Larhyss Journal, ISSN 1112-3680, n°57, Mars 2024, pp. 55-79

THE WATER MANAGEMENT SYSTEM IN THE VILLAGE OF MENADES IN ALGERIA BETWEEN PAST AND PRESENT

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Research Article – Available at http://larhyss.net/ojs/index.php/larhyss/index
Received April 2, 2023, Received in revised form March 1, 2024, Accepted March 3, 2024

ABSTRACT

Given the importance of water in human life, most communities have developed specific systems to exploit water resources in various aspects of life. From region to region, settlement to settlement, a set of determinant factors have contributed to these systems' creation and development. In this research, we have tried to highlight the particularities of the traditional water management system in the case of the village of Menades. We also tried to identify the transformations (technical, economic and social, etc.) and the development process that have influenced this system over the last forty years to become what it is today. By addressing these aspects, we attempted to identify the current difficulties of water management in the village and their possible solutions. The methodological tools used were observation, interviews, Google Earth Pro software, and microbiological analysis of the water. The results of the research indicate that the system has evolved as a result of a number of exogenous and endogenous factors. This evolution presents some positive aspects, but also a number of challenges and problems to which the various stakeholders need to work together to find appropriate solutions.

Keywords: Water management, Thala, Tharga, Menades village, Evolution.

INTRODUCTION

Water management methods and means differ from one culture to another and according to the different settlement areas of communities (Jelisavka et al., 2019; Jayasena et al, 2021; Aroua, 2022). Climate, topography, and soil quality also play a crucial role in developing appropriate irrigation systems for each region.

In addition, the diversity of water management activities, going from agriculture to architecture, plays a role in determining the characteristics of these systems. The Mediterranean region settlements are an example of the multiplicity of water uses. In this region, water is used in agriculture for irrigation, in urban and rural architecture as a component of building materials (cob, adobe, mud bricks, cement mortar, concrete, etc.), and as an element that composes the inside and outside of space. By widening the geographical field of research to include the five continents, the diversity of water use methods related to social and economic activities is further confirmed (Ballut and Fournier, 2013).

The technical progress of communities is an important aspect affecting the production of water systems. Not so long ago, in most Mediterranean countries, especially in southern regions, the difference between rural and urban area water regarding water management techniques was huge.

In general, urbanization increases the complexity of water management systems. However, developing these systems is vital to meet the growing needs for water, both quantitative and qualitative. However, the simplicity of water use systems does not necessarily mean they are inefficient. Moreover, they can be better than relatively modern systems once their environmental and social benefits are considered.

In the Mediterranean countryside, we have noticed that rural water use systems are not the same as those in urban areas, and we have noticed peculiarities in each region, even for each human settlement (village, hamlet, arch).

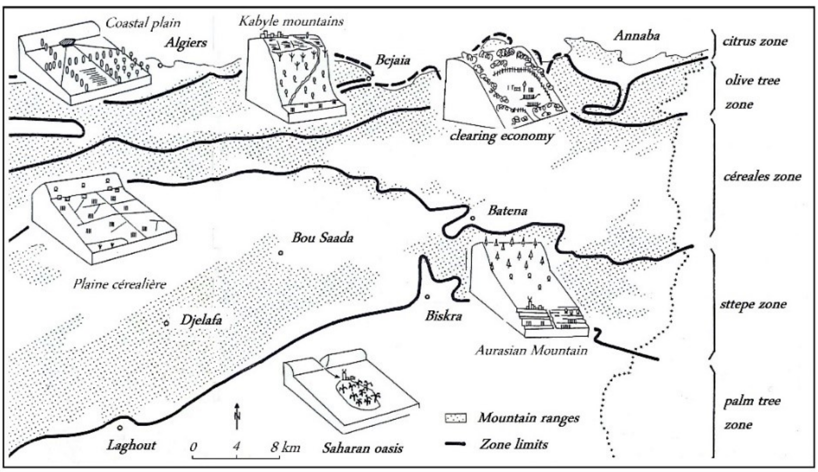

Figure 1: Diversity of agrarian landscapes in Algeria according to bioclimatic zones (Côte, 1996) translated by authors.

For example, in the case of Algeria, Côte (1996) has shown this diversity by evoking these systems and the resulting cultivations of the climatic zones from north to south. He mentioned five different geographical zones: the citrus, the olive, the céreales, the steppe, and finally the palm zone. Côte has clarified that in each of these zones, people have responded to the climatic conditions (abundance or scarcity of water) by developing human settlements and adapting agriculture (Fig.1).

In this research paper, we try to highlight the particularities of the traditional water management system in the case of a relatively small Kabyle village called Menades, in the Beni Ouartilane region in the extreme northwest of the Wilaya of Sétif (Figs. 2 and 3). Additionally, we attempt to identify the transformations and the development process that influenced this water management system over the past forty years to become what it is today.

Furthermore, understanding the social and economic dimensions of the village water management system will be crucial to our research, as well as its technical description and relationship to the natural and social environment. Finally, we try to answer the following questions: What are the current water management problems in the village?

What are the possible solutions to these problems?

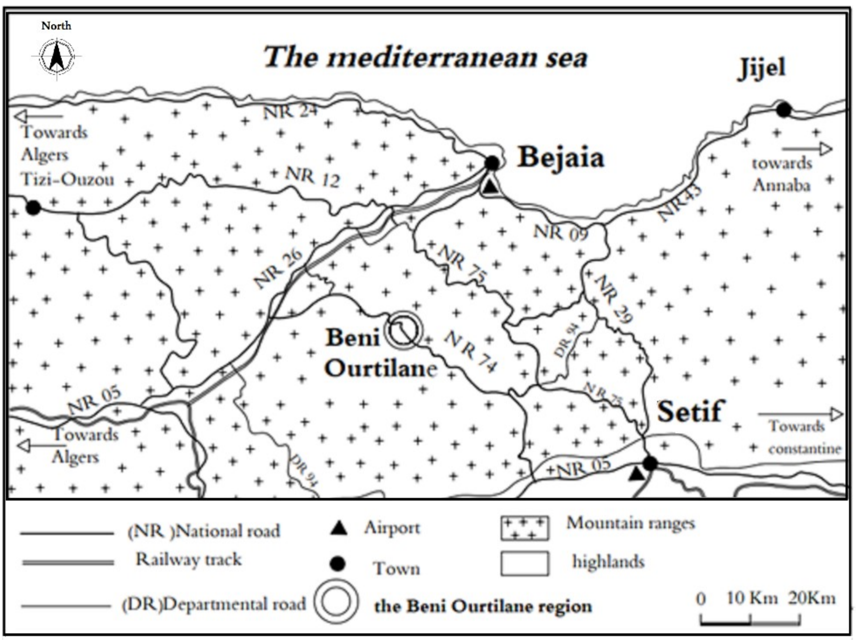

Figure 2: Card of the Beni Ourtilane region. (Fontaine, 1983)

