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SÉRIE INVESTIGAÇÃO 2015/25

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**Natural characteristics of the Palestinian region of the Jordan Valley**

*Safa´ Hamada*[1]
*António Vieira*[2]
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**Resumo:**

This paper focuses on the study of the natural characteristics of the Palestinian part of the Jordan Valley. The study of the natural factors of the region consists of an array of elements. Location was investigated since it affects the human distribution and activities. Also, the geological structure and the development of the sedimentary rocks of the region were investigated. The geological structure is considered one of the most significant factors that determine characteristics of the region which, in turn, affects patterns of land use. In addition, the geological strata may contain mineral resources that may change the pattern of agricultural land use in the region. Topography of the region was also studied as it governs the soil distribution through the process of erosion and sedimentation. Furthermore, soil characteristics change horizontally because of the differences in the degree and direction of slope. Climate characteristics were also investigated, where each climate element was studied separately, then, the sources of surface and underground water were studied. The study also discussed soil types and vegetation in the Jordan Valley.

**Palavras-chave:** Jordan Valley, Geology, Topography, Climate, Soil, Water resourses.

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**Introduction**

The surface area of Palestine is relatively small, with an extent of about 27,000 square kilometers, but it contains a huge diversity of geomorphological units. Mountains are located in the central part of Palestine (Fig. 1), while the coastal plains exist in the western part (Fig. 2), and the Jordan Valley in the east, and lastly, the Negev desert in the south (Fig. 3). These units extend from north to south, except in the Negev desert unit, which occupies the southern part of Palestine (Fig. 4).

Most of the Rift Valley is below the Mean Sea Level, and its climate is mostly dry and semi-dry. It consists of sub-regions mainly: Al-Holah plain and Tiberias lake in the north, Jordan Valley and the Dead Sea in the middle and Araba Valley in the south.

Fig. 1. Al-Jaleel heights (WAFA INFO, n.d.)

Fig. 2. Akka's plain (Palestinian Archive at Birzeit University, n.d.)

Fig. 3. Negev desert (Tourist, n.d.)

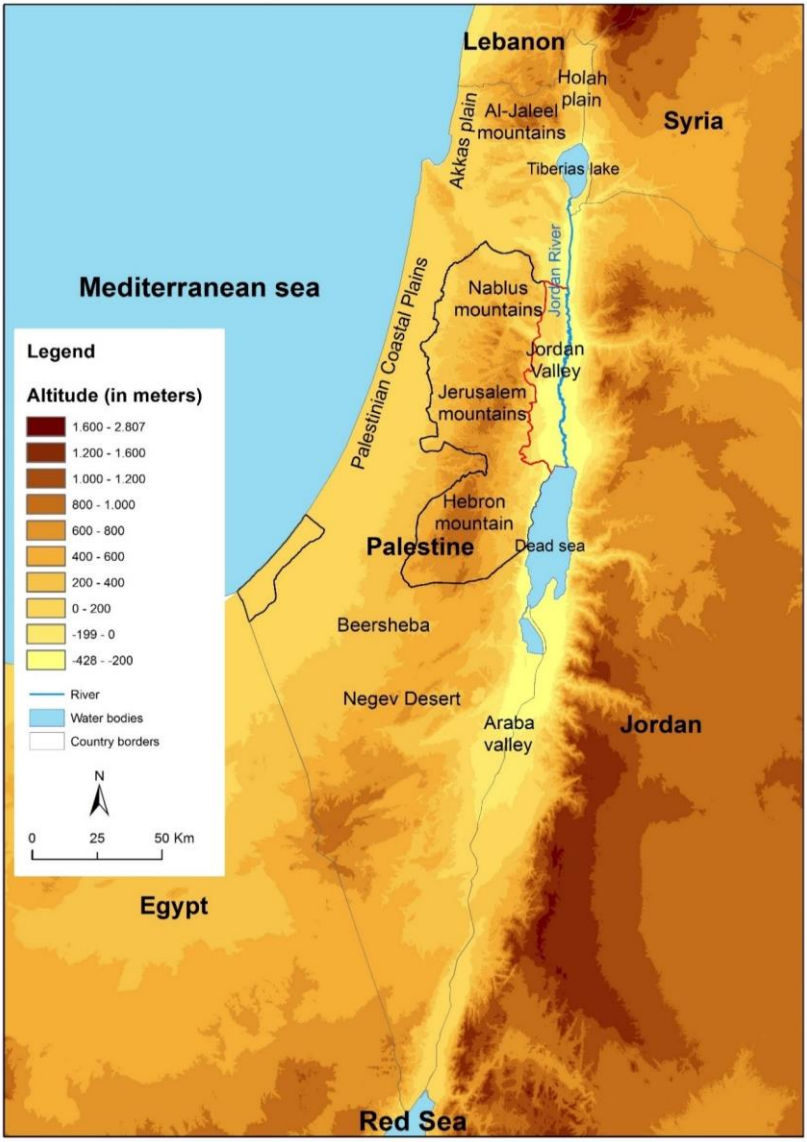


Fig. 4. Topographical regions of Palestine.

**The Study Area**

The Jordan Valley (Fig. 5) extends from Lake Tiberias, located at (212 m) below sea level in the north to the Dead Sea in the south. It is located between the Jordan River in the east and the eastern slopes of Nablus and Jerusalem mountains in the west (Al Quds Open University, Geography of Palestine, 1999).

Geographically, the study area is located between the longitudes (35.29 – 35.66) to the east of Greenwich Line, and latitudes (31.75 – 32.51) to the north of the equator (Hamada, Vieira, & Ghodieh, 2015).

The Jordan Valley is divided into three areas:

• The Northern Aghwar, Ein el Beida, Bardala, Kardala, Marj naja, Al Farisiya, Al Malih, Khirbet ar Ras al Ahmar, Khirbet Atuf, Kharbet Humsa, Az Zubeidat, and Marj al ghazal. The population of this area, according to estimates of the Palestinian Central Bureau of Statistics (PCBS) in 2011, is about 6041(Hamada et al., 2015; Palestinian Central Bureau of Statistics, 2008).

• Central Aghwar: Fasayil, Jiftlik, and Froush beit dajan. The population of this area, according to the estimates of the PCBS in 2011 is about 6124 (Hamada et al., 2015; Palestinian Central Bureau of Statistics, 2009a, 2009b).

• Southern Aghwar: Jericho, An Nuweima, ´Ein ad Duyuk al foqa, ´Ein as Sultan camp, Aqbat Jaber Camp, Deir al Qilt, Deir Hajla, An Nabi Musa and Al ´Auja. The population of this area, according to estimates of the PCBS in 2011 is about 38491 (Hamada et al., 2015; Palestinian Central Bureau of Statistics, 2009a).

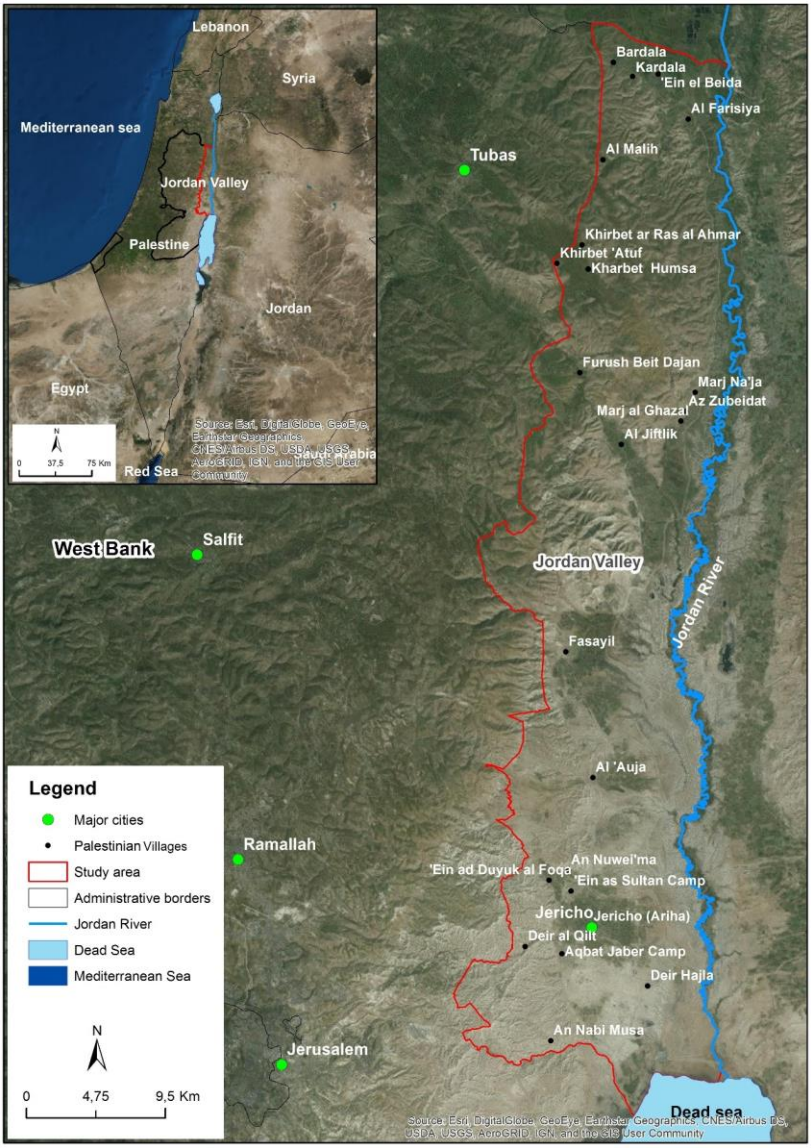


Fig. 5. Location map of the study area

**Geology**

The Jordan Rift Valley was formed many millions of years ago in the Miocene epoch (23.8 - 5.3 Myr ago) when the Arabian Plate moved northward and then eastward away from Africa. One million years later, the land between the Mediterranean and the Jordan Rift Valley rose up, and so the sea water stopped flooding the area (Horowitz, 2001).

