

Leros has a semi-mountainous relief with gentle slopes, with its highest peak being Skumbardos at 326 m. The average annual rainfall is estimated to be between 431 mm (YPAN 2005b) and 498 mm (Filippidis 2012, period 1988-99). The geological profile of Leros includes carbonate rocks (marbles) by 36.8%, impermeable sedimentary formations of the Paleozoic by 35.9%, permeable alluvial deposits by 10.5% and magmatic, volcanic and metamorphic rocks totaling 16.8%.

Leros is a fertile island and agricultural land covers 23% of its area. The local temperate climate favors the cultivation and growth of horticultural crops, olives, citrus fruits, cereals, vines, and tropical plants such as dates, guavas and lotuses. Surface waters in Leros are scarce and ephemeral. Aquatic ecosystems appear as a stream (Partheni), estuaries, salt marshes, reservoirs and marshes (YPAN 2005b; Katsadorakis & Paragamian 2007). The intermittent Partheni stream feeds the Partheni coastal marsh (0.3 Km<sup>2</sup>), which has a seasonal presence of surface water. Freshwater supply is affected by the homonymous dam, while human activities have shrunk and disturbed the wetland (WWF, YPAN 2006). The Rina spring, which is located at the downstream side of the dam, has an annual yield of approximately 216,000 m<sup>3</sup> of brackish water (YPAN 2005a). Two more coastal marshes are found on the island: Gourná (0.4 Km<sup>2</sup>, very degraded by human activities) and Kokkalis (WWF).

Two ground water bodies are identified in Leros, as displayed in Figure 29. These are "Leros A" (EL 1400361), with an area of 51.3 Km<sup>2</sup> and "Leros B" (EL 1400362), with an area of 2.5 Km<sup>2</sup>. According to the assessment and analysis from the RBD Management Plans, "Leros A" is classified as of good chemical and quantitative condition, while "Leros B" is in poor chemical and quantitative condition (YPEN 2023).

### 7.3.2 Challenges and Suggestions

Until a few years ago, drinking water was supplied from springs, some boreholes and rainwater tanks, the Hellen-

ic Survey of Geology and Mineral Exploration (HSGME) drilled seven boreholes with an approximate yield of 250,000 m<sup>3</sup>/year (YPAN 2005b) between 1985-87. However, in recent years, the large increase in consumption and the over-pumping of the aquifers in the summer season resulted in their salinization, which led to water transfers to the island in order to cover their needs (2004-2010).

It is noted that, according to a recent study by HSGME, the groundwater body of Northern Leros has been degraded due to salinization. Also, a deficit in water balance in southern Leros is attributed mainly to increased irrigation needs (YPAN 2007). In 2002, the construction of the Parthenio dam with an active volume of 785,000 m<sup>3</sup> was completed, but it has not been operational, due to leakages. To ensure drinking water, a brackish water desalination plant, with a capacity of 200 m<sup>3</sup>/day, was built in 2004 and a large seawater desalination unit, with a capacity of 2000 m<sup>3</sup>/day, was built in 2016.

With these measures, both water transfers and the over-pumping of groundwater stopped. In addition, 17 small desalination units were constructed providing 12 m<sup>3</sup>/day of drinking water, free of charge. Covering water needs through these systems has a lower cost than the cost of bottled water, while the environmental burden from plastic bottles has been reduced by 2/3. Finally, as sealing of the Partheni dam has not yet been carried out, a new desalination unit, using renewable energy sources is expected to operate soon. However, challenges related to low quality of potable water produced by the desalina-

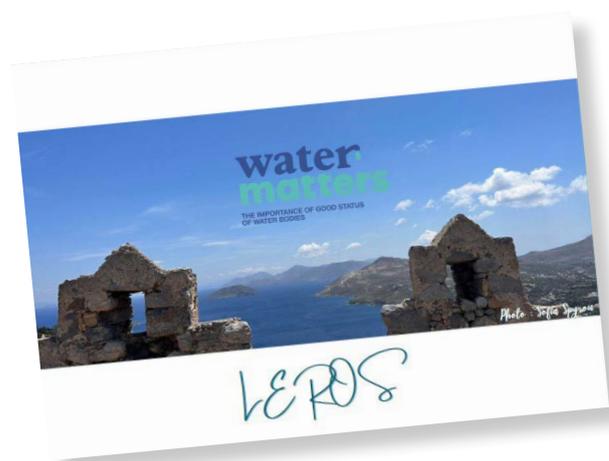
**FIGURE 29**  
The two groundwater bodies of Leros.