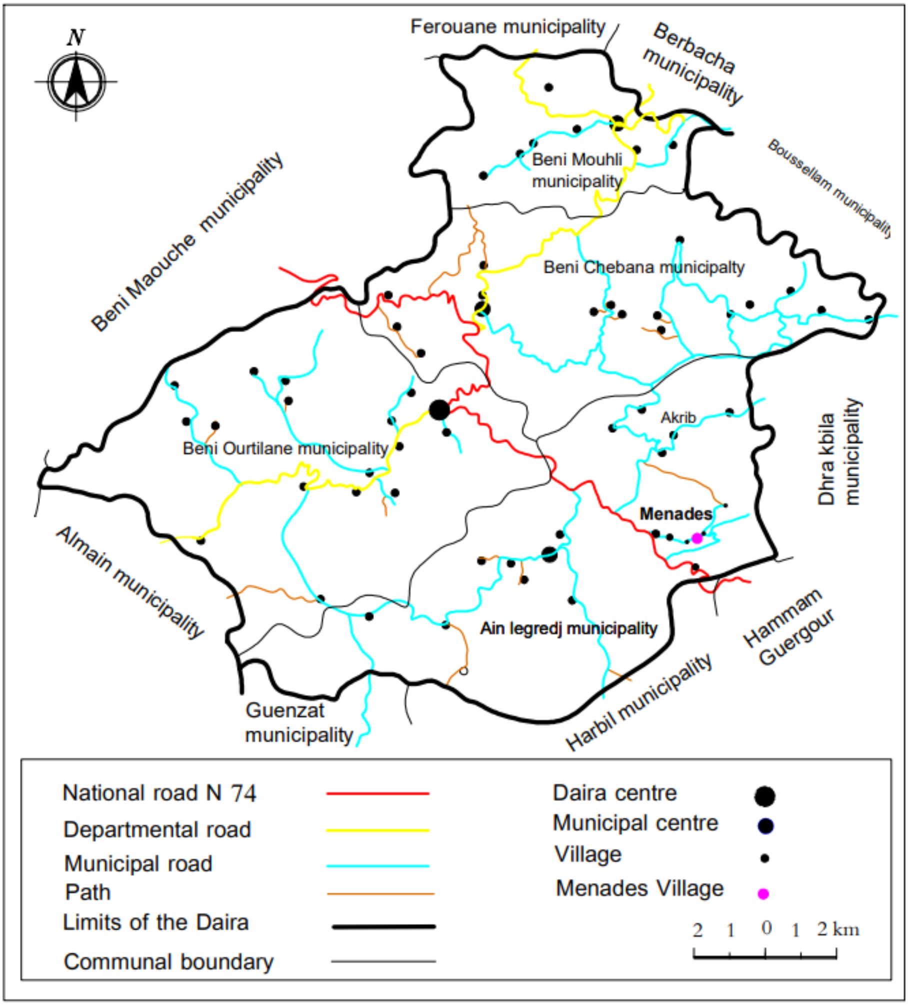

Figure 3: Card of the most important settlements in the Beni Ouartilane region (Kezzar & Souar, 2023)

Several studies have addressed rural and urban water use systems. According to the literature review, we selected documents and articles related to our research topic or case study. The selection included the research by Marquez et al (2023) into water supply in the mountain village of Drave in northern Portugal, which aims to understand the evolution of water demand and supply in the village of Drave, from the sixteenth century to the present day, and to present a possible solution to meet future water needs. The selection included also the research of Schelle (2011) concerning the water and irrigation sciences and techniques mentioned in southern Algeria historical manuscripts. This work aims to identify how water is present in the Algerian desert and the means of its management.

Schelle (2011) revealed that Algerian desert communities developed systems allowing them to draw, exploit and manage water rationally because it was crucial for their lives. We have noticed this closely through three study cases of water management systems: the Ksar of Ghardaïa, the Ksar of Beni Yazgne in the M'zab Valley in southern Algeria and the oasis of Sfissif in the Ksour mounts in southwestern Algeria. The first was developed in a work entitled "The irrigation system in the M'zab Valley - Beni Yezgen, study case" (Maarouf and Al-shihani, 2022). The second was discussed in a work entitled "Water in Ghardaia (Algeria) artificial system by excellence" (Dahmen and Kassab, 2020). The third was presented in a work entitled "Traditional irrigation system and methods of water harvesting in the oasis of Sfissifa ksour mountains – Algeria" (Derdour et al, 2022). In addition to the description of the traditional water use system, the latter was interested in the details of the water quality in the study area.

Another interesting study selected in our literature review aims at the water and related traditions in the Ksour region (Khelifi, 2003), in which we have found that, in addition to the technical aspect related to the use of water, societies have inherited rituals expressing their beliefs toward the water and its importance. In the sources mentioned above, we have noticed some similarities and variations in our case study (Menades village) regarding the water management system, evolution, and rituals.

In addition, literature related to the heritage of the Beni Ouartilane region and its surroundings was studied. Among others, we can mention the book entitled "The Cultural Heritage of the Beni Ourtilane Region, Monuments and Personalities" by Aberezzak Djedjig (2018), the book entitled "Beni Ya'la, insights into heritage, customs and traditions" by Abd-elkarim Bouamama (2004) and one of the works of Ali Benarab (2013) entitled " Basics on the commune of Aïn Legradj, Beni Ourtilane region ".

They preferred to gain insight into our study case's geographical and cultural characteristics. These three works retraced the origins of the villagers; they described the architecture of the villages and the agricultural activities carried out there depending to the seasons; they gave valuable information on the religious scholars of the 19th and 20th centuries and their impact on local society. They also evoked events from the period of the war of liberation (1954-1962). These sources enable us to understand some important details of the local culture and traditional daily life of the region's inhabitants.

MATERIAL AND METHODS

To answer our research questions, our methodology is based on observation by inspecting Menades village and its surroundings. A camera and traditional documentation materials were used to record observations concerning water resources and their domestic and agricultural uses. During our visit, we were accompanied by an old farmer who showed us the boundaries of the irrigated land perimeter. This visit is scheduled on August 5th, 2023. Another visit was undertaken to take an inventory of water resources (wells, springs, fountains, wadis). We also conducted interviews with the six elderly inhabitants of Menades (a woman aged 82 and 05 men aged 89, 60, 73, 76, and 93). To conduct these interviews, we used open-ended questions on the origin of the village, its water management system, and its evolution (Figure N 04). The interviews were conducted in August 2023. Additionally, we used the Google Earth application to obtain data about surfaces, distances and slopes. We also asked a private laboratory (the IDRES laboratory located in the Bejaia city) to carry out analyses (bacteriological) of the water quality of the main village's fountain.

Open interview questions

Q1: What are the origins of the inhabitants of Menades village?
Q2: Why did they choose to settle on this place?
Q3: If the abundance of water was one of the factors that led to the choice of this place, what water resources would the villagers use?
Q4: How did the villagers use water in their daily lives?
Q5: Who was the initiator of the water-sharing system in the village?
Q6: How did the villagers share the water from the main fountain (Thala) to irrigate the vegetable gardens?
Q7: What do the villagers do in times of drought?
Q8: What changes have you noticed in the domestic and agricultural use of water in the village of Menades, from the 80s to the present day?

DESCRIPTION OF MENADES VILLAGE AND ITS EVOLUTION

Etymologically, the name of the village "Menades traces back to the local Amazigh expression *"aman zeges*" which means containing abundant water. Menades village is a secondary settlement making part of a series of villages: *"Lazib or Thamagazth"*, *"Bounter", "Menades"*, *"Tizi Al-Askar"*, and *"Ichenbouthegh".* These villages are accessible through national road n°74 and a municipal road of 5.12 km. The geographic situation is between 36°24'40.27"N to 36°24'58.31"N and 4°55'56.60"E to 4°56'15.21"E, and it covers an area of 26.2 hectares, representing 0.66 % of the territory of Ain Legredj municipality one of the four municipalities of the Daira of Beni Ouartilane (Figs .2 and 3). The study case is approximately 10.8 km from the chief town of the *daira*, while it is approximately 4.7 km from the chief town of the Ain Legredj municipality. Menades is located to the southeast of *Boumoussi* Mountain (1240 m) in a relatively flat site characterized by an average altitude of 1050 m, abundant water resources and fertile soils.