The waters formed a narrow, crooked bay, connected to the Mediterranean through what is now the Marj Bin Amer plain. By about two million years ago, as the mountains rose, this bay became an isolated inland sea that submerged the Rift Valley from Lake Tiberias to Wadi Araba in the south.

As the earth cycled through its ages of ice and heat, rain and drought, the shoreline of this lake advanced and retreated. At times, the waters deepened and flooded the rift; at others, they vanished completely. The most recent of these pre-historic lakes, known to geologists as Lake Lisan, formed around 70,000 years ago. At its height, its surface was more than 100 meters above the level of today's Dead Sea. But towards the end of the last ice age, as the climate grew warmer and drier, Lake Lisan began to evaporate faster than it was replenished (Horowitz, 2001).

By about 15,000 years ago the shoreline had retreated to roughly the level we see today, slowly concentrating the salt and killing the plants and animals that lived in the lake. The flat plain that runs along the valley floor is the lakebed, exposed by the retreating waters, and the Dead Sea is all that remains of Lake Lisan (Horowitz, 2001).

The geological and environmental evolution of the valley since its inception in the Oligocene, can be seen in a variety of sedimentary and magmatic rock units look closely at Fig. 6 preserved as continuous sequences in the deeper basins. The outcropping formations around the basins represent alternating deposition and erosion phases.

This dominant physiographic and geologic feature is a 375-kilometer (km) long strike-slip fault zone that affects the climate, hydrology, and anthropogenic activities of the region. -Vertical displacement of the faults of more than 3000 meter resulted in the development of Hula, Lake Tiaberias, Jordan Valley and the Dead Sea (Al-Zoubi, Heinrichs, Sauter, & Qabbani, 2006).

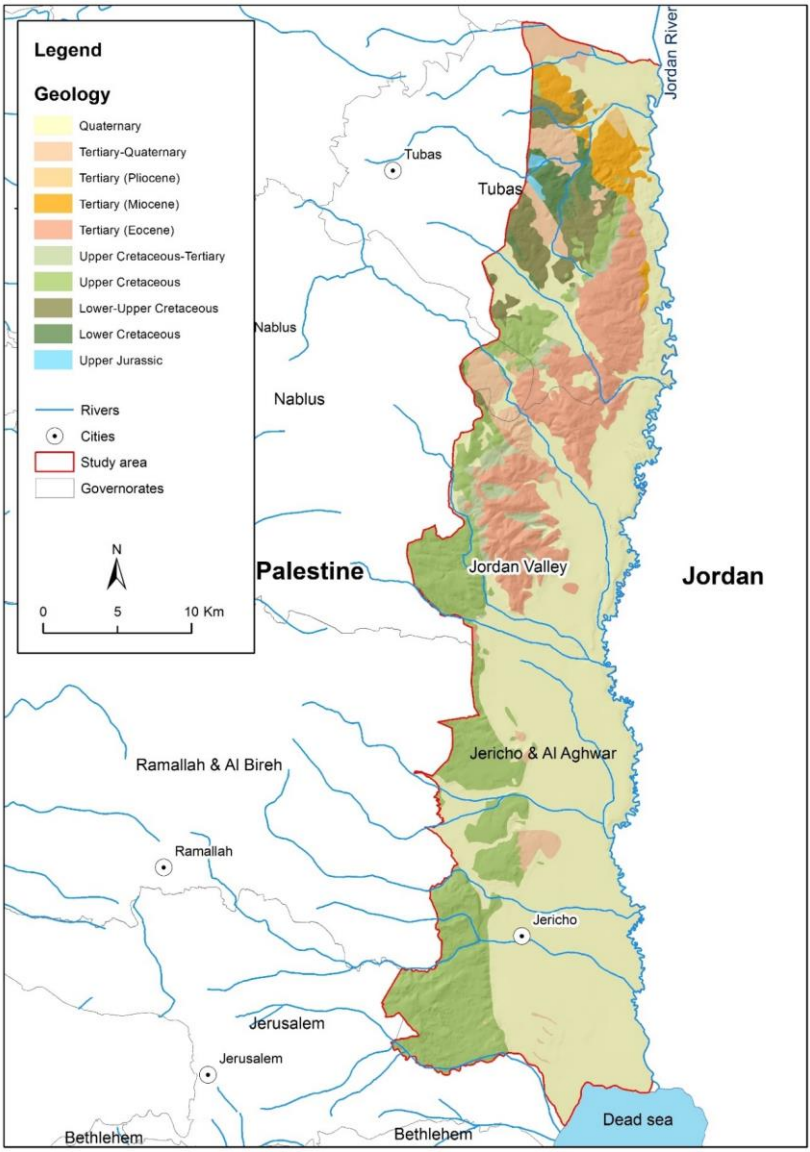


Fig. 6. Geology of the Jordan Valley

From Fig. 6 we can observe that the majority of sedimentary rocks which appear in the Jordan Valley area go back to Mesozoic and Cenozoic, while the oldest sedimentary rocks are deposited in the upper Jurassic, the lower and the upper cretaceous. The oldest rock appear in the eastern slopes of the northern and central highlands of Palestine which have high slope steps and tough rocks, while the youngest rocks appear in flat plains like Al Auja, Jericho, Fasayil, Ein el Baida, Kardala, and Bardala.

Consequently, we can identify a very diverse set of lithologic materials in the study area, which we are going to characterize briefly, according to the representation in Fig. 6

1. Mesozoic configurations

Mesozoic geological formations that appear in the Jordan Valley go back to upper Jurassic and lower/ upper cretaceous, it's as follows:

*1.1. Upper Jurassic*

The oldest rock layers in the Jordan Valley go back to the time of the upper Jurassic, through Fig. 6, note that these formations are found in a small area in the north-western region of the Jordan Valley. These layers consist of multi-colored clay rocks due to the existence of iron oxides. At the end of this Era a significant decline has occurred in the area of east Palestine and in parts of the Arabian Peninsula, which has led to a deposition of limestone and dolomite (Abed, 1999).

*1.2. Cretaceous*

It's divided into upper and lower cretaceous, and the majority of this period's configurations appears on the surface of ground in the west of Jordan Valley at the foot ofthe mountains at the center of Palestine, where Cretaceous is characterized by thick formations.

*1.2.1. Lower cretaceous*

The configurations of this epoch spread in a small area in the north-west of Jordan Valley. The lower cretaceous consists of sandstone, dolomite, marl, sand, shale, clay and sandy limestone. The upper part mostly consists of shale and carbonates formation. The lower part mostly consists of water-bearing sandstone (Buhairi, 1973).

*1.2.2. Upper cretaceous*

Its configurations include cenomanian, turonian, senonian, campainian and maastrichtian that consist of chalk, chert, limestone, and marl. Limestone and chert

layers are prolific aquifers in a big part of Jordan Valley. Wells are highly varying and a large number of them are controlled by cavernous zones in the limestone that are affected by the geologic structure. Flowing wells are common in such areas. Limestone and dolomite layers are prolific aquifers in the eastern and western mountain basins (Abed, 1999).

2. Cenozoic

This era is subdivided into two periods, which are Tertiary and Quaternary. As we can see in Fig. 6, the sedimentary rocks of Cenozoic (Tertiary and Quaternary) cover a large area of Jordan Valley and the majority of this era's rocks appear in the northern, eastern and central parts of it.

*2.1. Tertiary*

It's spread in Eocene, Miocene and Pliocene configurations of Jordan Valley. Jordan Valley was formed in Miocene, and the continental sediment is deposited in Jordan Valley.