EL1400362    EL1400361



tion plants remain, while losses of water in the distribution network are an important issue that needs to be tackled.

Proposals of the project team prioritize the sealing of the Parthenio reservoir, but also suggest several other actions: repair and replacement of old parts of the water distribution networks, rainwater harvesting in households, improvement of water resources management actions such as the construction of micro-dams (it is noted that the Italians had built a retention dam in the area of Sykamia to increase infiltration, which currently ensures approximately 20 m<sup>3</sup>/day), informing and raising awareness of residents and visitors concerning water savings and reuse (greywater) and lastly promotion of alternative farming methods with less water requirements, with an emphasis on reducing water consumption and enhancing its efficient use.



#### Problems and suggestions for saving water from residents of Leros

- Repair of the dam in Partheni area
- Repair of the water supply network as there are many leaks
- Modernization of water supply network
- Utilization of rainwater in cisterns
- Strengthening the culture of integration of grey water systems in the new luggage (houses, hotels, etc.)
- Continuous and strict quality controls on drinking water
- Try to turn off the tap when you brush your teeth,
- We always use the washing machine when we have a full load.
- The water from boiling the spaghetti can be used for watering the pots
- Inform the children/students how to save water in their daily life

## 7.4 | KALYMNOS

### 7.4.1 Main features

Kalymnos is a part of the Dodecanese island complex and administratively belongs to the South Aegean Region. It has a population of 17,797 permanent residents (census 2021), including population from Pserimos and Telendos, demonstrating a 6% increase compared to 2011. Kalymnos has an area of 111 Km<sup>2</sup> and high population density (161 inhabitants/ Km<sup>2</sup>). It is a semi-mountainous island with its highest peak being Profitis Ilias (678 m), located in the central part of the island.

The average annual rainfall is quite high, compared to the other islands examined and is estimated to range from 543 mm (YPAN 2005a) to 559 mm (Karpouzos & co. 2006). Morphologically, the island can be divided into the northern part where one ridgeline can be identified and the southern part, where three ridgelines run in parallel. Plain areas occupy a small extent of the island (10%), are covered by crops and are located at the estuaries of the main watercourses in the areas of Panormos, Vathy and Kalymnos (YPAN 2006a). Concerning its geology most of the island of Kalymnos (78%) is composed out of carbonate rocks (marbles, limestones and dolomites of the Lower Cretaceous). In contrast, igneous, volcanic and metamorphic rocks (slide materials and landslides) occupy only a minor extent (2%). Finally, the clastic sedimentary rocks of the island include the impervious schists of the Neopaleozoic (5%) and the more recent alluvial deposits (15%).

There are no permanent surface water systems, but there are about 20 springs scattered over the island. The main groundwater reserves are the alluvial aquifers of Vathy and Pothia valleys which serve irrigation needs (YPAN 2005). Water supply needs of the Municipality of Kalymnos are met by a combination of springs, boreholes, wells and small desalination units.

Three groundwater bodies are identified in Kalymnos, as displayed in Figure 30. These are "Pothia" system (EL 1400370) with an area of 12.6 Km<sup>2</sup>, "Vathy" system (EL 1400380) with an area of 32.4 Km<sup>2</sup> and the "Kalymnos" system (EL 1400390) with an area of 65.2 Km<sup>2</sup>. According to the assessment and analysis from the RBD Management Plan "Kalymnos" system is classified as of good chemical and quantitative status, while the remaining two ("Pothia" and "Vathy") are of poor chemical and quantitative condition (YPEN 2023) due to overexploitation and salinization (for "Vathy": 1400-1500 mg/l Cl).

