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Case Study: Analysis of the Physical Factors of Palestinian Bioclimate

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Abstract

This study analyses the physical factors of the Palestinian bioclimate, the mean monthly and annual temperature, mean monthly maximum temperature, and mean monthly minimum temperature using data from six weather stations from the Palestine Meteorological Department, recorded in two periods: The first period from 1969 to 1981, the second period from 1975 to 1995 (more than 32 years). Statistical tests included a bioclimatic analysis of Palestinian meteorological stations for the periods from 1969-1981 and 1975-1995 by using bioclimatic classification of the Earth of Rivas Martinez Salvador, with regard to thermicity index, compensated thermicity index, annual ombrothermic index, and simple continentality index. The bioclimate of Palestineis affected by various factors, such as the Jordanian-Syrian desert, and its natural geography and topography, among others as well as biodiversity. Annual ombrothermic index value ranging between 0.6 to 3.4 and simple continentality index was from 12.4 to 18.1. It is concluded that the occupied Palestinian territories belong to the arid, semiarid, dry, sub-humid and humid ombrotype, and the Inframediterranean, Thermomediterranean and Mesomediterranean bioclimatic belt.

Keywords

Indices, Biodiversity, Bioclimatology, Ombrotype, Thermotypes

1. Introduction

Palestine is the conventional name used to describe the geographic region between the Mediterranean Sea and the Jordan River and various adjoining lands, the Holy Land and the Southern Levant. Palestine has historically been known by other names including Canaan, Syria Palestine, Southern Syria, Jund Filastin and Outremer [1]-[4]. Geomorphological, although it is a comparatively small area, the West Bank is also characterized by a wide variation in topography [5]. The topography of Palestine has several main geographical features that can be eas-

ily identified on a map of Palestine: the coastal plain, the central highlands/central hill country, the Jordan Rift/Great Rift Valley, the trans-Jordanian highlands/Transjordan, the Jordan River, the Sea of Galilee, the Dead Sea and the Mediterranean Sea (**Figure 1**).

The mountainous area of the West Bank serves as the main rainfall collection and replenishment zone for the underground water aquifers. The current climate conditions reveal the cascading effect of bioclimate change. The start and duration of the seasons have changed, and this has exposed Gaza to more fragility [6] [7]. In the other side, climate is considered vulnerability as the propensity of people or systems to be harmed by climate hazards in the context of other domains of vulnerability, as well as in relation to response capabilities in both the short-term (coping) and the long-term (adaptation) [8]. Therefore, climate change has lead to the change in the physical factors of the Palestinian bioclimatic, hydrological cycle and other the environment factors.

The main aims of the present study are to contribute to the knowledge of the mean temperature occurring in Palestine over the past few decades at the monthly, seasonal and annual resolution, and to analyze the physical factors of the bioclimate according to data from the Palestinian meteorological stations for several years.

2. Materials & Methods

2.1. Study Area

Palestine is located between longitudes 34˚15' and 35˚40' east and between latitudes 29˚30' and 33˚15' north. The geographic location of Palestine plays a major role in affecting the features of its climate and the climate diversity between the southern and northern parts.