The urban development of the village

Historically, the old village center was simply a group of constructions that farmers used as shelters and warehouses during olive and other crop harvesting seasons. According to the interviewers, during the first decade of the last century, farmers gradually began to settle in, and the settlement began to expand, and became a small village at independence (composed of à mosque, a cemetery, and 16 *hara).* At that time, it was inhabited by several extended families whose origins go back to the villages of the Arche *Ghaboula* located to the northeast of Mount *Boumoussi*. Before the War of Liberation, the inhabitants of Menades enjoyed self-sufficiency, exploiting what was available to them as local resources in agriculture and grazing. Because of the seven years of war and displacement to the mother villages of the *Gheboula* Arch, some of them were forced to migrate for work in Algerian or French towns. This would later contribute to the expansion and radical change of the village (Kezzar, 2020).

Over time, the village grew, its urban fabric in 1978 becoming 21 dwellings, and its population, for the same year, was 290. At this stage, the village was beginning to incorporate certain features of modern architecture into its buildings, in terms of the materials used, the allocation of space, and the opening up to the outside world. These are the preliminary results of the inhabitants' contact with urban culture and their return with new ideas and the financial resources to put them into practice. During this period, the outskirts of the village were little affected, as urban expansion was minimal (Kezzar, 2020).

Between 1978 and 1987, the village's population increased by 47, to 337. The village has grown further, recording the construction of 43 new buildings, three of which are public services, and the others private homes. 24 of these are two-story private homes with modern, urban features. They belong to emigrants working in France in particular. During this period, the village's road network developed considerably and was partially tarmacked. The village was connected to the electricity grid in 1984 and a sewage system was installed in 1987. During this period, the village's agricultural land suffered a remarkable decline as a result of urban expansion outside the traditional fabric. (Kezzar, 2020)

Between 1987 and 1998, the village recorded further demographic growth, with a population of 969 in 1998. The village also expanded, with the construction of 20 new dwellings and the extension of several others. This period saw a relative slowdown in urban expansion in relation to the village's agricultural land capital After that, between 1998 and 2008, the village recorded a decline in its population reaching 758 in 2008. The number of new buildings built during this period is 14. The area of agricultural land surrounding the village therefore continued to decline (kezzar, 2020).

Finally, during the period 2008-2022, the population of the village decreased again to 647, and the urban expansion continued with the construction of 10 new residential buildings, most of which were the result of benefiting from the state's program for rural housing. The village was also provided with a potable water network in 2014, and it was connected to the natural gas network in 2015 (kezzar, 2020).

Menades, with its present spatial structure, embodies the state of most Beni Ourtilane villages. The new urbanization model (linear and fragmentary) is gradually replacing the old compact model of the traditional village. Many others changes have accompanied these urban transformations in the water management system.

Climatic characteristics of the study area

Concerning the climate, according to data from the Beni Ourtilane station located 7km from the village, reported by Chouache (2013), the area is characterized by an average annual rainfall of 419.5 mm with a wet period from June to September and a dry period from October to May. According to data from the same station, absolute minimum and maximum temperatures vary between 3°C in January and 32.8°C in August (see Figure. 4 and Table.1). According to older climatic data recorded between 1913 and 1943 at the Genzet station (located 14 km from Menades) reported by the Centre National d'Etudes et d'Analyses pour la Population et le Développement CENEAP (2009), the village is close to an area where annual rainfall is 686 mm, the absolute minimum temperature is -4°C and the maximum temperature is 38°C. A comparison between the rainfall map drawn up based on data from the Guenzet station (1913-1943) and that drawn up by ANRH (national water resources agency) based on more recent data (between 1970 and 1994) shows a decrease of around 100 mm on average per year between the two observation periods.

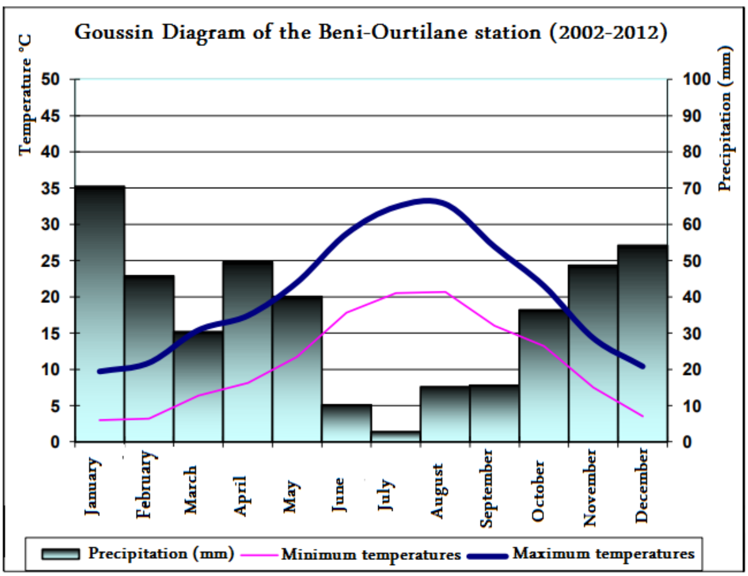

Figure 4: Goussin diagram of the Beni-Ourtilane station (2002-1012) (Chouache, 2013)

Table 1: Temperature and precipitation at Beni Ourtilane station between 2002 and 2012 (Chouache, 2013)

Months	Min temp	Max temp	Average precipitation	Average heat
January	3	9,7	70,5	6,3
February	3,2	10,9	45,8	7
March	6,4	15,4	30,4	10,9
April	8,1	17,4	49,6	12,7
May	11,7	22	40,1	11,2
June	17,7	28,7	10,2	23,2
July	20,5	32,4	2,8	26,4
August	20,7	32,8	15,2	26,7
September	16	26,9	15,6	21,4
October	13,2	21,5	36,4	17,3
November	7,5	14,3	48,7	10,9
December	3,5	10,4	54,2	6,9
average	10,9	20,2	34,9	15

Table 2: Monthly rainfall distribution (mm): Guenzet reference station, according to Seltzer- ONM, reported by CNEAP (2009)

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average precipitation	102	86	72	51	50	28	07	08	38	56	92	99	689

GENERAL SPATIAL STRUCTURE OF MENADES VILLAGE

In general, Menades village consists of the following components: the built environment, road network, cultivated land, uncultivated land (unexploited land bushes), and water sources. A description, composition, and function of all these elements are shown below (Kezzar, 2020) (Fig. 5).

The built environment: The village is composed of 110 buildings, 101 residential or dual-use constructions (residential and tertiary), and 9 constructions for purely tertiary use. The map above shows that Menades shifted from an old compact urban environment to a dispersed or linear new urban fabric. A third hybrid urban form shares the two aspects (Fig. 6).

The old urban environment includes 16 contiguous houses (Kabyle Hara), a mosque, and four isolated houses. Old building materials are entirely local: stone, earth, wood, locally made bricks, hay, etc. An irregular alley of 2.5-3,5 m crosses the village. The latter has branched off two secondary alleys. These three paths connect the Menades to the surrounding farmland and the new extensions.

