National Technical
University of Athens
School of Civil
Engineering

Optimizing water infrastructure solutions for small-scale distributed settlements

Case study: Municipality of Western Mani

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Introduction

- The Municipality of Western Mani (WM) is located in the southern part of Greece in Peloponnese. The region has a high rate of rainfalls mainly in the mountainous areas.
- Rainfall is mainly observed during the autumn and winter months, from October to March, while there is a significant decrease in the summer.[1]
- The problems that arise focus ,for the most part ,on the quantitative aspect [2-5]. The geological background is extremely permeable as it consists mainly of karstic limestone. Therefore, there are not only limited surfaces water resources but with limited water supply ,as well.[6]

Source :
https://vemaps.com/europe-continent/eu-c-04#google_vignette

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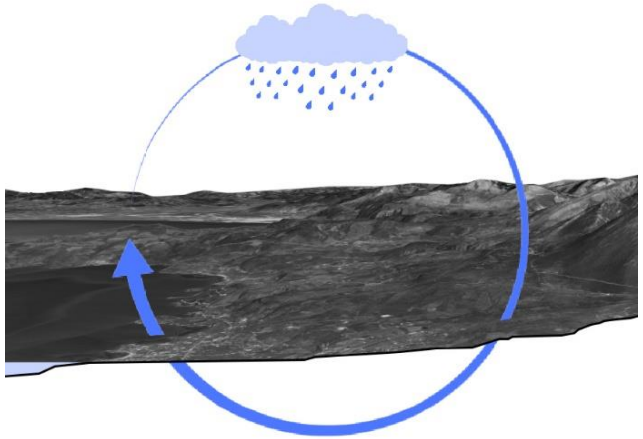
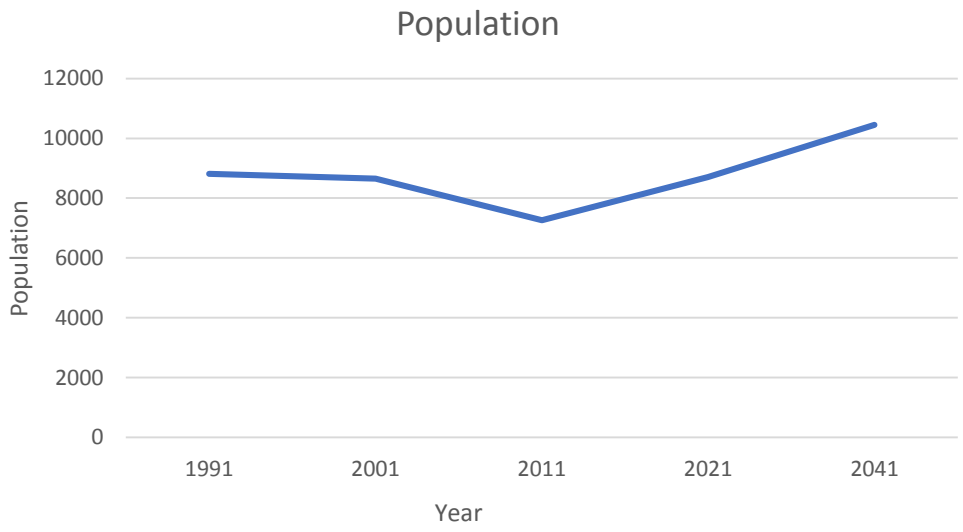


Population / Tourism

- According to demographic data, Western Mani's (WM) population decreased from the year 2001 to the year 2011. However, it is estimated an increasing trend in the past decade. [7]
- Taking that into consideration, in order to hypothesize the future number of inhabitants after 20 years, we design our infrastructures for 20% more population
- In the past few years it has also been observer a rise of the tourism during the summer months.