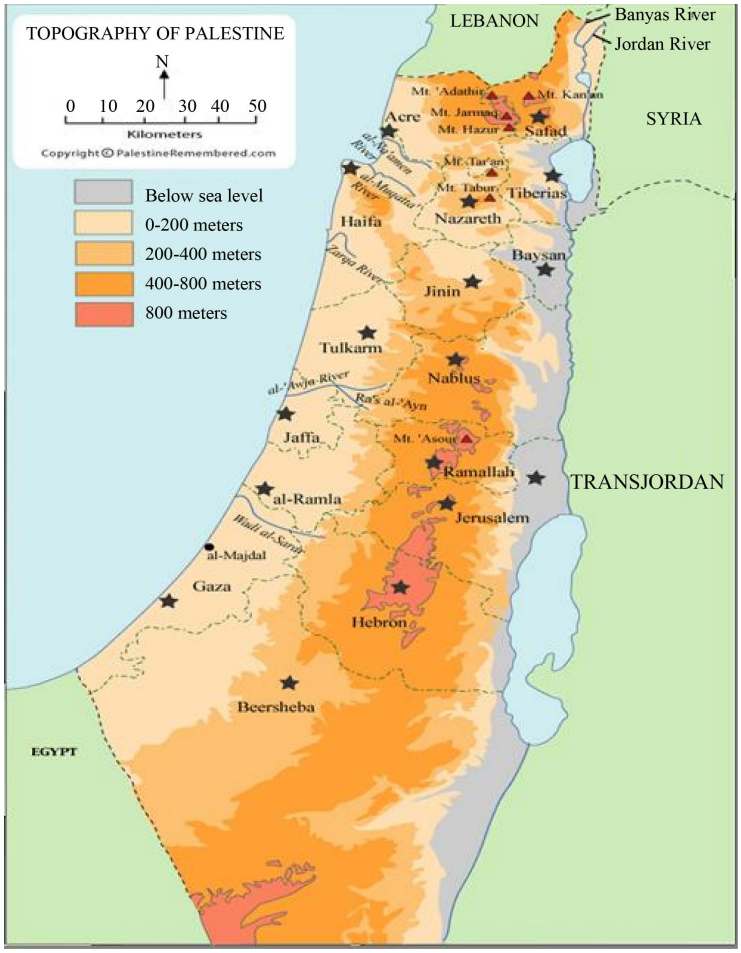


Figure 1. Topography of Palestine.

2.2. Climate and Bioclimate Data

The thermal regime varies significantly with altitude and continentally, especially in winter: from west to east it undergoes a transition from a typical Mediterranean to a continental climate. The winter rain regime has been extensively studied [9]-[13], and changes in annual rainfall patterns [14] [15]. The mountainous regions tend to be windy, very cold and sometimes snowy. The peak of Mount Hermon is covered with snow most of the year [16]. Data were used from the meteorological stations in Palestine (**Table 1**).

Mean temperature data from six stations with records from 1969 to 1981 and from 1975 to 1995 have been analyzed in this study. A bioclimatic analysis has been made of the data from the Palestinian meteorological stations of the same years ago, so we are dependent in the bioclimatic analysis about used temperature and rain full amount of data for Palestinian Meteorological Stations, elaboration the diagram bioclimatic according the professor Rivas Martinez Salvador in 1996 [17]-[19], and [20]. An analysis was made of the thermicity index (It), compensated thermicity index (Itc), diurnality index (Id), annual ombrothermic index (Io), simple continentality index (Ic), monthly estival ombrothermic index (Ios1), threemonthly estival ombrothermic index (Ios3), annual ombro evaporation index (Ioe), annual positive temperature (Tp), annual negative temperature (Tn), positive precipitation (Pp), mean monthly temperatures(Tm), mean monthly maximum and minimum temperatures.

3. Results and Discussion

3.1. The First Period from 1969 to 1981

Table 2 shows the sign and magnitude of trends, as well as the statistical significance for each of the six sites analyzed for bioclimatic belts and annual ombrothermic index. **Table 3** shows the number of weather stations with bioclimatic factors physicals for Palestine provided by the Palestinian meteorological stations for the years in the study. These tables reveal a clear tendency towards climate change in Palestine during the study period in the six stations in the various years (with regard to thermicity index, compensated thermicity index, mean temperature of the annual warmest month, mean monthly temperatures). **Figure 2** shows that the analysis of physical factors, and the climate of Palestine and the Palestinian territories belongs to the humid, sub-humid and arid ombrotype.

Tm: mean monthly temperatures, (It) thermicity index, (Itc) compensated thermicity index, (Io) annual ombrothermic index, (Ic) simple continentality index, (Twm) mean temperature of the warmest monthly, (Tcm) mean temperature of the coldest monthly, (Ios1) monthly estival ombrothermic index, (Ios2, Iso3) bimonthly, three monthly estival ombrothermic index, (Tm. M. Max) mean monthly maximum temperatures, (Tm. M. Min) mean monthly minimum temperatures. **Table 2** shows the bioclimatic analysis according to the data from the Palestinian meteorological stations in two stages.