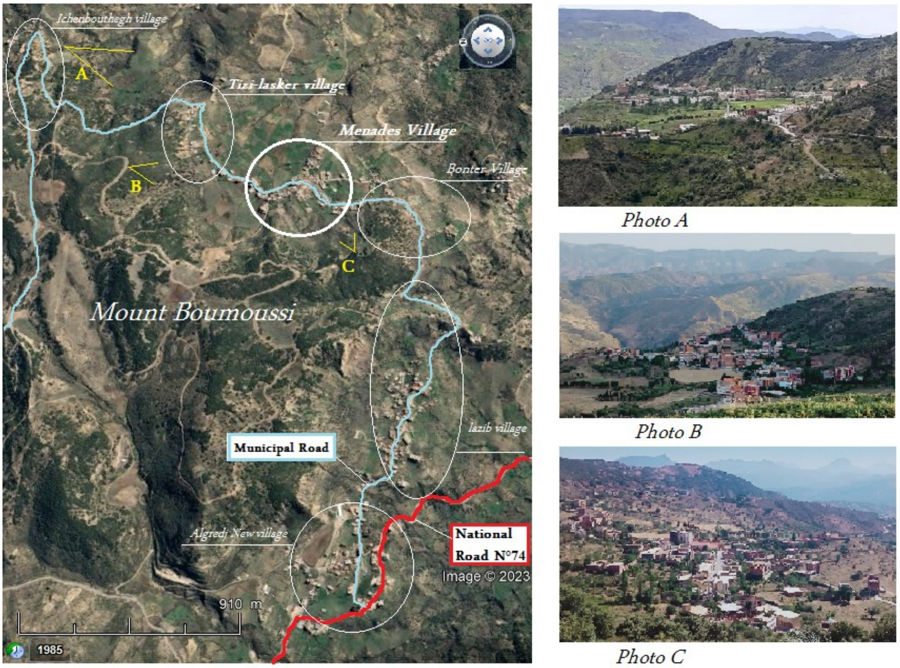

Figure 5: Satellite image of the settlements located on the southern and southwestern slopes of Mount Boumoussi (Google Earth, 2023), treated by authors, Photos A, B and C (Kezzar and Souar, 2023)

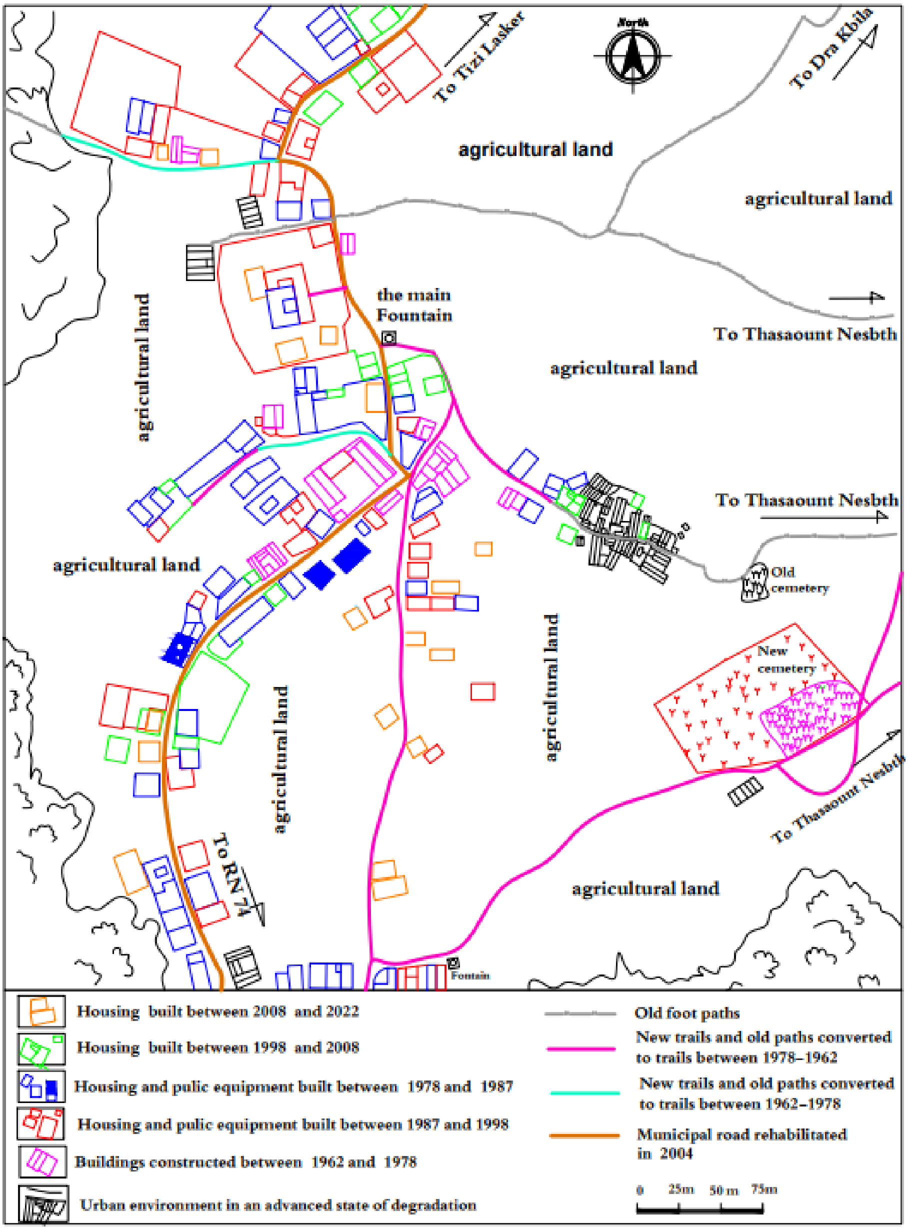

Figure 6: Card of the spatial structure of Menades Village in 2023, (Kezzar and Souar, 2023)

The transitional urban environment, characterized by interweaving aspects of forms and building materials, extends the old and traditional center along the communal road. From a morphological point of view, we note that the model of (Kabyle Hara) is predominant in this case, with little change in dimensions. However, from a constructive point of view, we noticed a partial introduction of some modern materials such as concrete, reinforced concrete, bricks, and modern tiles. This part of the village includes 5 houses, a school, and a trading space.

The new urban environment comprises 82 moderns, multistory houses along the municipal road. This part of the village has public buildings such as the primary school, the mosque, the health center, the municipal office, and shops.

- The network of roads and lanes includes the following:
- Communal Road: asphalted, its width varies between 04 and 08 meters; it connects Menades and several villages to National Road n°74.
- Tracks: unpaved and branching off into paths. Pedestrians and cars use them.

Footpaths: suitable only for pedestrians and animals, linking the village to neighboring farmland, some of which are old, and others are newly created.

Agricultural land

According to their nature of exploitation, these lands can be classified into six categories, namely, orchards, including market garden orchards, fruit tree orchards (figs and olives), wheat and barley fields, land with double management (fruit trees with cereal cultivation or fruit trees with vegetable cultivation), and fallow land.

The bush areas are named by the village's inhabitants *"elghaba",* a site used by the village's inhabitants to graze. This was crucial activity in their life. It was also a source of wood for domestic heating and other activities, such as agriculture and construction. Significant parts of this land were reclaimed but neglected as they became less productive.