### 7.4.2 Challenges and Suggestions

Kalymnos faces shortage of freshwater resources and struggles to meet human and environmental demands. Water shortage is exacerbated by insufficient information about the importance of water and its efficient use (a typical example is the careless use of potable water in courtyards). Over-pumping of aquifers and lack of rainwater utilization, although some relevant old infrastructure still exists (Figure 31), are among the main challenges to be addressed on the island.

Due to the prevailing geological formations (limestones and alluvial deposits) and the extensive contact of the land

**FIGURE 30**  
The groundwater bodies of Kalymnos.



**FIGURE 31**  
Sloping roof in Kalymnos for rainwater collection (Photo: Eugenia Tsianou).



area with the sea, the exploitable water resources are limited. The water balance is in deficit and severe water supply problems arise, especially in summer, when water needs for tourism and agriculture are increased. At the same time the exploitation of groundwater reserves of "Vathy aquifer", had reached limit levels already a decade ago (Ministry of Development 2006a).

As Mr. Lazaris from the municipal water and sewerage utility has stated, during summer conductivity of the boreholes reaches 6000  $\mu\text{S}/\text{cm}$ , while in the winter it ranges between 2000 and 4000  $\mu\text{S}/\text{cm}$ . They also present increased concentration values of arsenic (As) of natural origin. At the same time, the groundwater body of "Vathy" is affected by the existence of an uncontrolled waste disposal area (UWDA) and a wastewater treatment plant (WWTP). The UWDA where waste incineration still takes place (Figure 32) should be upgraded without delay.

Sampling conducted by HCMR, suggests that water quality in Kalymnos supply network is degraded and unsuitable for drinking (see 7.7). Replacing the old and leaking water supply network of asbestos cement pipes, has been included in the management plan of the Municipality and today approximately 40% of it has been replaced. Other necessary actions are the expansion of rainwater harvesting among household, the reuse of greywater, the support of integrated action for water resources management (such as the construction of micro-dams to recharge aquifers and protect them from salinization), the promotion of alternative cultivation methods with less water requirements that put an emphasis on reducing consumption and

enhancing efficiency of use in conjunction with actions to raise awareness among residents and visitors on water saving issues.

During the visit of the "Water Matters" project team in Kalymnos (May 2023), an automatic water monitoring station has been installed in a small pond, adjacent to Vathy harbor (Figure 33). Through the monitoring station, hourly measurements of water level are collected, in addition to measurements concerning the main physicochemical characteristics of water quality: water temperature, electrical conductivity, dissolved oxygen, pH and redox potential. The station's data is openly accessible to all and shared via the website <https://hydro-stations.hcmr.gr/>.

**FIGURE 32**

Uncontrolled waste disposal area of Kalymnos with waste incineration (Photo: Nikos Skoulikidis)



**FIGURE 33**

Left: The small pond where the automatic monitoring station was installed, large sea bass can be seen (Photo: Nikos Skoulikidis). Right: installation of the automatic station for water level and physicochemical parameters monitoring (Photo: Sofia Giakoumi)



## 7.5 | PSERIMOS

### 7.5.1 Main features

Pserimos, also called Kapari, is located in South Aegean, north of Kos and southeast of Kalymnos. Geographically it is included in the island complex of the Dodecanese and administratively belongs to the Municipality of Kalymnos. With a maximum altitude of 268 m, it has the lowest relief of the examined islands and is characterized as semi-mountainous. It is one of the smallest islands of Dodecanese (14.8 Km<sup>2</sup>). With a permanent population of 80 inhabitants (2011 census) it has the lowest population density (5.5 inhabitants/Km<sup>2</sup>) among the six study areas.

The average annual rainfall has been calculated based on the meteorological station of Kos at 431 mm (YPAN 2005). There is a developed animal husbandry, mainly goats and sheep. One of the few livestock farmers on the island (Mr. Sakellaris Mavros) manages 800 animals by himself and produces milk and cheese. According to him their grandparents practiced crop rotation, in which one year they cultivated half of the island and the other half was used for grazing and the following year vice versa. In this way they maintained balance in nature and improved soil fertility with organic fertilizer.