Nevertheless, in the first period, we can observe that the precipitation amounts differ from one station to another, with the highest proportion in Hebron and Al-Arroub (located in Hebron) 596 mm and 633 mm respectively, and the lowest at the Jericho station. The mean temperature of the warmest month in Jericho is about 22˚C; Al-Fará (in Nablus) is about 19.5˚C, while the lowest mean monthly temperature is in Hebron with 4.0˚C. The monthly, biomonthly, three monthly estival ombrothermic indexes were equal to zero for most stations except Hebron and

Table 1. Coordinates of meteorological stations Palestinian.

Station	Latitude (North)	Longitude (East)	Elevation m
Jenin	32.28 N	35.18 E	178
Gaza	31.30 N	34.27 E	13
Tulkarem	32.19 N	35.01 E	83
Nablus	32.13 N	35.15 E	570
Al-Arroub	31.50 N	35.09 E	887
Ramallah	31.89 N	35.21 E	856
Jericho	31.51 N	35.27 E	−260
Hebron	31.32 E	35.06 E	1005

Table 2. Bioclimatic analysis of Palestinian meteorological stations in the periods 1969-1981 and 1975 to 1995 (32 years).

Station	Tm	P. mm	Io	Ic	It/Itc	Twm.	Tcm.	Tm. M. Max.	Tm. M. Min.	Iso3
					1969-1981					
Jericho	22.4	166	0.6	13.0	528/528	22.0	7.4	34.8	15.3	0.0
Hebron	15.5	596	3.2	15.0	297/297	10.2	4.0	19.9	11.1	0.01
BeitGad	21.3	414	1.6	15.0	466/466	18.2	7.1	26.7	13.5	0.0
Al- Fara	23.6	225	0.8	17.0	524/524	19.5	9.3	30.2	17.0	0.0
Gaza	19.8	446	1.9	12.4	467/467	17.5	9.4	23.6	16.1	0.0
Al-Arroub	17.1	633	3.1	16.7	428/428	21.3	4.4	22.9	10.4	0.0
					1975-1995					
Ramallah	17.2	636	3.4	14.9	306/306	10.5	4.4	21.1	31.1	0.01
Jericho	22.7	168	0.6	13.0	496/496	19.1	7.8	29.6	15.7	0.0
Hebron	15.5	628	3.4	15.3	294/294	10.0	4.0	19.6	11.2	0.1
Gaza	19.9	441.3	1.85	13.6	457/457	18.0	7.8	25.8	13.9	0.0
Nablus	17.2	664	3.1	13.4	378/378	13.0	7.2	21.6	13.6	0.0
Tulkarem	20.1	652	2.7	12.8	468/468	18.8	7.9	25.7	13.9	0.0

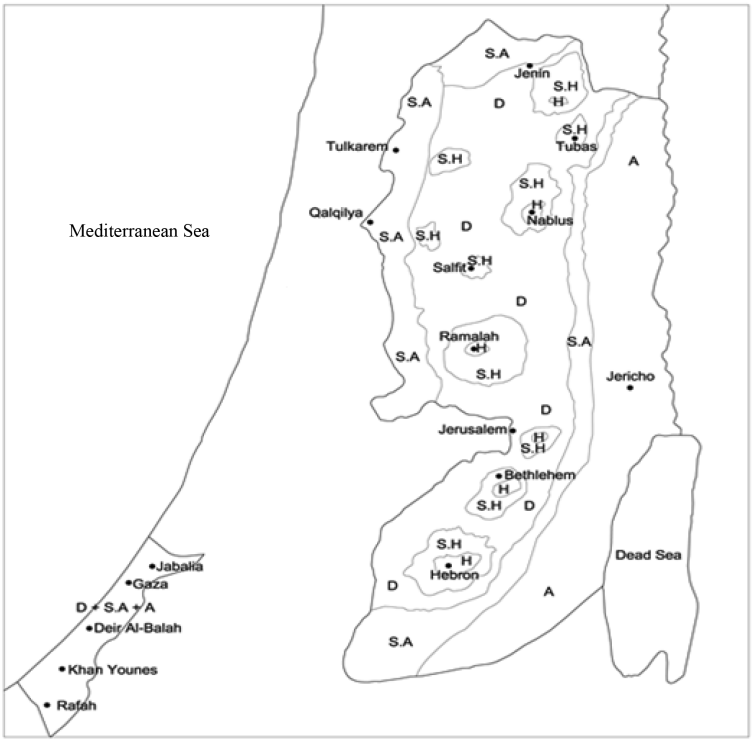
Table 3. Bioclimatic belts and ombrotype in Palestine.Simple continentality index (Ic), ombrothermic index (Io) and compensated thermicity index (It/Itc).