WATER RESOURCES AND THEIR MANAGEMENT SYSTEM IN MENADES VILLAGE

The Menades water management system is an integral part of its spatial structure. Thirty to forty years ago, water was an essential element in the economic and social life of its inhabitants, and it is considered one of the primary elements that contributed to maintaining the inhabitants and their children in the village.

In Menades village, water can be extracted through wells, which evolved from a dozen to more than 60 wells. Additionally, a central fountain called the *"thala"* with an average annular flow of 1.5 liters/second and an artesian well was used starting in June 2003. In addition to these resources, there are two rivers with seasonal flow, on which the villagers had little dependence on their water needs. There are also a few permanent springs, some of which have been managed, and others are still in their natural state. The following card

(Fig. 7) describes these resources and their place in the village water use system (Kezzar, 2020).

Wells: The number of wells in the village and its surroundings constantly increases, from 2 to 3 per year. They are used to meet household needs and irrigate seasonal crops during summer. Their depth varies from 3 to 15 meters in most cases. For the artesian wells, there is the public well that has been dug and equipped with a 200 m^2 water tower and a distribution network covering Menades and neighboring village of "*Bonter"* In addition, three other artesian wells have been constructed illegally and serve, like the other wells, to irrigate crops and provide for their households' needs

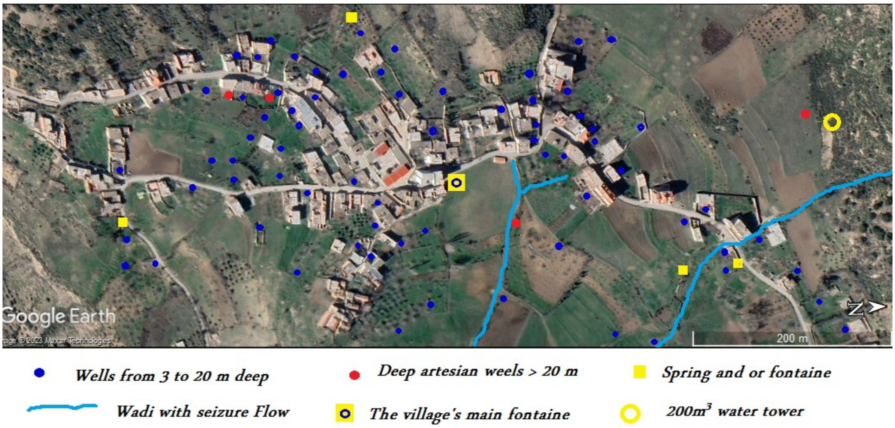

Figure 7: Menades village water sources (Google Earth, 2023), treated by authors

The central fountain *"thala"*

Mentioned above, together with other water resources, was the most prominent factor of stability of the population in this region, as it flows constantly but also for its clean, fresh, and good quality water. *Thala* managed and maintained by the village committee called *thajmath.* The village people developed a *"thala"* in several stages by building structures from the spring to the fountain and crop fields. In what follows, based on the information obtained from the interviews, we will describe these structures as follows.

First, the spring's water catchment is located 310 m from the fountain, 48 m above it. The Menades inhabitants have been using water since the first years of their settlement in the village site with traditional means and techniques. During the summer of 2020, just after the fountain had dried up, the village's inhabitants rehabilitated the catchment by carrying out large-scale earthworks and drugging a well approximately ten meters deep. The well is built with vertically arranged reinforced concrete pipes. It was built to store the water from the spring and bring it to the fountain. This project has cost the villagers a considerable amount of money and much effort (Figs. 8 and 9).

Second, the pipe brings water from the spring catchment area to the *"elkhozna"* structure by the Menades inhabitants, that is to say, the reservoir. It was previously made of stones in a covered gutter, buried and renovated several times using metal pipes, while it was renovated using plastic pipes in 2020 (Figs. 8 and 9).

Third, the reservoir or "*elkhozna*" is an underground structure approximately three meters deep (2.5 x 2.5 m²) built to store water from the spring. After storing the water, it is conducted through a second channel 35 meters long with a diameter of 100 mm to a second reservoir. Before its renovation, this channel was an underground pipe made of stone. The second "reservoir" has almost the same characteristics as the first, but it is shallower (approximately 0.75 m) (Figs. 8 and 9).

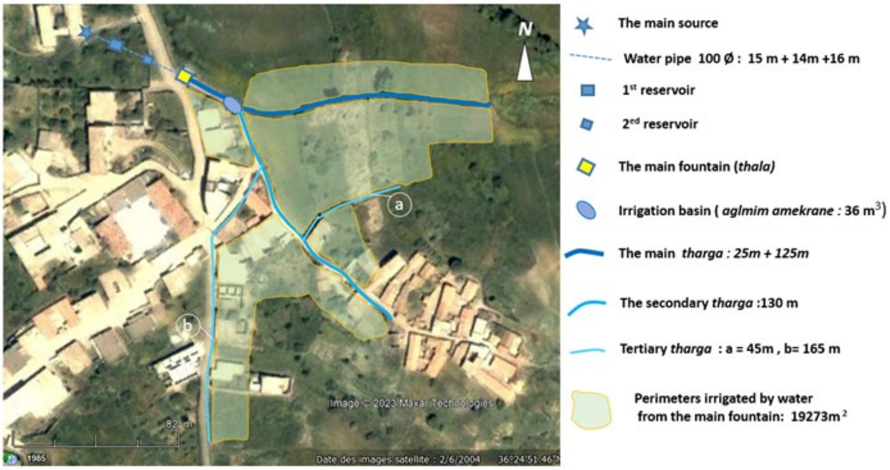

Figure 8: Menades water management system main traditional components. (Google Earth, 2004), treated by authors

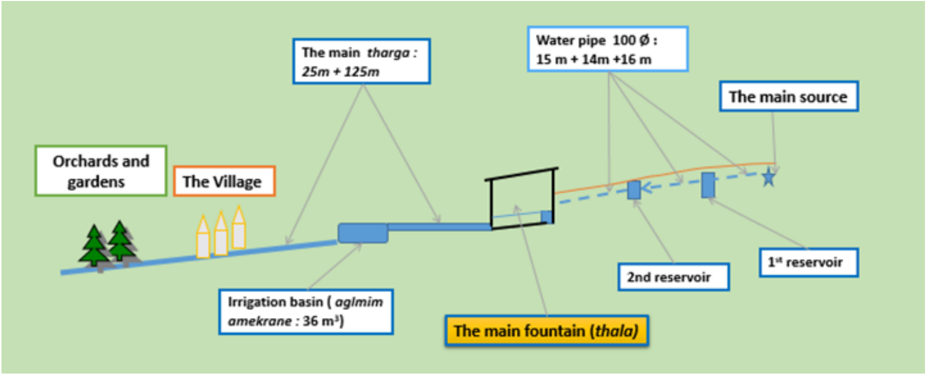

Figure 9: Schematic section showing the components of the traditional water management system at Menades, (Kezzar & Souar, 2023)

Fourth, the building of the *"thala"* fountain is where water from the canal coming from the second reservoir flows out. The end of this canal is called the *"asherchour";* it constantly flows into an inner pool of water called the *"aguelmim".* The latter is used as a reservoir for laundry. During fullness, it flows into a watering trough for cattle such as cows and sheep (Figs.9 and 10). The importance of the *"thala"* is not limited to its functional role but goes beyond. It is a place where the village women meet to wash clothes, fetch water and share conversations about their joys and interests. It is the only daily meeting place for the village's women.