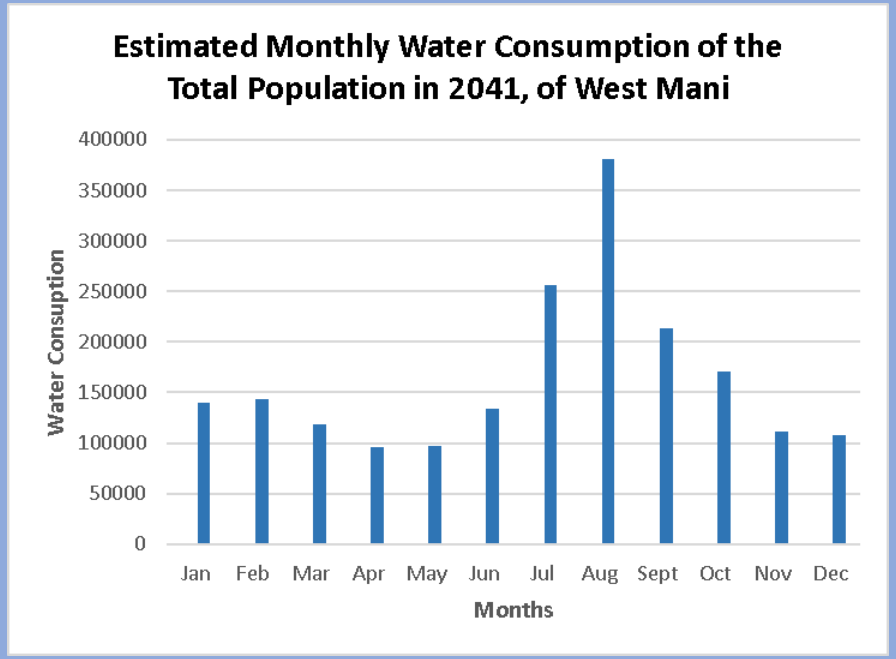


POPULATION CENCUS	POPULATION					
	1991		2001		2011	
Kallikratis Program	Permanent	De Facto	Permanent	De Facto	Permanent	De Facto
Municipality of West Mani	6843	8816	6658	8647	6945	7258
Lefctro District	4346	5908	4267	5558	4699	4855
Avia District	2497	2908	2391	3089	2246	2403

Source : Hellenic Statistical Authority, Demographic characteristics / 2011https://www.statistics.gr/el/2011-census-pop-hous

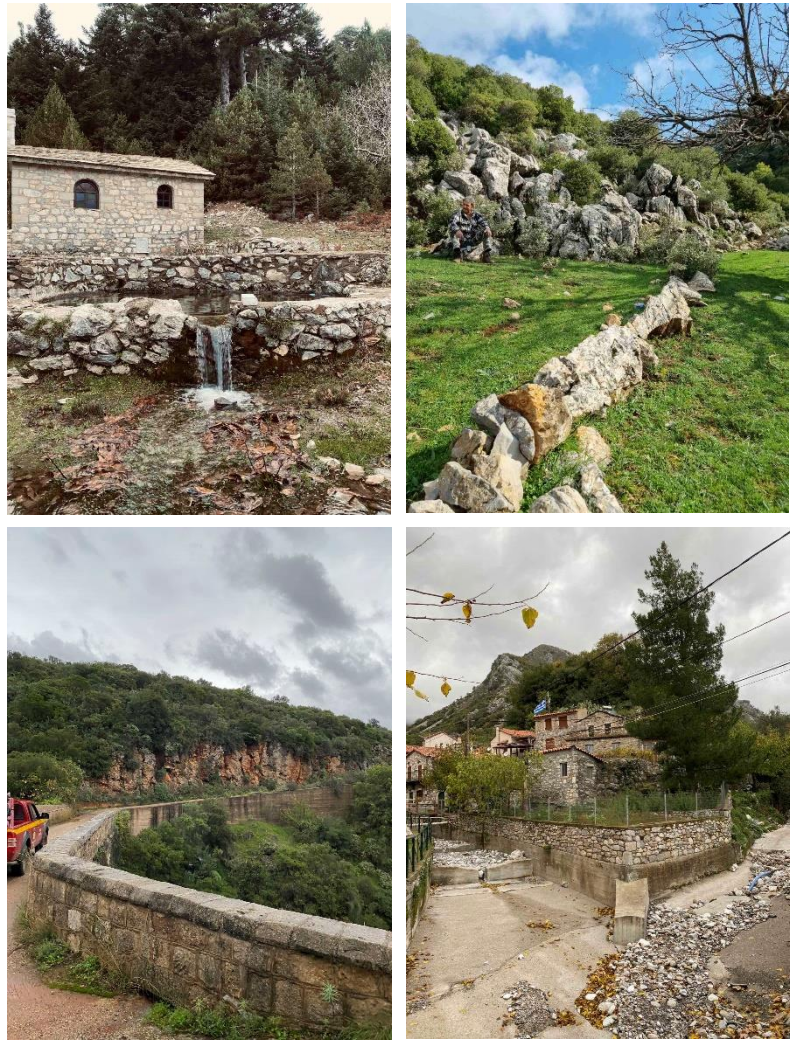
Water needs

- Lack of data through the past few years. In particular the only data that have been found refer to the year 2019.
- The majority of the data are available only annually → impossible to use them reliably
- Estimated water consumption in our study area is about 300 L / d / inhabitant. [8]