Pserimos is almost exclusively covered (88%) by carbonate rocks (limestones and dolomites). Flysch (8%) and small occurrences of volcanic tuffs (0.2%) constitute the impermeable formation of the island, while the water-permeable alluvial deposits occupy 3.8% of island's surface. In limestones aquifers that lay below absolute sea level and are in direct contact with the sea, groundwater is discharged to the sea. Conversely, water re-

serves with limited extent develop within the carbonate caps on flysch at positive elevations (above sea level). The central part of the island, hosts productive aquifer pockets at a shallow depth. For example, Kampos (Figure 34 right) has a 10 m deep borehole, with a capacity of 5 m<sup>3</sup>/hour of hard brackish water.

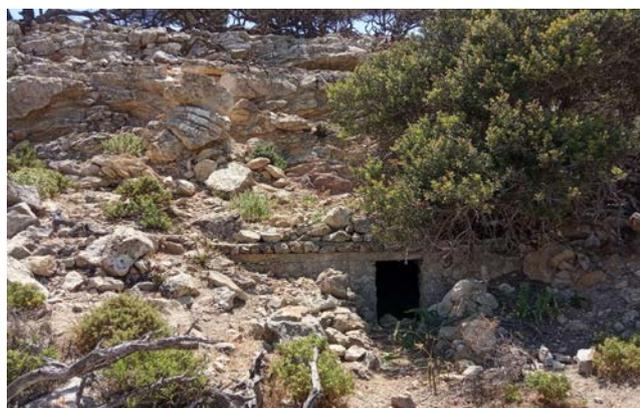
The groundwater body of Pserimos (EL 1400910) has an area of 14.6 Km<sup>2</sup> and develops in dolomites and limestones of high permeability. According to the assessment and analysis from the RBD Management Plan it was classified as of good quantity and chemical status (EGY 2023). Apart from the low-flow spring of Taxiarchis (formatted at the contact between limestone cover and impermeable substrate) located above Kampos (Figure 34 left) there are also coastal low yield springs. The low-flow spring (1 m<sup>3</sup>/hour) located 1.5 km south-east of the island's settlement, is exploited for the residents' water needs (YPAN 2006a). An operating seawater desalination unit with a 100 m<sup>3</sup>/day capacity, which has significantly increased quantity and upgraded quality of water for consumption in Pserimos, contributes to the improvement of quality of life for both the islands few residents and numerous visitors.

### 7.5.2 Challenges

Pserimos is an arid island and during summer months water needs intensify, due to the arrival of visitors. Most of the land in Pserimos is almost public, owned by the Municipality of Kalymnos and therefore farmers have to rent it. This condition creates insecurity for the farmers who

FIGURE 34

Pserimos: The Taxiarchis spring inside the limestone cover (left) and Kampos with a water collection system (right) (Photos: Nikos Skoulikidis)



want to buy land, whilst the Municipality of Kalymnos refuses to sell. The few farmers of the island do not have the opportunity to join subsidized programs, either because they do not own the land (which is often a prerequisite) or because they do not know the procedures. As a result, younger people want to leave the island when their elderly relatives die. Under these conditions of abandonment by the central state and due to possible future desertification of this parched island we do not know if any proposals for

management and proper use of water will be of any use.

In the central part of the island, shallow boreholes could be drilled, but the exploitable volume of water is not known and hydrogeological surveys are required (YPAN 2006a). Recharge of the groundwater bodies could also be achieved by the construction of small dams. Promoting rainwater harvesting in households and using alternative farming methods with less water requirements are also possible solutions to the problem of water scarcity.

**FIGURE 35**

Travelling for water matters awareness campaign to Pserimos, May 2023  
(Photos: Nikos Skoulikidis).