The Tertiary sedimentary rocks in the Jordan Valley are divided into two parts, the upper part which includes marl and clay, and the lower part consists of water-bearing conglomerate, sand and gravel. It also consists of chalk, limestone and sandstone (Abed, 1999).

*2.2. Quaternary*

The Quaternary period follows the Neogene period and extends to present. The Quaternary Period is divided into two epochs: the Pleistocene (2.588 million years ago to 11.7 thousand years ago), and the Holocene (since 11.7 thousand years ago to present) (Gibbard, Boreham, K.M. Cohen, & Moscariello, 2007). The Quaternary in Jordan Valley contains sedimentary rocks, which were deposited in Holocene. Alluvial sediment fans are deposited along flanks from aquifers that contain most of the freshwater of the basin (Buhairi, 1973).

**Topography and Landscapes**

The Jordan Valley extends from Tiberias Lake located at -212 m below sea level to the Dead Sea located at -400 m below sea level. The length of the Jordan Valley from north to south is 150 km. The Jordan Valley descends 180 m from north to south, at rate of 1.7 m per kilometer. The study area is the part of Jordan Valley that

extends along the western bank of the Jordan River from the Armistic Line (green line), in the north, to the northern tip of the Dead Sea, in the south. It is approximately 70 km long with a total area of about 400 $km^2$. Elevation of the study area ranges from 200-300m below sea level (The Applied Research Institute – Jerusalem (ARIJ), 1994).

The landscape and topographic conditions in the study area are varied and can be categorized into three types: mountainous areas, foothills, and flat areas.

(1) Mountainous areas are located in the upstream area of Al Far'a Valley. The elevation reaches up to 600 m above sea level.

(2) Foothills cover most of all study area with steep slopes. The elevation of the foothills ranges from 0 to 200 m above sea level.

(3) Flat areas, which are lower than sea level and has relatively high agricultural production lie along the Jordan River. The length of the area is about 10 km and the width is between 1 to 2 km.

**Climate**

The climate in a region is the sum of an array of factors and variables that influence it, so that it differs from a region to another. It is one of the natural elements that affect life and activities of human beings.

The terrain of Palestine is considered one of the most important geographical factors that influence the spatial variations of climate elements. The distribution of rainfall, temperature and humidity takes the form of longitudinal ranges that stretch from north to south and their borders coincide with the boundaries of the terrain and extend in the same direction.

The Jordan Valley, as a natural region in Palestine, has a climatic privacy since it is surrounded by mountains from east and west directions. Therefore, it is far from marine influences that bring winter rains in Palestine.

The study area is highly influenced by the Arid and semi-arid climate Fig. 7, which is characterized by long, hot, and dry summer, and short moderate winter. The climate conditions of the study area is described in the following sections.

The climate of the Jordan Valley is characterized dry, hot summer and warm winter. Freezing and frost rarely occur in the area.

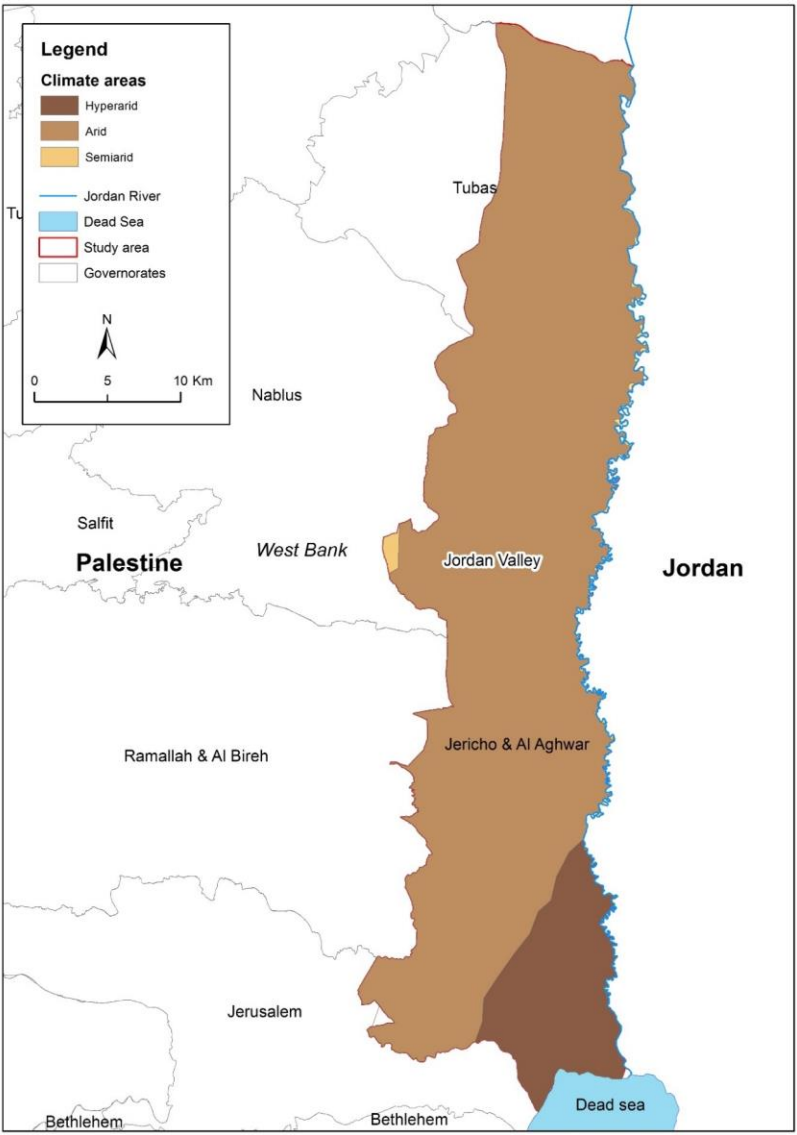


Fig. 7. Climate zones in the Jordan Valley

The most important climate elements that influence the planning of land use are temperature, humidity, winds, rains, solar radiation, and evaporation.

Temperature

Temperature is the main climate element on which nearly all climate conditions depend. It affects air pressure, which in turn affects winds that affect rainfall. In addition, temperature is a measurement of thermal energy that air acquires from solar or terrestrial radiation. Temperature differs from a place to another due to the geographical location, altitude, and the dominating winds (Al-Jawhari, 1981).

The location of the Jordan Valley to the east of the mountain heights prevents the north-western winds from reaching the area. Temperature increases as we move from north to south. From Fig. 8, It can be observed that January is the coldest month of the year (13º), whereas August is the hottest month (32º). The highest values of temperature were recorded during the period between 1988 and 2012 as it reached 48 degrees in August. The lowest values of temperature were registered during the same period in January as it reached 5 degrees in 2008 according to the Palestinian Department of Meteorology ("Climate data for the years 1988-2012," n.d.).

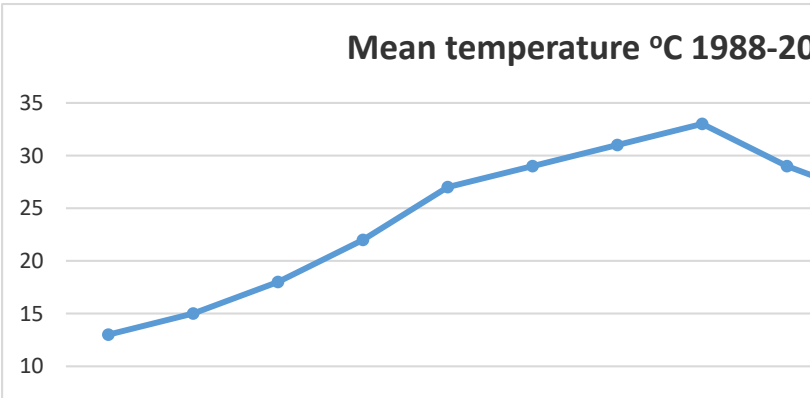


Fig. 8. Mean temperature in the southern part of the Jordan Valley (Jericho)

Rainfall

Rainfall is the main water source in the study area. The major portion of rainfall in the study area is observed in winter, especially between mid-November and March, with marked annual variations. Due to the high average temoerature, potential evaporation rate exceeds the average rainfall (Fig. 9).