Methodology

- Examining all the possible options that have been proposed to increase the water availability
- Apply a multi-criteria decision-making approach increasing water resilience
  - Critiria Election
  - Data Quantification
  - Sollution Comparison



Western Mani

Solutions and Criteria

Possible Solutions

- Water ponds
- Dam (Nedontas river)
- Dam (Lagada)
- Desalination
- Wells/Boreholes
- Cisterns(traditional)

Criteria

- Environmental Impact
- Political Difficulty
- Construction Feasibility
- Resilience of Supply
- Risk of the construction
- Adequacy
- Pipe Network Length
- Construction Time
- Cost

Decision-Making Methods

Making informed decisions based on understanding and knowledge requires comprehensive analysis and reasoning of the problem from multiple angles[9]. Some of the methods that examined in order to achieve this purpose are listed below:

- Using a cost-benefit analysis that translates all the criteria into monetary value.[10]
- Conducting a survey and use people's willingness to pay (WTP).
- Hedonic pricing method (HPM). [11]
  - This method compares the prices of similar marketable goods to identify differences that may reasonably be due to the existence of non-marketable items.
- Multiple-criteria decision analysis (MCDA)
  - When it comes to decision making, traditional approaches based on quantitative methods such as MCDA have been largely impractical. Complex problems, including multiple unmeasurable criteria, require human experience and intuition to compromise conflicting criteria.[12]
- Formulating a multicriteria-tableau

Multicriterion table

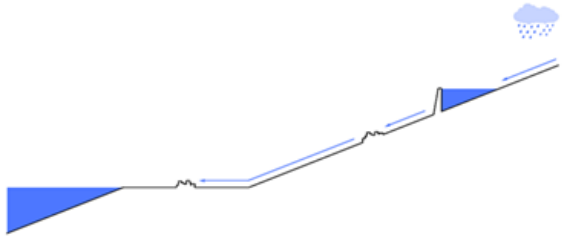
- Created an overall summary of the results in symbols and colors.
- Summarize the problem in a multi-criteria tableau that describes the reference values.
- Many of the criteria can be evaluated by numbers, but other could not. The measurable as well as the non-measurable criteria were expressed schematically following the same scale.[9]
- We classified the effect of each criterion based on the following table[13]:

SYMBOLS				
Very bad	Bad	Neutral	Good	Very good
				

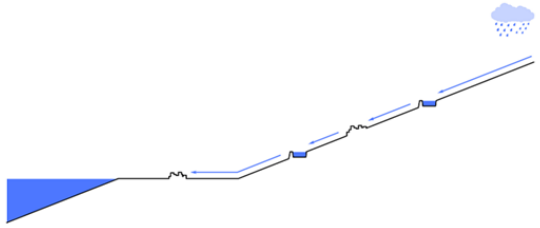
Multicriterion table

	Dam (Nedodas River)	*Water Ponds*	*Dam (Lagada)*	*Desalination*	*Wells/Boreholes*	*Cistern (traditional)*
Environmental Impact	✗	✓	✗	✗	✗	✓
Political Difficulty	✗	○	✗	✓	✓	✓
Construction Feasibility	○	✓	✗	✓	✗	✓
Resilience of Supply	✓	✓	✗	✓	✗	○
Risk of Construction	✗	○	✗	✓	✓	✓
Adequacy	✓	✓	✗	✓	✗	✗
Pipe Network Length	✗	○	○	○	✓	✓
Construction Time	✗	✓	✗	✓	✓	○
Cost	✓	✓	✗	✗	○	○