## 7.6 | TELENDOS

Telendos is a very small island in South Aegean, located at a distance of about 900 m off the west coast of Kalymnos. Geographically, it is included in the Dodecanese group and administratively belongs to the Municipality of Kalymnos. It has an area of 4.5 Km<sup>2</sup> and 94 permanent residents (2011 census).

It is a barren and rocky island, best described as a small mountain mass in the sea reaching an altitude (maximum) of 459 m. Its lowland parts are formed on the southeast side of the island, behind the designated traditional settlement. Telendos was once united with Kalymnos but the two islands were separated after a strong earthquake in 535 AD, when the intermediate part connecting them sank, along with the entire city of ancient Pothia (then capital of Telendos), as reported in chroniclers.

Based on the meteorological station of Kos, the average annual rainfall has been calculated at 513 mm (Ministry of Development 2005). Similar to Kalymnos and Pserimos carbonate rocks prevail in Telendos as well. Telendos is impacted by water scarcity. The island's water supply is met by a desalination unit with a capacity of 100 m<sup>3</sup>/day, which is currently under-functioning, and by rainwater harvesting tanks in households (Figure 36).

**FIGURE 36**  
Rainwater tank and cistern in Telendos (Photos: Nikos Skoulikidis)



## 7.7 | ASSESSMENT OF WATER QUALITY IN KALYMNOS, PSERIMOS AND SANTORINI

Between 2-6/4/2023 and 17-19/5/2023, after visiting Santorini, Kalymnos, Telendos and Pserimos in the course of the "Water Matters" program, HCMR collected water samples to conduct water quality assessments. Samples were taken from 4 water sampling locations in Kalymnos and from 3 points in the Vathy pond system. Samples were also taken from a spring and a well in Pserimos and a spring in Santorini.

According to the results of the chemical analyses of HCMR, water from the network in Kalymnos is unsuitable for drinking: the total hardness of the water (1020.8 mg/l CaCO<sub>3</sub>) is 6.7 times higher than the limit of very hard water (180 mg/l, according to Hem), while according to Greek legislation on "Quality of water for human consumption" (Government Gazette 3525, 25/5/2023), the concentration of sodium (1069.3 mg/l) exceeds by 5,3 times the parametric value (threshold) in drinking water (200 mg/l), the chloride concentration (2002 mg/l) exceeds by 8 times the parametric value (250 mg/l) and the sulfate concentration (274.1 mg/l) is also above the parametric value (200 mg/l). Additionally, the concentration of nitrates (30 mg/l), is below the parametric value (50 mg/l), but is indicative of pollution, possibly due to the use of nitrogen fertilizers. Finally, the low ammonia and nitrite values (8 and 16 µg/l, respectively), attest that water reserves are not affected by organic pollution (e.g. municipal sewage). On the contrary, an analysis carried out on a sample of water that was taken from the supply network and then treated in a private desalination unit, demonstrated very satisfactory results in terms of water potability: moderate hardness and concentrations of main ions and compounds of nitrogen and phosphorus below the parametric values.

Also in Kalymnos, the Scalia spring, near Emporio, exhibits acceptable values of total hardness, major ions, as well as nitrogen and phosphorus compounds. But the high value of nitrates (62.7 mg/l) exceeds the limits of drinking water (50 mg/l), which makes it unsuitable for drinking. It could be estimated that the Scalia spring is affected by the use of nitrogen fertilizers.

In Vathy, next to the harbor, there is a semi-natural formation of a water body (pond) fed by three little springs with brackish water of varying salinity. Conductivity in the pond is just over 8,000 µS/cm and it has an unpleasant smell of bleach. The bottom of the pond has been covered for the last two years by the rose algae *Gelidium crinale*.

Large sea bass and bream, showing signs of illness (blurry-eyed sea bass and white-headed bream) along with mullets and eels were found inside. Water from the pond outflows through an artificial channel and discharges in the sea, after meeting an adjacent ditch that carries water together with wastewater from the adjacent WWTP, as can be concluded from the very unpleasant smell.