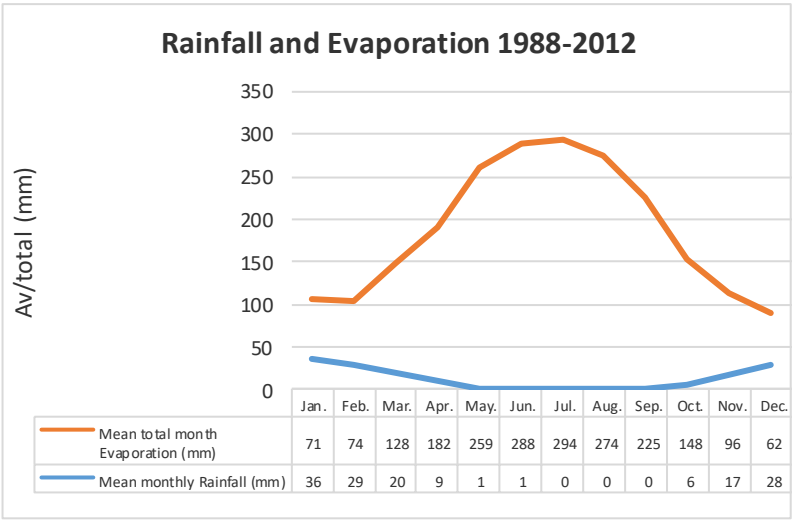


Fig. 9. Rainfall and evaporation in the southern part of the Jordan Valley (Jericho)

Due to the dry climate that dominates the Jordan Valley, the rainfall is characterized by short heavy - raining storms that cause torrents and floods following rain storms in the area.

Rainfall distribution in the Jordan Valley: rainfall decreases as we move from north to south. From Fig. 10 which shows the distribution of rain quantities in the Jordan Valley (Ghour areas), we can notice that the lowest amount of rainfall occurs in the most southern region northern the Dead Sea, reaching 100 mm. The average rainfall increases northward gradually and reaches 375 mm in the eastern slopes. This increase is due to the increase of elevation above sea level.

According to the records of the Department of Metrology in Jericho, which is located in the south of the Jordan Valley Region (Ghour), the annual average of rainfall during the period between 1988 and 2012 was about 147 mm, whereas the rainy days ranged between 20 and 25 days a year. In the northern area of the Jordan Valley region in Bardala, the average of rain during the period between 2009 and 2012 was about 260mm, and the number of the rainy days in the year was between 30 and 61 days.

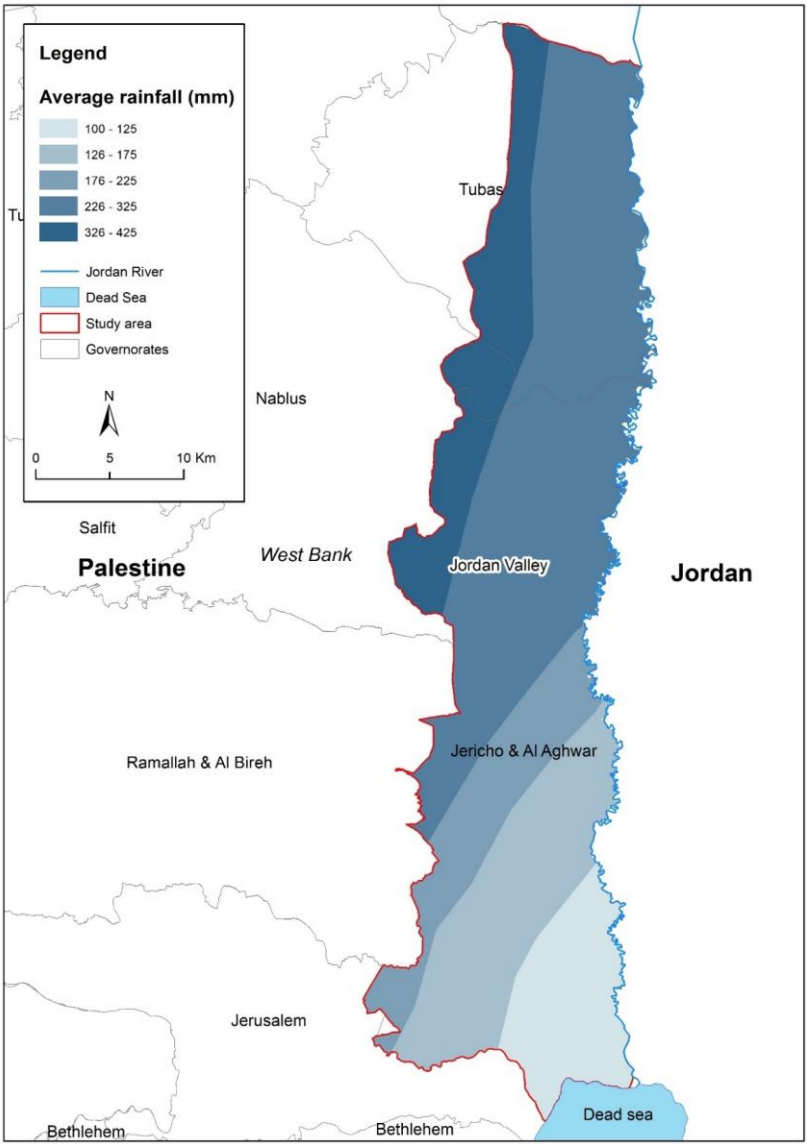


Fig. 10. Rainfall in the Jordan Valley

Wind

The average annual wind speed in the Jordan Valley is approximately 3.27 m/s. The wind direction during the day changes from north-westerly at night to southerly during the morning hours at a speed of 3 m/s. The southern winds from the Dead Sea starts as about 8:00 a.m. until 2:00 p.m. and changes gradually to northerly and north-westerly until it reaches its climax at 6:00 p.m. at a speed of 5 m/s. In spring, the wind speed is between 15 – 20 m/s. However, the average wind speed during the whole year is 12 m/s. From the deserts of Arabia, the hot khamaseen winds blow on the Jordan Valley, carrying dusts and sands ("Climate data for the years 1988-2012," n.d.).

Evaporation

In the Jordan Valley, evaporation is very high because of the high average temperatures, and the western winds that soothe temperatures do not reach the Jordan Valley due to mountain barriers lie to the west of the Valley. Evaporation rate ranges between 1650 mm at the foot of the eastern slopes to 2150 mm in the farthest south of the Jordan Valley. If we look at the evaporation rate in Fig. 11, we notice that evaporation amounts increase as we move to the south and east as a result of higher temperature and lower sea-level.

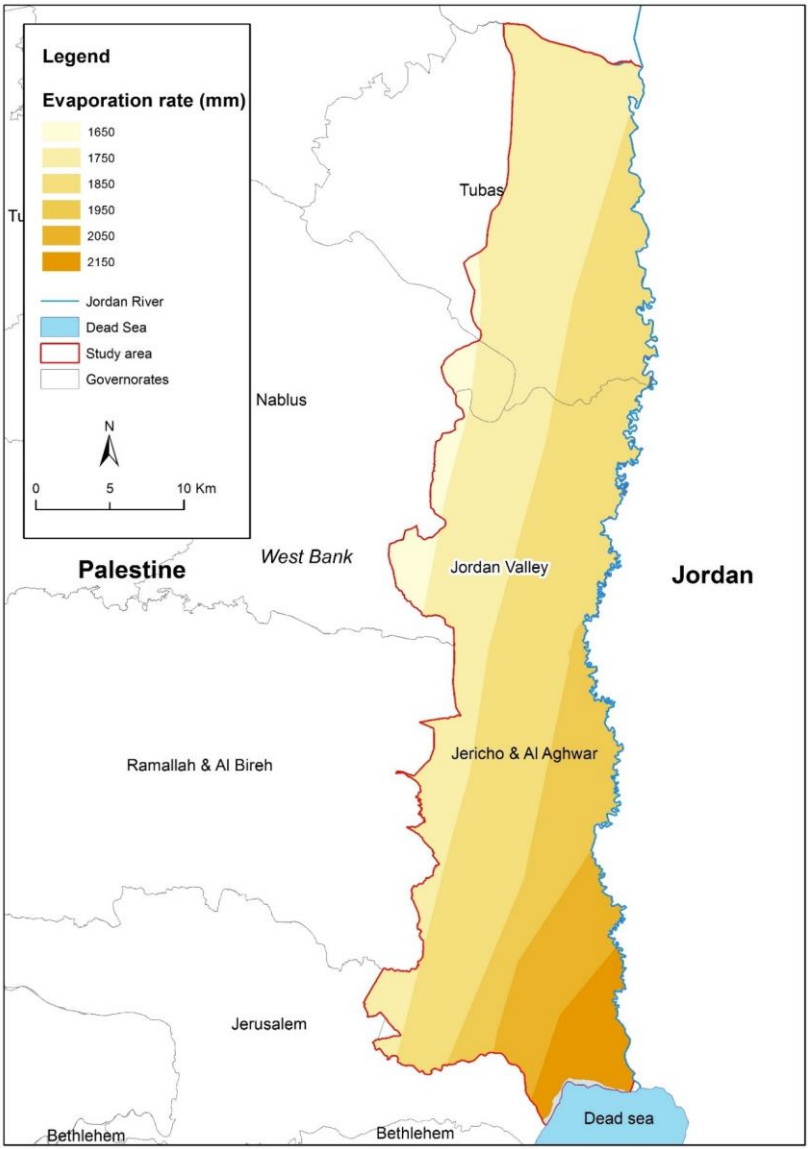


Fig. 11. Evaporation Rate in the Jordan Valley

Relative Humidity

In the southern part of the Jordan Valley near Jericho, the average of relative humidity between 1988 and 2012 is estimated at 51% ("Climate data for the years 2009-2012 for bardala station," n.d.). The highest average was in winter when it reaches 70% during day time and 85% during night. In winter, average of relative humidity ranges between 51 and 67% ("Climate data for the years 2009-2012 for bardala station," n.d.). The relative humidity decreases as temperature rises. In the northern area of the Jordan Valley, in Bardala, average of relative humidity between 2009 and 2012 was approximately 55% ("Climate data for the years 2009-2012 for bardala station," n.d.).