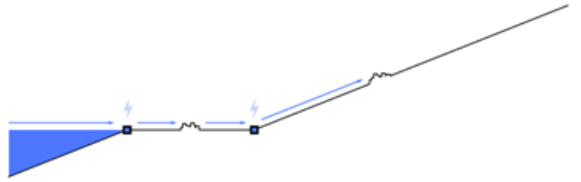
Possible Solutions-Cross Section



Nedontas Dam

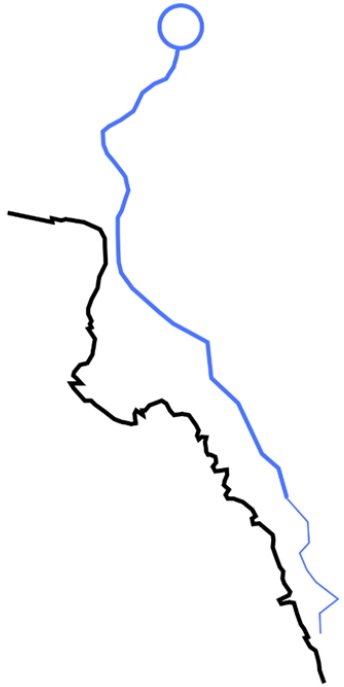


Water Ponds



Desalination

Possible Solutions - Top view



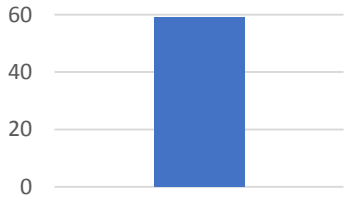
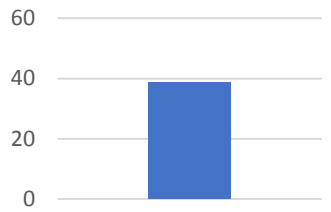
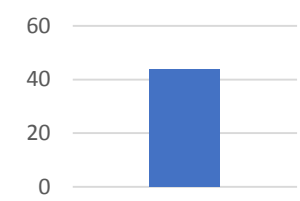
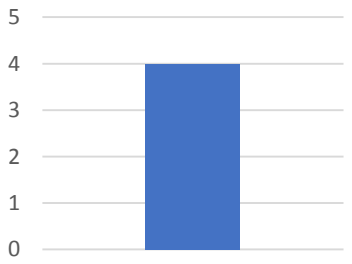
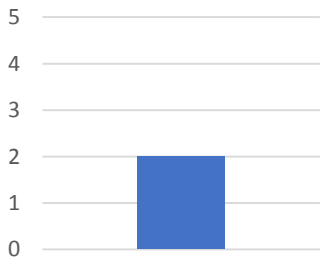
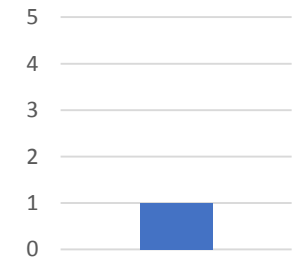
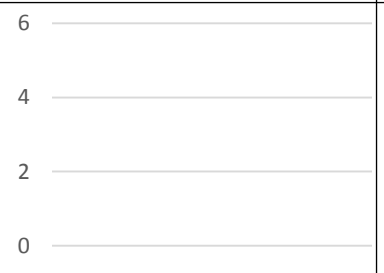
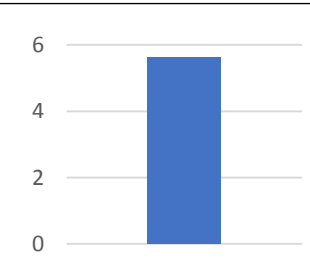
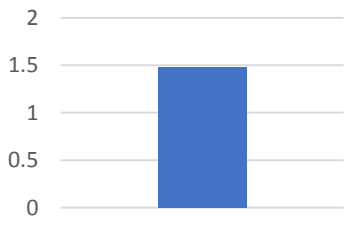
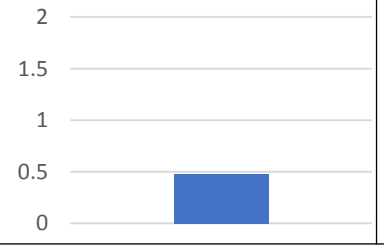
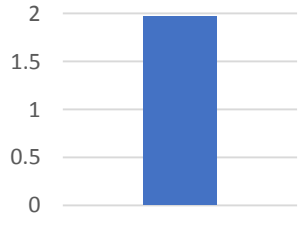
Nedontas Dam

Water Ponds

Desalination

Measured Criteria

In order to have a more complete picture of the solutions that are most likely, we compared the easily quantified criteria based on the actual numbers that characterize them[14]:

	Dam (Νέδοντας river)	Water ponds	Desalination
Pipe Network Length (km) (sum)	59.1 	38.8 	43.7 
Construction Time (years)	4 	2 	1 
Energy Consumptions (kWh/m^3)	0 	0 	5.631 
Total Cost(€/m^3)	1.478 	0.479 	1.969 

Conclusion-Optimal Solutions

- As shown in the previous table the dam and the desalination are expensive and difficult to implement solutions, on the other hand water ponds are the safest and most economical solution and will adequately cover the problem.
- Although multi-criteria analysis is a theoretical, quite questionable method, it does not cease to help us to examine and compare our choices and to have an overview of the problem and the potentially optimal solution.

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