Provinces	Termotype	Omprotype	Ic	Io	It/Itc
Ramallah	Lower mesomediterranean	Upper dry	16.4	3.1 - 3.4	306/306
Nablus	Upper thermomediterranean	Upper dry	18.1	3.0 - 3.1	378/378
Jericho	Lower inframediterranean	Upper arid	13	0.6 - 1.0	528/528
Hebron	Lower mesomediterranean	Upper dry	17.6	3.1 - 3.4	297/297
Tulkarem	Lower inframediterranean	Lower dry	16.0	2.2 - 2.7	468/468
Beit gad	Upper inframediterranean	Upper semiarid	15.0	1.6	466/466
Al-Arroub	Lower thermomediterranean	Upper dry	16.7	3.1	428/428
Al-Fara	Lower inframediterranean	Upper arid	17	0.8	524/524
Gaza	Upper Inframediterranean	Upper semiarid	12.4	1.9	467/467

Jenin, which have a very low three monthly estival ombrothermic index of about 0.01. This factor appears similar to another recent study [21], because there are no found rainfalls and compensations in these areas.

3.2. The Second Period from 1975 to 1995

The series indicate that the mean monthly temperatures over the period 1975-1995 is between 15.5˚C in Hebron station, and 22.7˚C in Jericho station, while in 1968-1981 the mean monthly temperature is between 15.5˚C in Hebron station and 22.4˚C in Jericho station. The annual mean rainfall was between 160 mm at Jericho station, and 664 mm at Nablus station. The rainfall year 1991-1992 has the highest quantity rainfall throughout the past thirty years, the quantity of rainfall ranges between 352 mm in Jericho station with an increase of 192 mm over the normal average, and 1388 mm in Nablus station with an increase of 720 mm over the normal average, the mean monthly maximum temperature is between 19.9˚C in Hebron station, and 34.8 in Jericho station, while it is 23.6 in



(H) _HUMID
(S.H) _SUBHUMID
(D) _DRY
(S.A) _SEMIARIAL
(A) ARIAL_

Figure 2. Ombrotype of Palestine.

Gaza station (1969-1981). In general, the lowest mean monthly temperature was recorded in the Hebron station and the highest in Jericho. Time series data indicated that the mean monthly minimum temperature over the period 1975-1995 was between 11.2˚C in Hebron and 15.7˚C in Jericho. There is a difference in temperature between the previous stages in the regions and by Israeli research demonstrating that the average temperatures in the eastern Mediterranean have increased steadily over the last 100 years [22]. A different approach for explaining climatic in the southern Israel was presented by Alpert and Mandel [23]. Ben-Gai *et al.* [24] also mentioned the different approaches regarding the role of the sensible heat flux in explaining regional climate change and climatology.

3.3. Analyses the Physical Factors of the Bioclimate

However, there are some studies suggested that precipitation levels may decrease for Israeli-Palestinian region [11] [25] [26]. Annual precipitation rates are deemed likely to fall in the eastern Mediterranean decreasing 10% by 2020 and 20% by 2050-with an increased risk of summer drought [27]. In **Table 2**, the thermicity index and compensated thermicity index was highest in Al-Fara (524/524), Jericho (528/528), and lowest in Ramallah and Hebron (about, 306/306, 294/294 respectively for the period 1975 to 1995 only). The annual ombrothermic index was highest in Hebron and Ramallah with 3.4 and lowest in Jericho, Gaza and Beit Gad village in Jenin, with values of 0.6, 1.85 and 1.6 respectively. The simple continentality index was found to be highest in Nablus and Hebron and lowest in Jericho and Tulkarem in the studies periods. The amount of rain falling and the rest of factors in Palestinian areas during the periods (1969-1981 and 1975-1995) results in (**Table 2**), show the differences in temperature between the stations during the periods previous; such as the mean monthly temperatures are the highest in Jericho, with 22.7˚C, Tulkarem with 20.1˚C, and Al-Fará in Nablus with 23.6˚C, while the lowest, in Ramallah, Nablus and Hebron are 17.2˚C and 15.5˚C respectively. The mean monthly rainfall is highest in the province of Nablus (664 mm), Tulkarem (652 mm) and Ramallah. Through the results in this paper, we find that