Climate of the study area is extremely dry because of limited rainfall, high temperature and high evaporation. Rainfall is limited during winter to spring, and is scarce in summer. Therefore, most localities in the study suffer from shortage of safe and reliable water supply for domestic and agricultural uses in summer.

**Water Resources**

Study of water resources is essential for integrated planning purposes, because all social and economic issues, land used and land cover depend on water availability. In order to put an effective and integrated urban plan for the Jordan Valley region, it is necessary to analyze the availablity of water resources in some details.

The Jordan Valley is one of the main water resources in the West Bank. It contains surface water of the Jordan River basin, floodwater, and water flowing into the Jordan River from West Bank streams, and groundwater from the eastern part of the mountain aquifer. Amount of these resources varies from one place to another, and from year to year. Water sources are affected by factors of location, topography, geology and climate (Yacoubi & AbdulGhafoor, 2011).

Groundwater

Groundwater is the main source of water in the the Jordan Valley, such as wells and springs. Modern sediments, water reservoir, and Eocene water reservoir are the most important renewable groundwater reservoirs in the Jordan Valley. Amount of ground water in the two reservoirs depends on the amount of annual rainfall on the mountain heights in the eastern basin, which extends from the heights of Nablus, until

Hebron heights. These two reservoirs are fed directly by surface water; in addition to groundwater from mountainous areas (Palestinian Water Authority, 2014).

*The Eastern Aquifer*

Eastern basin (Fig. 21) is one of the most important groundwater resources. It extends along the eastern half of the West Bank; with an area of 2900 square kilometers. Topography of this basin can be divided into three parts: mountainous highlands, eastern slopes, and the Jordan Valley including the Dead Sea. The Palestinians exploit 40% of its water, while Israeli settlers exploit 60%, (Yacoubi & AbdulGhafoor, 2011).

This basin consists of several underground reservoirs that belong to the Pleistocene epoch, Eocene, and Alcinomenaan.

This basin is characterized by high degradation of elevation, from 900 m above sea level in the highlands, to 396 m below sea level in the Jordan Valley. Most of the eastern basin is located within the areas characterized by low average rainfall, while western part of it is located within heavy rains region (highlands of the West Bank). These high lands provide the eastern grundwater basin with about 125-197MCM per year. The Palestinians have 103 wells in the Jordan Valley.

In the Jordan Valley, there are 46 springs or 35% of the total number ofsprings in the West Bank, and their annual average discharge is about 37 MCM.

The most important springs are: Bardala, Far'a, Fasayel, Aldyouk, Nu'ayma, Ain Sultan, Quilt, and others (Palestinian Water Authority, 2010).


Fig. 12. Ground Basins in the West Bank.

*Wells*

The estimated number of macro-Palestinian Wells in the Jordan Valley is about 209 wells; only 89 wells used by Palestinians, (Fig. 13), due to .

1. Old wells: drilled in the early fifties.
2. Shallower depths wells: well depth is of no more than 200 meters.
3. Low water levels with high salt rate.
4. Israeli occupation prevented the Palestinians from the rehabilitation of these wells.
5. Israel drilled several deep wells; (of which 27 wells with high production capacity in the Jordan Valley), which affected the Palestinian wells (Palestinian Water Authority, 2014).
6. Israel produces about 32 MCM from these wells annually, most of which is designated for Israeli colonies (coloneis) and a small portion of which is supplied to the Palestinian villages. Israel also supplies colonies with water for agricultural use in the Jordan Valley without consideration of the Palestinian localities need (B'Tselem, 2011).

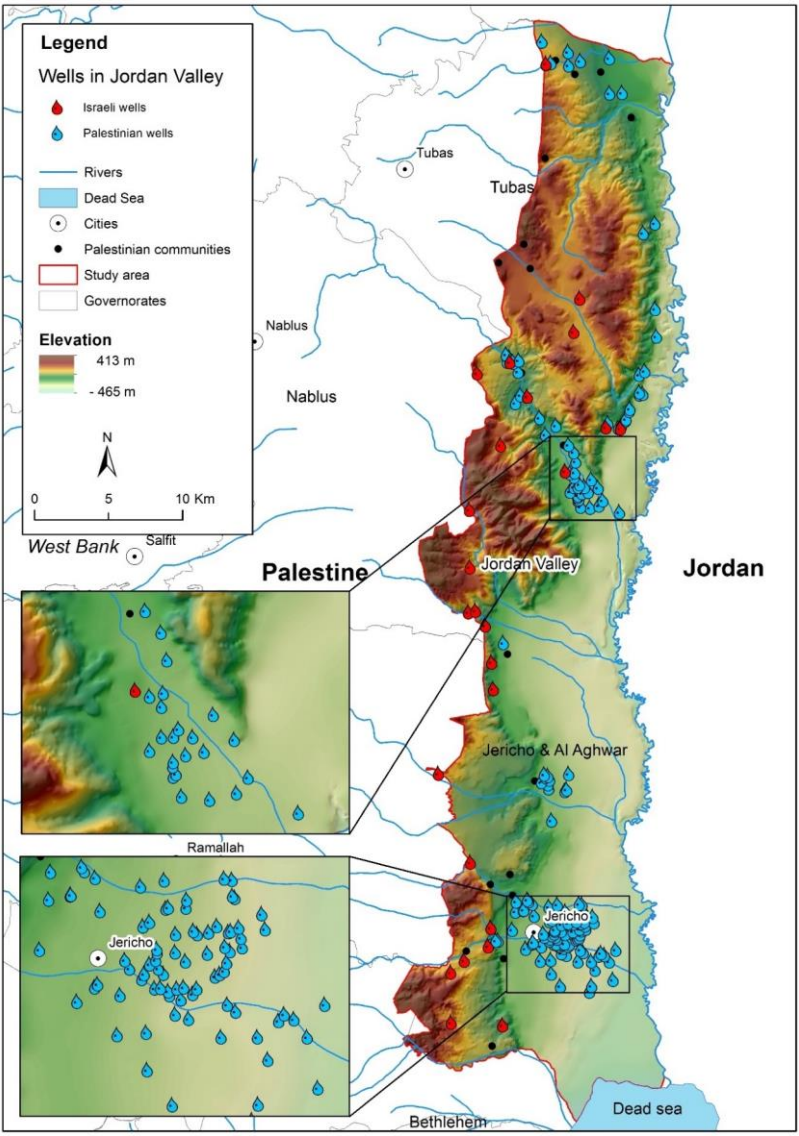


Fig. 13. Groundwater wells in the Jordan Valley

*Springs*

Springs are the second largest water source and are mainly used for agricultural irrigation (Rumman, 2010). Springs flow in many areas, the number of major springs is 22 springs, and their water feed from the mountain aquifers Fig. 14. The estimated overall water flow of these springs is about 44 MCM / year. Water from these springs is used for agricultural and drinking purposes. There is a group ofsprings known as "springs Alvchkha" which has a discharge rate of between 80-100 MCM / year. Springs discharge rate varies from one season to a nother depending on rainfall rate on the surrounding mountains. Springs have had a particular importance in the Jordan Valley. Due to the agricultural based economy of many Jordan Valley communities, 87 % (or 25.3 MCM) of the total amount of spring water was consumed by agriculture, and only 13 % (or 4 MCM) were given for domestic consumption (Palestinian Water Authority, 2010).

Springs in the Jordan Valley have both decreased in discharge and quality. Along with old spring canals, the flow is expected to drop further 25 -30 % (Rumman, 2010).

Recent findings of the Palestinian Water Authority in the Water Supply report (2010) alerts of high levels of chloride concentration (from 25 to 1,000 mg/l) and high levels of salinity in springs. Most of the affected springs are located in Jericho Governorate. Due to the excessive extraction from the Mountain's aquifer, water table has declined and risks further intrusion of salty water (Palestinian Water Authority, 2010).

Agricultural wells are an important irrigation source in the Jordan Valley and represent 39 % of the total local resources. However, their number has decreased from 774 in 1967 to 328 in 2005, where only 250 are operational. The springs are decentralized and individually owned (Palestinian Water Authority, 2010).