During the project team's visit to the island, on-site measurements of physicochemical parameters and sampling were carried out in one of the sources that feed the pond, in the outlet channel from the pond and in the channel that receives the waters of the pond and the WWTP. The on-site measurements and chemical analyses of HCMR showed that in all cases the water was brackish. Sampling and identification of benthic invertebrate species within the pond showed degraded biological quality (pollution resistant species). The spring water feeding the pond has very low concentrations of ammonia, nitrite and total phosphorus, indicating that it is not affected by sewage. The water outflow from the pond shows only a small increase in the concentrations of these compounds, indicating that it is not affected by permeable cesspools or underground inflow of treated water from the WWTP unit. Moderately increased concentrations of these compounds in the water leaving the pond, is assumed to be mainly due to the decomposition of fish excrement and/or the disposal of organic waste from the neighboring residences within the pond.

In the ditch that receives water from the pond combined with outflows from WWTP and outflows in the sea, the values of nitrogen and phosphorus compounds are very high compared to the water leaving the pond: ammonia is 285 times higher, nitrite 52 times higher and total phosphorus 32 times higher, confirming the disposal of insufficiently treated waste waters by the WWTP. According to assessment and classification of the physico-chemical status of surface waters in the context of the WFD implementation (Skoulikidis et al., 2006), the water of this ditch is characterized as bad, in terms of phosphates and nitrates, and poor in terms of ammonia and nitrites. In conclusion, the WWTP waste does not seem to affect the water in the pond. The problems manifested on the fish of the pond, are assumed to be due to the discharge of detergents from the neighboring houses, as evidenced by the strong smell of bleach. Finally, it is recommended to improve the efficiency of the WWTP.

In Pserimos, samples were taken from "Taxiarchis" spring and the coastal well in Marathota. "Taxiarchis" spring is formed at the contact of a limestone cover that overlies an impermeable bedrock and is fed by rainwater penetrating the karstified limestone. The spring has low conductivity (400  $\mu\text{S}/\text{cm}$ ) and normal concentration values for major ions and compounds of nitrogen and phosphorus. The Marathota shallow well shows limited influence from the sea and normal values for nitrogen

and phosphorus compounds. In both cases the water can be used for drinking purposes.

In Santorini, sampling was performed on 6/5/2023 at the spring of "Zoodochos", which is located inside a cave of Ancient Thira. This little spring exhibits fitting quality attributes and its water can be used for drinking purposes.

Finally, we note that in all the aquatic systems examined the nitrate values are relatively high and waters have elevated levels of hardness, compared to other regions.

**FIGURE 37**  
 Samplings for water quality issues in the islands. (Photos: Sofia Giakoumi, Nikos Skoulikidis)



## CHAPTER 8

# Examples of Good Water Practices in Norway

## 8.1 | WATER-WAYS IN NORWAY AND GREECE

Although Norway has an abundance of fresh water when compared to Greece, climate change imposes the need for cultivation of a modern water consciousness in both countries, with the aim of water saving and achievement of sustainable water use in households, enterprises and life style.

### 8.1.1 Water-ways in Ottadalen valley

The Norwegian case study of good water practices, presents an established practice in the mountain valleys of Norway, which although it dates back to the 18th century, is still in operation. It concerns the use of remote and inaccessible water bodies in the Lom-Skjåk mountain valleys. As it turns out a similar irrigation practice has been used in some communities in Greece.

The "water ways", "*bordvassvegar*" in Norwegian (Figure 38) represent an innovative solution to a challenge that many countries have to deal with: How to transport water from the source to the people. The "water ways" have been in use since the 15th century and are the manifestation of a unique case of cooperation and resilience of a community. The farmers dug irrigation canals from the mountain lakes or edge of the glacier into man-made reservoirs. Finding the way was difficult, since the water had to pass through rocks and cliffs and cross other streams, the farmers built different constructions to get the water down to the valley, for example rows and rows of connected wooden, hollowed out logs. One "water way" could supply multiple farms, and every farm that had been cooperating in the making process and the annual inspection and maintenance, could use the "water way".