there is a big difference in the physical factors of the bioclimate in Palestine between the study periods. In Jericho area, we see that the (It/Itc) is about (528/528); Io is 0.6; mean temperature of the warmest monthly (Twm) had sought 22.0˚C at the first period, while in the second period (496/496) and (Twm) is to 19.1˚C; and in Gaza compensated thermicity index are (467/467); (Io) annual ombrothermic index is 1.9; mean monthly Maximum temperature is 23.6˚C; (Ic) simple continentality index is 12.4; (Twm) is 17.5 and precipitation is 446 mm at the first period. While in the second period in Gaza station, (It/Itc) are (457/457); (Ic) is 13.6; mean monthly minimum temperature is 13.9˚C while 16.1˚C at the first stage; meanmonthly maximum temperture is 25.8˚C and precipitation is 441.3 mm, there is a difference between the factors bioclimatic, station to another in Palestine and the rest of the information shown in (**Table 2**). It means that there is a difference in these factors between the three periods due to the difference in biodiversity, mountain range extending from north to south and running parallel to the coast, amount of water that falls, natural geography and topography, the level of elevation above sea level and other factors, therefore, these factors affect the biology of plants, bioclimatology, climatology, and on the economy in Palestine especially in the agricultural sector in current and future [28], and the environment in general such as land degradation, and its driving forces are climate and bioclimate factors variations and human activities. Land condition becomes the key to interaction between biophysical and human system in the desertification processes [29]. This interaction is complex to the extent that the land management practices affect the condition of the land. Environment is influenced by climatic and bioclimate factors. Conversely, the bioclimate restricts the range of land management practices that can be sustainably employed [30]. In the other side, the need to deal and cope with climatological hazards is commonly understood in intergovernmental and aid agency for as a purely technical matter and the creation of the Palestinian society to these climatic changes in all respects and until now climate and bioclimatology changes have not been securitized [31] [32].

The Occupied Palestinian Territory (OPT), with a total area of 6023 km^2, is located in South-West Asia in the heart of the Middle East. It consists of two physically separated land masses: the West Bank and the Gaza Strip with a total area of 5661 km^2 and 362 km^2 respectively [33]. It represents approximately 21% of the territory of historic Palestine (27,000 km^2). The bioclimatic belts in the occupied Palestinian territories belong to the inframediterranean (45% - 50%), thermomediterranean (35% - 40%), mesomediterranean (less than 5% - 10%), and we believed that found regions belong to the supramediterranean but it's less than 1% of the total area of the West Bank. The territories of Jericho and Gaza present a tropical xeric and desert bioclimate, and upper inframediterraneanthermotype; and an arid, semi-arid and dry ombrotype. According to the analysis of physical factors, ombrotype of Palestine have the following bioclimatic.

According to (**Table 2**) and (**Figure 3**), we can observe that there is a difference in the Palestinian bioclimatic belts or thermotype among different regions; Ramallah and Hebron stations have the highest value of annual ombrothermic index with 3.2 to 3.4, as they have low temperatures and high precipitation. The thermicity index and compensated thermicity index was highest in Jericho (528/528) and Al-Fara (524/524), and lowest in Hebron and Ramallah, as shown in **Table 3**. The simple continentality index was highest in Nablus (Al-fara) and Hebron station and lowest in Gaza and Jericho. In general, the occupied Palestinian territories belong to the arid, semiarid, dry, sub-humid and humid ombrotype. In place with semi-desert and dry climates olive cultivation is located, while the cereal is developed in sub-humid and humid. In **Table 3**, the Jericho region belongs to the classification established as desert and semi-desert, with an upper arid ombrotype and a low lower inframediterranean thermo type. As the precipitation is about 200 mm to 300 mm, the ombrothermic index is about 0.6 to 1.0. It has high temperatures due to its location below sea level at −260 meters, to the change in topography and other factors. The provinces of Ramallah, Hebron, Tulkarem and Nablus belong to the upper dry and lower dry, especially the mountain regions or highlands.