Other possible environmental threats to groundwater quality is wastewater dumping from Palestinian areas and Israeli colonies that are not connected to any sewage networks (Isaac,J., Gigliol, I., & Hilal,J., 2009).

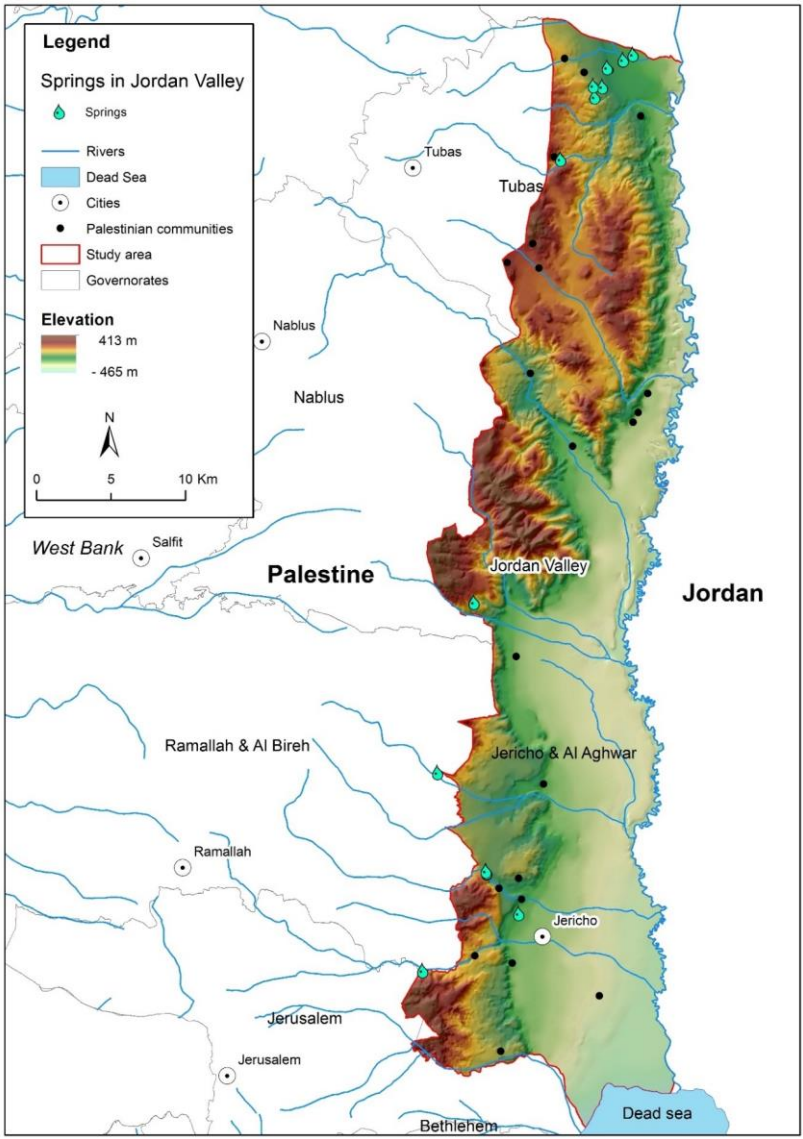


Fig. 14. Springs in the Jordan Valley

There are 34 Israeli colonies established in the Jordan Valley with a population of 10512 settlers. Colonies are characterized by unsustainable water consumption. 100 liter per a person/day is a sustainable level of water consumption, according to the World Health Organizations definitions. Colonies in the Jordan Valley are using between 300 - 400 liter of water per person/day (Office for the Coordination of Humanitarian Affairs (OCHA (Office for the Coordination of Humanitarian Affairs)., 2012). This constitutes more than 5 times the Palestinian allowance (Ma'an Development center, 2011). Further, many springs and wells in the Jordan Valley have been taken over by settlers and colonies expansion (OCHA (Office for the Coordination of Humanitarian Affairs), 2012).

Surface Water

Surface water in Jordan Valley (Fig. 12), is represented by the water running in the valleys in winter. The total sum of flowing water from floods in the valleys in West Bank is estimated around 110 MCM/year, which forms an important source if it's harvested well..

*Jordan River*

Israel and Palestine share the Jordan River with three other riparian countries: Lebanon, Syria, and Jordan. Israel and Palestine also share groundwater aquifer basins, three in the West Bank, and one in the Gaza Strip extending along Mediterranean coast.

The headwater of the Jordan River at an altitude of 2200 m above sea level (Hasbani, Dan and Banias rivers) lie in Lebanon, Israeli occupation and Syria. These rivers meet to form the Upper Jordan River, which flows into the Lake of Tiberias. After leaving Lake Tiberias, the lower Jordan River forms the boundary between Palestinian territory which was occupied by Israel in 1948 and Jordan, and then between West Bank and Jordan (Jordan Valley) before flowing into the Dead Sea at an altitude of about 350 m below sea level, (Fig. 12). The total flow amount of the Jordan River varies between 1287 MCM/year and 1671 MCM/year. Israel withdraws water from the north-western portion of Lake Tiberias and transports it out of the Jordan River Basin through its National Water Carrier, where Israel pumps about 500 MCM from the river through this carrier to the coastal cities and Negev Desert. Palestinian legal share of the Jordan River is about 257 MCM annually, according to Johnston's plan in 1955. Although, Israel has denied Palestinians access to the entire Lower Jordan River

since 1967 (Trade and environment database (DET), 1993). After the Six Day War in 1967, Israel declared the Jordan Valley a “closed military zone”, to which the Palestinians have been denied access (Attili, 2004).

The total air length of the river is approximately 140km; while the real length with the meanderings is about 350 km, and the estimated drainage area is about 43500 km² (Attili, 2004).

*Sub Valleys (Fig. 15)*

Table 1: Drainage of the main valleys in the Jordan Valley

| Valley name | The rate of annual flow (Million cubic meters) |
|---|---|
| **Valley al-Maleh** | 1.0 |
| **Valley Nu'ayma** | 1-2 |
| **Valley Fara** | 3.5-11 |
| **Valley al-ahmar** | 1-2 |
| **Valley Ouja** | 2-3 |
| **Valley Qelt** | 3-11 |

(Yacoubi & AbdulGhafoor, 2011)

From Table 1 it's clear that the annual flow rate of valleys in Jordan Valley vary from a valley to another, and it can be seen that Al-Fara'a and Al-Qalt valleys contribute by the highest flow rate of water, where Al-maleh valley has the lowest flow rate. Water of these valleys is often drawn from the springs that have different discharge values.

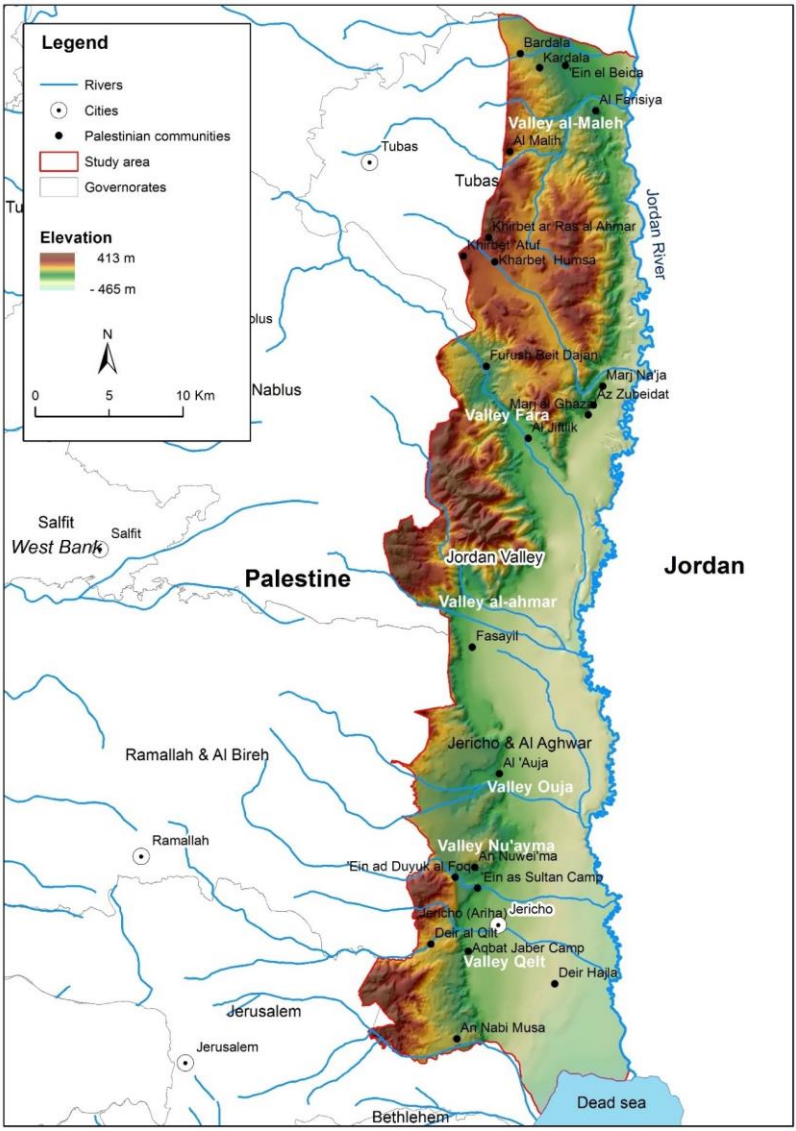


Fig. 15. Jordan River and sub valleys

**Soil**

Soil is formed from rocks of place and of that brought by wind or water. Glaciers of the last ice age acted as giant bulldozers pushing truly huge amounts of soil along as they grew, and dropping soil as they melted (Shawawrah & Hallaq, 2012).