FIGURE 38  
"Norwegian bordvassvegars"

(Left: photo by Roula Andriopoulou, Right: Web)

### 8.1.2 Water-ways in Lom Sják – a case study of good practices

With only 300 mm of rain per year, the areas of Lom and Sják in Innlandet region (Figure 39) resemble almost desert conditions. At the same time mountain farming has been, and still is, a very important issue for the community. In order to make their crops grow, locals had to collect water from the high mountain areas where the water was abundant. To do so, they created long waterways from logs and wooden planks from the edge of the glaciers on top of the mountains towards the fields.

An old expression in Lom says, "Give us sun, our Lord, and we shall provide ourselves with water". The sunlight, in long daytime hours in summer, results in glacier melting. By community efforts water was brought to the fields, and fields bathed in sun and sprinkled water provided crops and welfare.

The waterways were constructed by the farmers during the 18th Century. They proved to be economically resilient and were in full use until the 1980s. The longest waterway was 20 km. In total, 68 facilities of this type have been registered.

Today, a great number of wooden waterways have been gradually replaced by modern solutions like plastic piping, and in some cases even abandoned in favour of modern municipal infrastructure/services or even private supply and pumping facilities from water sources at lower elevations which are closer to farms. However, due to the significant financial cost of these facilities, some farmers still use the waterways, combining existing infrastructure with private and municipal water supply companies, so as to cover important irrigation needs of the agricultural community.

Farmer Sæbjørn Forberg highlights the economic advantage of the waterways by saying: "Traditional waterways are cheap since they are already established and therefore can be used almost for free." In order to be built and maintained, the waterways required a significant amount of labour and cooperation between farms. A necessary condition for the allocation and duration of the resources was the agreement and understanding between them.

Each waterway had a guardian, a "vassbas" whose duty was to supervise and organize the maintenance of the canals during the irrigation season, as well as to impose fines to other farmers if they did not cooperate properly. Fines were usually paid to parish for charity purposes. Every farmer could be a vassbas. The sharing of water required the cultivation of a spirit of collegiality, cooperation and solidarity among the members of a community, thus leading to its evolution and resilience.

**FIGURE 39**  
Lom, Norway (photo by Roula Andriopoulou)



## 8.2 | THE «RAISED FURROW»- IN KYRIAKOCHORI VILLAGE, FTHIOTIDA REGION, GREECE

A similar traditional practice of irrigation in mountainous areas is also found in other areas of Greece, as for example in Kyriakohori at Fthiotida. The so-called "Raised Furrow" (Figure 40) has been registered in the National Intangible Cultural Heritage Index since 2021.

The "Raised Furrow" is a traditional practice which has been used for the irrigation of crops from the 18th century until today. Locals lead the water of a mountain tributary of Inachos into a long groove with the help of gravity and

store it in an open, large cistern. From there, water is distributed to cultivations and houses via smaller channels. With this traditional method, farmers produce valuable agricultural products and strengthen the local community, with respect to the natural environment.

This good water practice has been used by the seventy households of Kyriakohori. It is associated with perceptions, knowledge and behaviours that are consistent with a sustainable way of managing natural resources

and promote the spirit of solidarity and cooperation of the community, along with its well-being. The tradition is passed through generations, in an experiential way.

In conclusion, these examples, which have many similarities and have been applied with great success in mountainous rural areas in Norway and Greece, are good water practice proposals that although dating

back in centuries remain modern and sustainable as low-tech cost-effective solutions based on valuable local community experience.

Traditional techniques of this type can support sustainable water management, by contributing to the cultivation of a modern water consciousness and utilizing the knowledge and experience of the past.

**FIGURE 40**

The "Raised Furrow" in Kyriakochori (Source: Web)



## CHAPTER 9

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- Water Academies, online courses about water scarcity in Mediterranean <https://www.eitfood.eu/projects/water-in-south-finding-innovative-solutions-for-water-scarcity-in-southern-europe/the-water-academies>
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# water matters

THE  
IMPORTANCE  
OF GOOD STATUS  
OF WATER  
BODIES

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