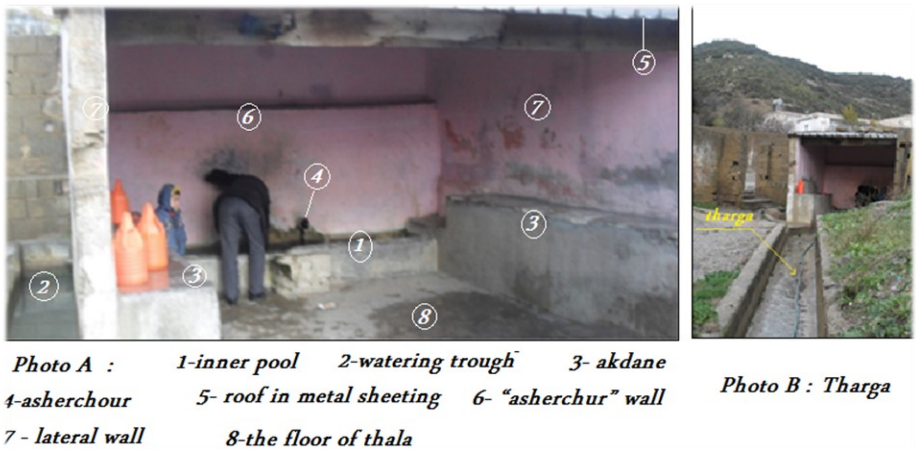

Figure 10: Photo A: view of the inner space of the "*thala*", *photo* B: "*Tharga*" from "*thala*" to the vegetable gardens, (Kezzar & Souar, 2015)

From an architectural point of view, the *"thala"* is a space limited by three walls and, with an average height of 3.5 m, covered with metal sheets. Below the two walls on the right and left, perpendicular to the *"asherchur"* wall where built *"ikdanene"* plural of "*akdane*", that is to say, some longitudinal benches 1.2 m high on which the women put the washing and the buckets. The floor of Thala is made of concrete with a particular slope toward the opposite side of the *"asherchur"* wall so that the water used flows into a shallow stream called *"tharga"*. This stream also receives water from the outdoor pond used for livestock (Figs. 9 and 10).

Fifth, "*tharga"* is a watercourse that brings water from « *Thala"* to a large irrigation basin called *"Aglmim Amqran".* Before its renovation in 2000 with brick and concrete, "*tharga"* was a simple stream created to transfer the surplus of water from the source to a second large external storage basin to irrigate gardens (Fig. 10).

Sixth, the large pool, *"agulmim amqran", is* 28 meters from the fountain. It is two meters deep, 8 meters long, and has an average width of 3 meters. This infrastructure was built of stones and concrete. Additionally, it is used for irrigation. From this large basin, two main streams of "*thirgoi"* plural of "*tharga"* flow into the vegetable and fruit orchards next to the village: one toward the eastern fields and the other toward the southeastern fields. The one heading east is 100% superficial; the second *Tharga* heading south is partially buried. From the latter, two secondary streams "*thirgoi"* branch off (Figs.8 and 9)

During hot and dry summers, *"tharga"* contributes to the softening of the heating atmosphere. This is noticeably felt when passing through the lane leading to the old part of Menades. A pleasant coolness emanates from *"tharga"*, which links this alley to the village entrance, and constant water flow causes green grass to grow. This has noticeably enhanced the village landscape.

Sharing the water from the main fountain to irrigate the vegetable gardens

According to the interviewees, in the late 1980s and early 1990s, Menades inhabitants shared irrigation water according to a system called *"nuba",* that is to say*,* a cycle in which everyone's part is determined according to the land surface and how far it is from the fountain. According to the interviewed inhabitants, the fountain water was controlled by *Sheikh Yahya Hamoudi Athani*, who was invited to the village for several days, especially for this purpose. Imam *Yahya Hammoudi Athani* lived between 1883 and 1972. He is a reformist scholar and eloquent speaker of the Amazigh language, reconciling people and solving their problems and conflicts. He was one of the first pioneers of the board of directors of the Association of Muslim Scholars, founded in 1931.

The cycle of this sharing system consists of 12 days, during which the water collected in the *"aglmim amqran" basin* is renewed both during the night period (from sunset until the return of the cattle in the morning) and the day (from the return of the cattle until sunset). Additionally, the sharing system is based on the principle of rotation, which means that the beneficiary of the day's water in one cycle benefits from the night's water in the next cycle. In 1987, this shared system was abandoned following the removal of the large irrigation basin for public health reasons.

According to our calculations, the area irrigated with water from the main fountain in 1962 was 19,273 m2. The expansion of the village's built-up area gradually reduced this surface area and that of non-irrigated farmland. The Table 3, based on the map of the village of Mendes in 2022 (Fig. 6), shows the surface area of the urban extension during the different phases of the village's evolution and the surface area irrigated by water from the main fountain.

Table 3: The surface area of the urban extension during the different phases of the village's evolution and the surface area irrigated by water from the main fountain.

Period	Built area (m^2)	Area of building extension (m^2)	Area irrigated by main fountain water (m^2)
1962	2837	/	19273
1963-1978	5 839	3002	18 743
1979-1987	14 781	8942	18 009
1988-1998	21 277	6 496	2213
1999-2008	23 203	1 929	920
2009-2023	25 646	2 443	0

The table shows the gradual decline in unirrigated and irrigated farmland in the village from 1962 to the present day. For irrigated land from 1987 onwards, there has been almost total abandonment for the reason mentioned above.

The quality of the water in the main fountain

In the absence of previous analyses of the water characteristics of the main fountain; we will address this aspect of the research based on the results of the analyses we carried out on 18 July 2023 using the IDRES laboratory located in Bejaia. Table 4 summarizes the results of the microbiological analyses.

Table 4: The results of the microbiological analyses of the water from the main fountain

Parameter	Results	Standards	Reference method
Escherichia coli /100ml	➢ 300	Absence	Iso 9308-1/1990
Enterococci /100ml	131	Absence	Iso 7899-2000
Anaerobes S.R /20ml	05	Absence	Iso 6461/1
Anaerobic Spors SR/ 20ml	Absence	Absence	Iso 6461/1

The data in Table 4 show the presence of 3 out of 4 parameters analyzed; this proves that the water of the fountain is of an unsatisfactory microbiological quality. The people interviewed said that in the past the water from this fountain was of very good quality. This change in quality is inevitably due to contamination caused by urban sprawl in the area around the main source.

Evolution of *Menades* water management systems

In short, the current system consists of *thala*, around sixty individual wells, 3 private artesian wells, a public artesian well with a 200m^3 water tower and a distribution network covering the entire village. There is also a sewerage network covering the entire village (Fig.7). Originally, around 1980, the system consisted of a dozen shallow wells, a few springs, and the main fountain with its irrigation infrastructure (fig.8), now abandoned. In what follows, we will discuss the evolution of the system on the basis of information obtained from interviews and observations.