Types of soil present in the Jordan valley

Fig. 16 shows that the Jordan Valley area contains the following soil types:

*Terra Rossa*: It's a type of red clay soil produced by limestone weathering. When limestone weathers, the clay contained in rocks is left behind, along with any other non-soluble rock material. Under oxidizing conditions, when soils are above the water table, iron oxide (rust) forms in the clay. This gives it red to orange color. Terra Rossa is typically found in regions with a Mediterranean climate (Abed, 1999).

This soil is characterized by a set of characteristics which are:

1. The color of this soil is red to light brown and rich with mud.
2. Terra Rossa is thick in valleys and plains, and thin on slopes.
3. It contains high amount of moisture, mineral substances, and lime. But it contains low organic matter. This soil is suitable for growing crops of wheat, grapes, olives, almonds and apple (Abed, 1999).

*Brown Lithosols and Loessial Serozems*: This type of soil association is found on steep to moderate mountain slopes, in the areas of southwest of Aqbat Jabber Camp and northwest of Nuwe'ma, covering an area of about 4670 hectares. The soil is originally formed from limestone, chalk, dolomite and flint.

The major vegetation types found on this soil are Anabasis articulate and Zygophyllum. The current land use is restricted to winter crops grown by Bedouins in some wadis (Dudeen, Lacirignola, Montanarella, Steduto, & Zdruli, 2001).

*Loessial Sernozems*: This type of soil association dominates the areas of Nuwe'ma, north of Al-Auja and south of Aqbat Jaber camp covering an area of approximately 4920 hectares. This soil is typical of plateaux and moderate slopes. The soil parent materials are loessial sediments, gravel and highly calcareous loamy sediments. Its major vegetation cover is an association of the Hammada scoparia. Most of the area covered by this soil is used for grazing, and only part of it is used for dry farming. There are also some irrigated orchards (F Bender, 1974).

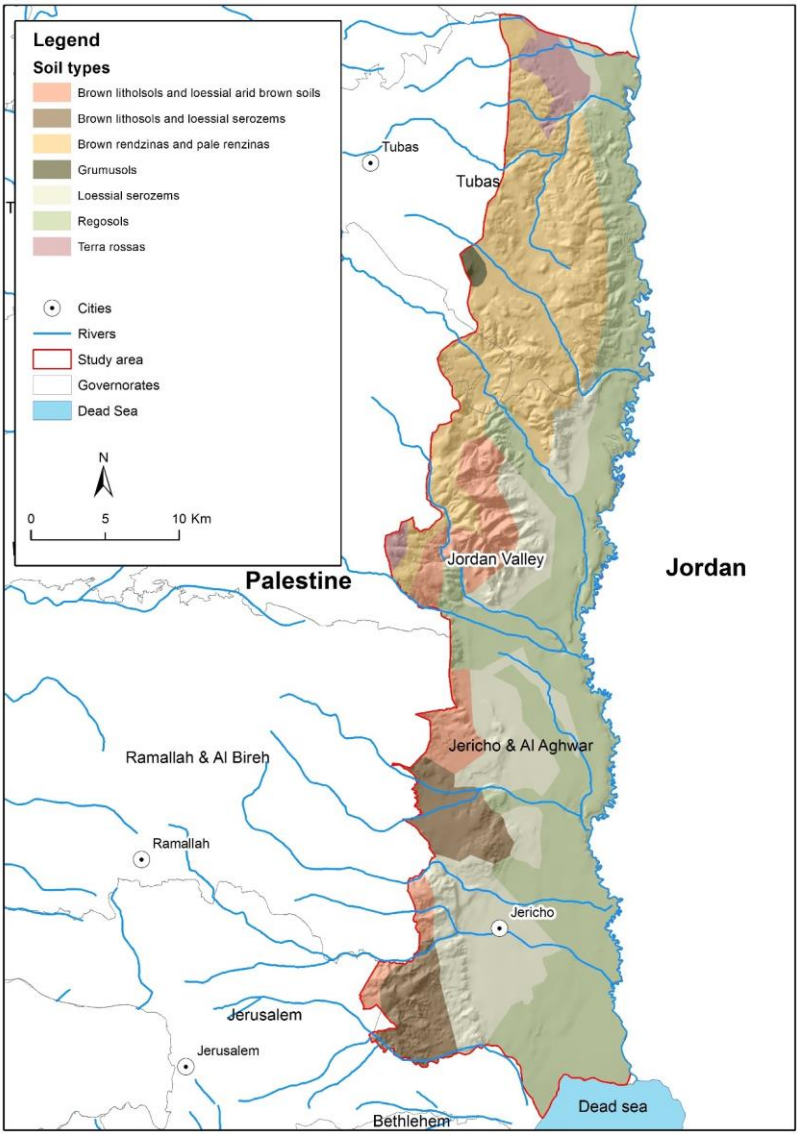


Fig. 16. Soil Types in the Jordan Valley

*Regosols*: This type of soil association characterizes the eastern border of the Jordan Valley. It is found as badland along terrace escarpments in the Jordan Valley,

covering an area of approximately 8880 hectares. The soil parent materials are sand, clay and loess. The soil dominant vegetation covers are Anabasis articulate, Salsola vermiculata and salsola tetrandra, and are used primarily for grazing (Al-shawawrah, 2003).

*Brown lithosols and loessial Arid Brown Soils*: This type of soil association characterizes the western part and covers an area of approximately 2410 hectares of the Jordan Valley. These types of soils are mainly found on steep rocky and eroded slopes. Brown lithosols are found among the rocks, while Loessial arid brown soils are found on flat hilltops, plateaux and foot-slopes. The parent rocks of this soil association are chalk, marl, limestone and conglomerates. Its major vegetation cover is Artemisia herba-alba (Dudeen et al., 2001).

*Brown Rendzinas and Pale Rendzinas*: This type of soil association characterizes in the northwestern part of the Jordan Valley. Rocky outcrops in these soils cover between 30-50%. Major vegetation cover includes Pinus halepensis, Pistacia lentiscus, Pistacia palaestina, Quercus ithaburensis, Ceratonia siliqua and Ballotalia undulatae. On such areas, cultivation of grapes and olives, field crops (wheat and barley), and grazing are the main land uses, especially in shallow and steep slopes areas (F Bender, 1974).

Soil problems in the Jordan Valley

In the Jordan Valley, the main soil problem is soil salinity. Soil salinity increases with time, and this is due to several reasons: the nature of soil parent material and its underlying substratum composed of lacustrine deposits; the climate which motivates large amount of evaporation leaving larger concentrations of salt in soil. Irrigation also leads to the creation of more saline soils. Salinity has negative impacts on vegetation (Dudeen et al., 2001).

The other soil problem is soil erosion in highlands of the Jordan Valley. The lack of vegetation due to the high temperature and low amount of precipitation, accelerates the desertification process.

**Vegetation**

Vegetation in the Jordan Valley and factors affecting its diversity:

Spread of vegetation is associated with natural factors, such as climate, topography, and soil. These factors are considered the main determinants of vegetation diversity and density in the Jordan Valley.

*Natural vegetation*

Natural vegetation in the Jordan Valley is divided into two main groups:

- Herbs and weeds (Fig. 17)

They are spread in most parts of the Jordan Valley, because they do not need large amounts of water. It is spread in plains and mountainous areas, either independently or together with other vegetation types such as forests and trees.

The most widespread herbs found in the Jordan Valley east Jericho and north Dead Sea are Natish (Sarcopoterium spinosa), Ghaisalan (Urginea martima), Zohhaif, Nafal, and there are some kinds of herbs that have waxy leasves that resist transpiration. They include Al-Bahmeh (Stipa capensis), Nafal, Handaquq, Al-khubaizah (Malva praviflora), and other herbs such as, Athbeh, Sa'raneh, and Ajram. The grazing season is primarily winter due to the warm climate. In the summer, farmers seek hilly areas where water and vegetation are more abundant and the weather is cooler (The Applied Research Institute – Jerusalem (ARIJ), 1994).