Moreover, the climate of Palestine is traditionally described as "Mediterranean", characterized by winter rain and summer drought. However, there is a great diversity in this climate, which is modified locally by latitude and altitude. This is especially apparent in the West Bank. Climate zones range from extremely arid to humid according to the De Martonne aridity index classification for arid area. The total area of extremely arid, hyper arid and arid climates is 2461 km^2 which comprises about 44% of the land area of the West Bank; the area of the semi-arid part is 1682 km^2 (about 30%); the sub humid area is 1435 km^2 (25%) and the humid area is 67 km^2 (1%) [5] [34]. We indicated the absence of the political control over the land by the Palestinians due to the severe measures of the Israeli Occupation confiscation of land and water, rapid growth of the population and the improper distribution of the population in arid, semi-arid and desert lands [35].

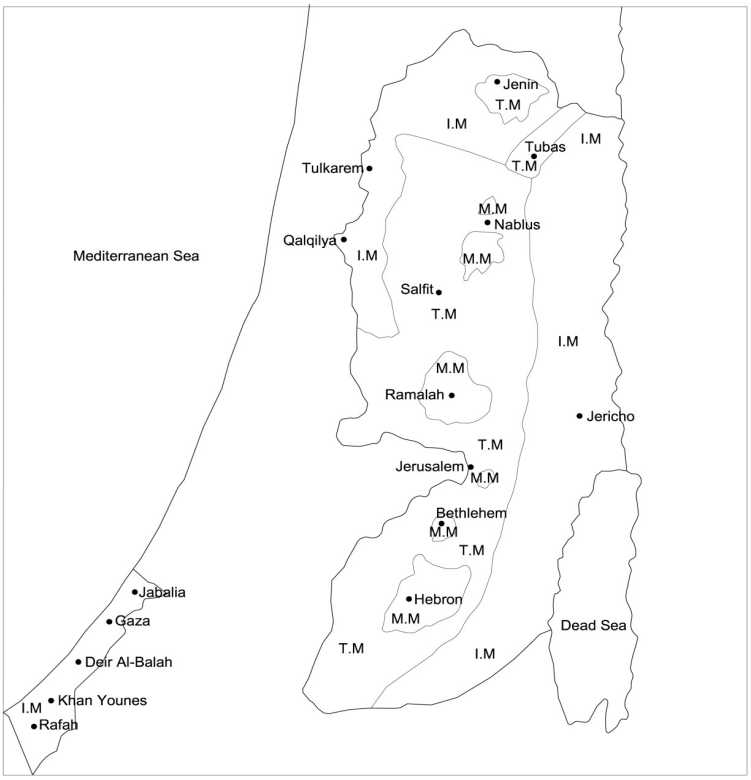


Figure 3. Thermotypes of Palestine.

4. Conclusions

The bioclimate of Palestine can be classified as Mediterranean pluviseasonal-oceanic, Mediterranean xericocea-nic, Mediterranean desertic-oceanic, while the latitudinal belt is subtropical, within the territorial of a tropical character. Continentally it is oceanic-low semi-continental, oceanic-low euoceanic, oceanic-low semi-hyper oceanic and oceanic-low sub-continental. In addition, the thermotype ranges from inframediterranean to meso-mediterranean (inframediterranean, thermomediterranean, mesomediterranean).

The physical factors of the Palestinian bioclimate are affected by several factors: 1) The Mountain range ex-tending from north to south and running parallel to the coast; b) The Sinai and the North African desert; c) The Jordanian-Syrian desert; d) The terrain and the extent of the rise or fall in sea level; e) Natural geography and topography. Palestine is located within a radius of 500 kilometers from the island of Cyprus, and as we move further from the center of this circle, the low air deflects or moves towards the north, and thus the low air moving away from Palestine leads to a decrease in the proportion of rain-fed on Palestine. This also plays an important role in influencing the physical factors of bioclimate and climate and then bioclimate influence on plant communities and biological resources.

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