These changes have occurred over the last 40 years. They have strongly affected the water management system in the village. His components and sharing logic were also affected; the large basin has been filled (in 1987) in under the pretext of health prevention. The secondary water stream *"tharga"* that irrigates the village vegetable gardens and orchards on the south side of the fountain is no longer functioning. In addition, even the *"nuba"* system has been abandoned due to changes in the lifestyle of the villagers, which is no longer based on agricultural activity as before. The evolution of other activities has led to a gradual decline in the number of orchards and vegetable gardens, now counted on fingers.

It should also be noted that between 1962 and 1987 there was a slight decline in the irrigated area (from 19,273 m^2 in 1962 to 18,009 m^2 in 1987), due to the spread of the village's built-up area. The urban mutations in the village have also influenced the quality of the water. The results of the microbiological analyses (Table. 4) tell us about the current poor quality of the water in the main fountain. New houses have been built near the spring, increasing the risk of pollution (sanitation water).

According to the people interviewed, the daily domestic consumption of a village family in the past varied between 40 and 60 litres, but nowadays a family's consumption is much higher. L'augmentation des besoins en eau des villageois les a incités à creuser plusieurs puits pour répondre à leurs besoins ; une dizaine de ces puits ont été construits dans une zone proche de la source principale. According to the people interviewed, this is one of the causes of the reduction in flow from Thala. This is pushing villagers to dig deeper wells.

The first work to capture the main spring dates back to the early years after independence. It was the commune's services that took charge of this operation. Subsequently, in order to increase the flow from the main fountain, the villagers undertook work to rehabilitate the infrastructure and tap new springs. The first operation dates back to 1988 and targeted all of the initial catchment infrastructure, as well as the catchment of a second spring located 40 m from the main spring. The immediate results of this operation were an increase in the flow of water coming from the main source and the installation of a new acharchour for the water coming from the second source. Following a period of drought, which led to a reduction in the flow from the first two springs, a second operation was undertaken in 2020, with the aim of tapping a third spring located 333 m from *Thala* and rehabilitating the infrastructure of the second spring. Despite major efforts, this operation produced unsatisfactory results, with almost no increase in flow recorded. According to the people interviewed, this is due to the drought that has been going on for several years (especially for the last 4 years). According to them, the village has never experienced such water stress. Figure 11 shows the two acharchour from the first two sources and the two taps for water from the third source.

The realization of a sewage network concretized the modernization project during the end of the 1980s, which allowed the elimination of the individual septic tanks of wastewater scattered in the village. However, this wastewater is drained and discharged directly into wadis with seasonal flow without any filtration or treatment. It harms the fauna and flora that live there. For example, crabs in the region have become very rare, and one can only blame water pollution.

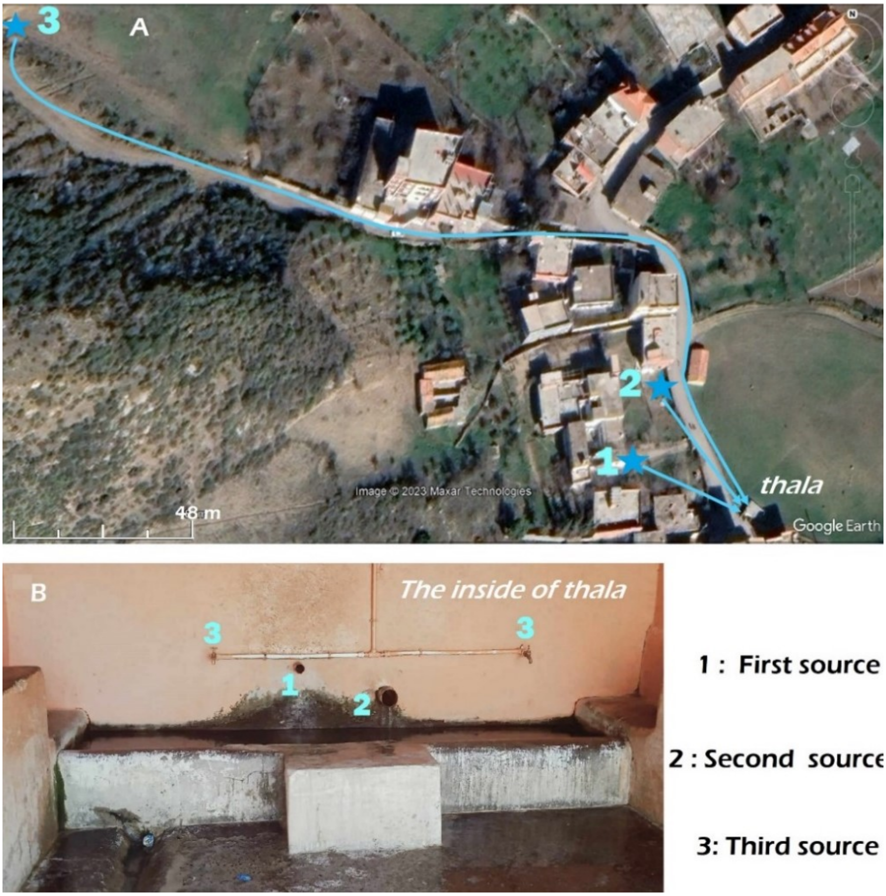

Figure 11: The 3 springs tapped towards *thala* following rehabilitation operations. Photo A : (Google earth, 2020) , treated by authors, Photo B (Kezzar &Souar, 2023)

The modernization of the water management system has also affected the traditional system by adopting a new distribution network consisting of a public artesian well (mentioned above), pumping devices, and water towers. Thus, all houses benefit from tap water with a heating system in most cases. In fact, despite its advantages and virtues, this new system has drawbacks. The lack of management and maintenance opens the door to many abuses and overruns. For example, waste of water (because the service is free), the use of water initially intended for domestic use in agriculture, and the municipality lacks the financial resources needed to be repaired frequently and renew equipment.

The urban expansion of the village (from a surface area of 2837 m^2 in 1962 to a surface area of 25646 m^2 in 2022) has led to a constant increase in impervious areas, which imposes the need to deal with rainwater by creating a specific drainage network. This water causes the deterioration of roads and tracks in winter. It even threatens buildings and agricultural fields.

According to the climatic data cited above (Fig.4 and table.2), the region recorded an annual decrease of around 100 mm between the period of observation (1913-1943) and the period of observation (1970-1994). This is due to climate change, which may continue and worsen in the future. This situation should further alarm the authorities, so that they can take the necessary measures at local and national level.

The abundance of water in this part of the Tellian mountainous region is directly related to rainfall during winter. In dry years, the water distribution system becomes more stringent, leading to quarrels between the villages' inhabitants. These conflicts gradually decrease toward the end of summer and the arrival of autumn due to its moderate temperatures and rainfall.

In the past, drought in the village was associated with certain rituals that were only remembered by the old inhabitants of the village. These are *Anzar* and *Thadla*.

Anzar: This can be described as a procession in which most villagers participate. In this event, they choose one of them - most likely a girl - with certain specifications. She rides a horse and wears an unusual dress, as the procession passes through the main village lane, and the participants repeat the phrase *"Anzar, Anzar, Aterwu Alma dhazar"* and this means, *Anzar,* we ask you to irrigate the land to the roots of the trees. They also pour water over the girl and wet her completely without interruption, according to the stories, until the procession reaches the fountain and the villagers disperse, hoping that their distress will be answered. This ritual is practised from November and December onwards when the autumn falls are late and tillage and sowing activities are disrupted. Abdelkader Khelifi (2003, p. 87) mentioned a tradition similar to *'Anzar'*, which is called the *'Ghandja'* song, which children in western Algeria sing while walking through the streets of villages or neighborhoods when the rain stops and drought prevails.