Fig. 17. Herbs and weeds in Jordan Valley region

- Forests

In the Jordan Valley there are a group of forest belonging to the Sudano Deccanian Enclaves climate, with more humidity and high temperatures on the banks of rivers and valleys. The plants present on this region are Zizyphus spina-christi, Lycium shawii (Awsaj), Acacia spp. Just in the rift valley these trees form forests or groups of trees. Rainfall ranges from 100-200 mm / year. Water flows from the Jordan River and springs has made the environment wet at the banks of the river and at the oases around the springs. Soil is mainly composed of volcanic soil (Regosols), but the soil of forests is Alluvial and Brown formed from deposits of all types of soils by water flowing from the river, springs and valleys (Abu Ayyash (Brigat) et al, 2007).

*Agricultural*

Jordan Valley has been historically an ideal place for agricultural activities. This is due to the valleys right all-year conditions and its rich soil and water resources, particularly fresh water from springs. This is the condition that made rural communities flourish in lush landscape and long fields of citrus fruit.

This zone is the most important irrigated area in the West Bank. Hot summers and warm winters characterize the climate of this region. The availability of both springs and groundwater makes this area most suitable for off-season vegetables and for semi-tropical tree plantations, including bananas and citrus. All strains and varieties of dates palm trees are still in existence. Citrus orchards with special taste and early ripping season are remarkable in the Jordan Valley. Recently, early grape strains began to take place as an economical cash crop. However, without access to water, this region would be a desert (Isaac & Hrimat, 2007).

However, during the past two decades the valleys farmers experienced how the spring water availability rampantly decreased. The main reasons of this are the political situation between Israel and Palestine that has left Palestine with an unequal share of natural resources and disempowerment for preventive action due to the strict permission system in the valley, weak agricultural institutions and climate change (large annual fluctuations, drought and increased maximum air temperatures). The only additional irrigation source for Jordan Valley's farmer is the private wells that were dug during Jordanian rule, prior to 1967 (The Applied Research Institute – Jerusalem (ARIJ), 1994).

Agricultural lands in the Jordan Valley contain three main groups of plants: Vegetables, which includes Tomato, Squash, Eggplant, Cucumber, Maize, Okra, Spinach, and others. Fruit trees, which includes Date, Banana, Lemon, Grape, Orange, etc. Field crops, which includes Wheat, Barley, Clover and others. The cultivated areas covered approximately 49.27 $km^2$ in 2008.

Table 2: Cultivated Areas of Fruit Trees, Vegetables and Field Crops in the Jordan Valley for the Year 2007/2008 ($km^2$)

| | | | |
|---|---|---|---|
| **Fruit Trees** | Unbearing | Irrigated | 3.12 |
| | | Rainfed | |
| | Bearing | Irrigated | 3.78 |
| | | Rainfed | |
| **Total** | | | 6.90 |
| **Vegetables** | Protected Irrigated | 1.86 | |
| | Open Irrigated | 35.07 | |
| | Rainfed | | |
| **Total** | | 36.93 | |
| **Field Crops** | Irrigated | 5.44 | |
| | Rainfed | | |
| **Total** | | 5.44 | |

(Palestinian Central Bureau of Statistics, 2009a)

From Table 2, we can see that vegetables occupied a large area of the cultivated area in the Jordan Valley. Due to the limited rainfall combined with the hot weather, irrigated agriculture is dominant in the region.

*Vegetables (Fig. 18, Fig. 19, Fig. 20)*

Table 3 shows that the total area of cultivated vegetables in the Jordan Valley in 2007/2008 is 36.93 $km^2$. The dominant types are squash and eggplant covering an area of 10.61km2 and 5.91 $km^2$ respectively.

Table 3: Area of Vegetables in the Jordan Valley by crop and type 2007/2008 ($Km^2$)

| Crop | Surface Tunnel | France Tunnel | Plastic House | Irrigated | Rainfed | Total Area |
|---|---|---|---|---|---|---|
| **Squash** | | | | 10.61 | | 10.61 |
| **Eggplant** | | | 0.004 | 5.91 | | 5.914 |
| **Maize** | | | | 5.13 | | 5.13 |
| **Tomato** | | 0. 003 | 0.31 | 4.27 | | 4.583 |
| **Cucumber** | | 0. 004 | 0.78 | 1.36 | | 2.144 |
| **Kidney bean (green)** | 0.004 | | 0.28 | 1.42 | | 1.704 |
| **Jew's Mallow** | | | 0.030 | 0.87 | | 0.90 |
| **Paprika** | 0.002 | | 0.29 | 0.60 | | 0.892 |
| **Cauliflower** | | | | 0.88 | | 0.88 |
| **Broad bean (green)** | | | | 0.81 | | 0.81 |
| **White cabbage** | | | | 0.80 | | 0.80 |
| **Okra** | | | | 0.57 | | 0.57 |
| **Snake cucumber** | | | | 0.48 | | 0.48 |
| **Pumpkin** | | | | 0.45 | | 0.45 |
| **Hot pepper** | 0.002 | | | 0.43 | | 0.432 |
| **Water melon** | | | | 0.14 | | 0.14 |
| **Kidney bean (yellow)** | | | | 0.14 | | 0.14 |
| **Muskmelon** | | | | 0.09 | | 0.09 |
| **Gourd** | | | | 0.08 | | 0.08 |
| **Spinach** | | | | 0.05 | | 0.05 |
| **Others** | | | 0.16 | | | 0.16 |
| **Total** | **0.008** | **0.007** | **1.854** | **35.09** | | **36.95** |

(Palestinian Central Bureau of Statistics, 2009a)

Fig. 18. Greenhouses where different kinds of vegetables are produced

Fig. 19. Production of vegetables

Fig. 20. Field for production of vegetables

*Fruit trees (Fig. 21, Fig. 22, Fig. 23)*

The total cultivated area in 2007/2008 was approximately 6.903 $km^2$. As we can see from Table 4 the total area of cultivated dates trees are the largest (3.457 $km^2$), and area of Banana trees comes in the second place (1.680 $km^2$), because climate in Jordan Valley is suitable for the growing of these kinds of trees.

Table 4 Area of Fruit Trees in the Jordan Valley by Crop and Type for the Year 2007/2008 ($km^2$)

| Crop | Unbearing (Fruitless) | | Bearing | | Total Area $km^2$ |
|---|---|---|---|---|---|
| | Irrigated | Rainfed | Irrigated | Rainfed | |
| **Date** | 2.166 | | 1.291 | | 3.457 |
| **Banana** | 0.400 | | 1.280 | | 1.680 |
| **Lemon** | 0.230 | | 0.409 | | 0.639 |
| **Shammoty Orange** | 0.100 | | 0.224 | | 0.324 |
| **Grape** | | | 0.311 | | 0.311 |
| **Clement** | 0.045 | | 0.045 | | 0.090 |
| **Navel Orange** | 0.035 | | 0.053 | | 0.088 |
| **Olive** | | | 0.085 | | 0.085 |
| **Pomegranate** | 0.080 | | | | 0.080 |
| **Mandarin** | 0.023 | | 0.026 | | 0.049 |
| **Poppy** | 0.017 | | 0.022 | | 0.039 |
| **Bomaly** | 0.014 | | 0.017 | | 0.031 |
| **Grapefruit** | | | 0.010 | | 0.010 |
| **Valencia Orange** | 0.005 | | 0.003 | | 0.008 |
| **Balady Orange** | | | 0.007 | | 0.007 |
| **Francawy Orange** | 0.005 | | | | 0.005 |
| **Total $km^2$** | **3.120** | | **3.783** | | **6.903** |

(Palestinian Central Bureau of Statistics, 2009a)

Fig. 21. Fruit trees

Fig. 22. A detail of a agricultural area used for production of fruit trees

Fig. 23. A perspective of a plain area used for fruit trees plantation

*Field crops*

Table 5 shows that the total area of the cultivated field crops in 2007/2008 is about 5.438 $Km^2$. Wheat occupies the largest area with approximately 3.200 $Km^2$, while the dry onion occupied the smallest area with about 0.093 $Km^2$.

Table 5: Area of field crops in Jordan Valley by Crop and Type for the Year 2007/2008 ($Km^2$)

| Crop | Irrigated | Rainfed | Total Area $km^2$ |
|---|---|---|---|
| **Wheat** | 3.200 | | 3.200 |
| **Barley** | 0.990 | | 0.990 |
| **Clover** | 0.730 | | 0.730 |
| **Potato** | 0.316 | | 0.316 |
| **Sem** | 0.109 | | 0.109 |
| **Dry onion** | 0.093 | | 0.093 |
| **Total $km^2$** | **5.438** | | **5.438** |

(Palestinian Central Bureau of Statistics, 2009a)

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