Thadhla: When the heat summer intensifies and the flow of water begins to drop, the village sages agree to choose one of the village boys according to specific criteria and assign him to put *"Thathla"*, which is a bundle of wheat harvested during the same season, into the *"Thit Agulmim Amekran",* that is to say, the outlet through which the water flows from the Great Basin to that *tharga*. According to oral testimonies, the villagers believe that this action helps to cool the air and lower the temperature. According to the climatic data for the region (Fig. 4 and Table. 1). This ritual is practiced in July and August when temperatures reach maximum values of over 35 C.

CONCLUSION

In this research, we have tried to highlight the particularities of the traditional water management system in the case of a Menades village. We have also tried to identify the transformations (technical, economic and social, etc.) and the development process that have influenced this water management system over the last forty years to become what it is today. In addressing these aspects of the research, we have tried to identify the current difficulties of water management in the village, as well as possible solutions.

In quantitative terms, the water resources exploited and the means of exploiting them have changed significantly over the last 40 years. Before the 1980s, in addition to the main fountain, the village had four springs and a dozen wells no more than 3 metres deep. Today, in addition to the main fountain, the village has four artesian wells (one public and 3 private), over 80 metres deep and more than 60 wells varying in depth from 3 to 20 metres. The village also has a drinking water network and a sewage system.

With regard to water management at the main fountain, the village has passed from a system that gives more importance to the irrigation of vegetable gardens than to domestic consumption to a system focused on supplying drinking water to homes. At present, the irrigated area is nil. Between 1962 and 1986 it fell from 19273 m^2 to 18009 m^2 due to the urban sprawl of the village. In 1987 it fell rapidly to 2213 m^2 following the removal of the irrigation basin and the "*nuba*". In 1999 it had fallen further to 920 m^2. On the other hand, domestic water requirements have increased from 40 to 60 litres per family per day to larger quantities today.

As regards the players involved in managing the village's water resources, before 2003 the collective resources were managed by the village's *"Thajmath",* but from that year onwards the municipal services became involved in managing the water from the public artesian well. The number of consumers rose from 290 in 1978 to 337 in 1987, then to 969 in 1998, then to 757 in 2008, and finally to 647 in 2022.

The results of the microbiological analyses of the water from the main fountain are as follows: Escherichia coli /100ml t greater than 300, Enterococci /100ml = 131, Anaerobes S.R /20ml= 05 and Anaerobic Spors SR/ 20ml= 0. These results allow us to say that these waters are of insufficient microbiological quality. This situation is inevitably due to contamination following the urban expansion of the village in an area very close to the source of the fountain.

Technically, the traditional exploitation of water resources is based on the use of elementary means (manual labour and local materials). As a result, the wells dug are shallow (<3 m). The introduction of new equipment (machines, pumps, jackhammers, etc.) and new materials (concrete, metal, PVC pipes) has enabled villagers to dig deeper wells (between 3 and 20 m) and very deep artesian wells (>80 m) in a shorter space of time.

The climatic data for the region show a decline in rainfall between the two observation periods (from 1913 to 1943) and (from 1970 to 1994) by an amount of 100 mm, which is certainly due to climate change. This situation has worsened over the last 4 years, according to the residents interviewed, which interviewed, aggravating the situation of water stress in the village.

At present, water stress and the growth in domestic water requirements are forcing local residents to find alternatives to the means and resources available. They are digging new, deeper wells, using more expensive means. This depletes their savings and available water resources. The current management of resources and means presents other problems, such as the irrational consumption of water from the public artesian well in summer. This contributes to the drying up of most of the village's wells and springs. This well also poses a problem in terms of the maintenance of its pumping equipment, which frequently breaks down. The proliferation of private wells in the vicinity of the main spring is also one of the reasons for its low flow. In addition, the urban sprawl of the village is creating large areas of impermeable land (2,837 m2 in 1962, 21,277 m2 in 1998, and 25,646 in 2023). This prevents the renewal of the water table and damages the village's road infrastructure, buildings, and farmland.

The challenges and difficulties posed by the current management of water resources in the village of Menades require certain measures to be taken by the various stakeholders, which we set out here in the form of recommendations:

- Villagers must adopt a less water-intensive lifestyle in their domestic and agricultural activities.
- Review the use of artesian wells as a solution for meeting the region's water needs. This solution could be replaced by hill reservoirs and rainwater retention basins.
- The village sewerage system has three rejects that need to be dealt with by the relevant services. This is to prevent pollution of the wadis.
- The effects of climate change felt in the village should be a wake-up call to the authorities to take the necessary environmental, economic, and social measures at the local and national level.
- The Menades village needs to be equipped with a rainwater drainage network that includes the possibility of storing rainwater for use during the dry season.
- The pollution of the water in the main fountain should incite the town planning authorities to be more rigorous in the application of servitudes and the health authorities to be more vigilant.

In short, the results obtained through this research enable us to say that all the objectives set at the outset have been achieved. These results have also helped to answer the questions raised by the research. These results highlight the importance of villagers' relationship to water. They also highlight the sensitivity of these relationships to exogenous and endogenous factors of evolution such as climate change, population growth, technical progress, and the involvement of a new player in management. These results have enabled us to identify the measures that need to be taken to remedy the daily difficulties faced by villagers in their quest to meet their water needs. We consider that the originality of this work lies in the fact that it uses an understanding of the past and the evolutionary process of a specific case to identify its current situation and remedy its difficulties.

Concerning the methodological tools, we used, the following can be noted: through observation, we were able to determine the different water resources and the means of mobilizing them (infrastructure and equipment), and we were also able to limit the perimeters of the area irrigated by water from the main fountain. In addition, the open interviews enabled us to collect data on various aspects: the traditional method of managing water for domestic consumption and irrigation, the operation of *Thala*, the stages in its rehabilitation, the evolution of the means of exploiting water resources, and the current difficulties in managing them. Despite its relative accuracy, the Google Earth

Pro software also enabled us to calculate the approximate surface areas of the irrigated perimeters and the perimeter of the built-up area of the village. Finally, the microbiological analysis of the water allowed us to verify its microbiological quality according to three reference methods.

We also add the idea that studying the water resource exploitation systems of other villages could contribute to a better understanding of our case study. Such studies will enable us to compare and reinforce observations and confirm testimonies. From a methodological point of view, we think that the tools we have used can be used for new case studies, provided that they are adapted to their specific nature. We would also add that the results of our case study cannot be generalized to other villages. This is because, despite the apparent similarities, each village has its specific characteristics (historical, topographical, social, etc.).

Finally, it is important to underline that the challenges presented by water management in the current context of water stress challenge all stakeholders (researchers from different fields, consumers, hydraulic services, associations, authorities, etc.) to work together to forge sustainable solutions that are adapted to different contexts.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

ACKNOWLEDGEMENTS

We would like to express our deep gratitude to all those who contributed directly or indirectly to the realization of this work by providing information or valuable references, especially: Nasli Ammar may God have mercy on him, Khirat Med Arzki may God have mercy on him, Khirat Ferhat, Kezzar Amar, Khirat Abelkrim, Touhami Mohand Akli and Bellili Houria. In addition, we would like to thank the correctors of this work, notably Mr Merzag Abelkader, Dr Kezzar Ramdane and Dr Kari Nabil.

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