

توقعات تغير المناخ لمؤشر قرينة الأراضي القاحلة في دولة الكويت في

الفترة من 1992-2020

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**Climate Change Projection for Aridity Index in the
State of Kuwait from 1992-2020**

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الملخص

هدف الدراسة: تهدف هذه الدراسة إلى تحليل مؤشرات قرينة الأراضي القاحلة من عام 1992 الى 2020 بالاعتماد على البيانات المناخية المسجلة في محطة مطار الكويت الدولي مثل كمية تساقط الأمطار ومتوسط درجة الحرارة السنوي، فضلا عن التوقعات المستقبلية لمؤشرات الجفاف في ظل سيناريوهات مختلفة لمسار التركيز التمثيلي (RCP) وتشمل خطط الاستجابة الإقليمية سيناريو تخفيف صارم (RCP2.6)، وسيناريوهين وسيطين (RCP4.5 و RCP6.0) وسيناريو واحد مع انبعاثات غازات الدفينة عالية جدا (RCP8.5). المنهجية: اعتمدت هذه الدراسة على الأساليب الإحصائية والرياضية لتحديد مؤشر دي مارتون ومؤشر بينا ومؤشر إرينك باعتبارهم الأنسب لوصف وتحليل مؤشر الأراضي القاحلة وأيضاً توقعات التغير لهذه المؤشرات في المستقبل. النتائج: حيث تشير النتائج إلى ارتفاع ملحوظ في درجة الحرارة في المستقبل في ظل جميع السيناريوهات حيث يبلغ الارتفاع من 0.96 الى 4.66 درجة مئوية خلال الصيف و0.10 الى 3.36 درجة مئوية خلال الشتاء وأيضاً انخفاض في نسبة تساقط الأمطار في شهري نوفمبر وديسمبر -6.8% وارتفاع هذه النسبة الى 19-25% من يناير الى أبريل، دون حدوث أي تغير في مؤشرات الأراضي القاحلة. الخلاصة: من المتوقع أن يكون لتغير المناخ تأثير عميق على دولة الكويت ومع الارتفاع الملحوظ في درجة الحرارة والانخفاض في تساقط الأمطار بسبب تغير المناخ سوف يزداد تكرار العواصف الترابية وازدياد الطلب على المياه والزيادة في استهلاك الطاقة.

المصطلحات الأساسية: تغير المناخ، دولة الكويت، الأراضي القاحلة، مؤشر دي مارتون ومؤشر بينا ومؤشر إرينك.

Abstract

Objective: This paper mainly focusses on the recent aridity indices from 1992 to 2020, future projections of annual precipitation and temperature as well future projections for the aridity indices under different scenarios of Representative Concentration Pathway (RCP) The RCPs include a stringent mitigation scenario (RCP2.6), two intermediate scenarios (RCP4.5 and RCP6.0) and one scenario with very high GHG emissions (RCP8.5). **Methods:** Statistical and Mathematical approaches used to investigate the aridity trend to track changes in the past, recent and future values such as the De Martonne, The Pinna Combinative, and Erinc Index. **Result:** The analysis results have shown that warming is prominent and indicate a notable warming in future under all scenarios with increase 0.69 °C to 4.66 °C during summer and 0.10 to 3.36°C throughout winter as well, presented decrease in precipitation from November to December by – 6.8% and increases by 19 to 25% from January to April along with no detected changes in aridity indicators. **Conclusion:** Climate change is expected to have a profound impact on the State of Kuwait. With the significant rise in temperature and decrease in precipitation due to climate change, the frequency of dust storms, water demand will increase, and energy consumption will increase.

Keywords: Climate Change, Kuwait, Arid land, De Martonne, The Pinna Combinative, Erinc Index

- **Introduction**

Global variability and climate change not only nature processes but also human caused factors and contributions (Onder, Aydin, Berberoglu, Onder, & Yano, 2019). Temperature changes and the rate of change are both important to be able to determine the possible effect of climate change (Environment Public Authority, 2019). Climate change and global warming have the impact on water resources is more pronounced in dry climate with low precipitation rate and high evaporation rate (Environment Public Authority, 2019). The State of Kuwait is vulnerable to climate change effects because of the important extent of dry land (Environment Public Authority, 2019).

Aridity plays a significant role for understanding climate conditions (Hrnjak, et al., 2014). Assessing and monitoring aridity help to comfort the threat of land degradation and desertification (Baltas, 2007), According to the American Meteorological Society aridity is the degree to which a climate lacks sufficient, life promoting moisture, and is the opposite of humidity in the climate sense of the term (Tabari, Talae, Nadoushani, Willems, & Marchetto, 2014). The aridity index is used for climate-based land classification from the standpoint of dryness (Hrnjak, et al., 2014). Aridity indices helps to find the status of arid climate and to find out the classification of climate regarding water availability at a given region (Sarлак, Omar, & Agha, 2018).

Aridity has been defined by various indicators which include temperature and precipitation (Hrnjak, et al., 2014). For this study the following indices such as De Martonne annual, monthly, and seasonally, The Pinna Combinative Index, and Erinc Index have been chosen since these are the most suitable for analysis

of climate conditions in Kuwait. The chosen indices are calculated by using temperature and precipitation data from 1992 to 2020 from Kuwait international airport meteorological station (KIA) from the Directorate General of Civil Aviation Department of Meteorological – Climate Division.

- **The objectives:**

- The main objective of this study is to determine an arid index showing the best representation for the State of Kuwait.
- A comparison is made between the climate indices of De Martonne (Annual, Seasonal and Monthly), The Pinna Combinative Index and Erinc Index.
- Identifying and understand the historical and projected aridity events and their risks at the country level.

- **The Importance of this study**

- This study mainly focusses to evaluate recent aridity indices from 1992 to 2020.
- Analysed the future projections of annual precipitation and annual mean temperature as well as future projections for the aridity indices under different scenarios of Representative Concentration Pathway (RCP) The RCPs include a stringent mitigation scenario (RCP2.6), two intermediate scenarios (RCP4.5 and RCP6.0) and one scenario with very high GHG emissions (RCP8.5) (World Bank Group, 2021).

- **Study area**

The State of Kuwait occupies the northern western corner of the Arabian Gulf, has a hyper arid desert climate, hot and dry (Environment Public Authority (EPA), 2019). In the State of Kuwait rainfall is rare and fluctuating, the amount of the rainfall varies greatly from year to year with annual rainfall ranging from

242 mm in 1976 to 31 mm in 1984 with overall average over the past three decades is about 105 mm (Al-Awadi & Al-Dossary, 2010). The average maximum temperature in summer during the day is 45 °C and in winter it drops to 7 °C also the humidity ranges from 85% in January to 30 % in June (Al-Awadi & Al-Dossary, 2010). Studies and research showed over the past years the desert environment is characterized by extreme sensitivity like other dry and semi dry environment in the world within the framework of a delicate balance between its various natural elements of climate, soil, vegetation and living organism (Al-Awadi & Al-Dossary, 2010). The occurrence of drought for years in row may extend for more than 15 years as it happened from 1958 to 1976 according to Al-Awadi & Al-Dossary, 2010 that the drought helped to create the proper conditions for soil erosion due to wind, dust and sand accumulation. The spread of dust and sandstorms and other environmental issues (Al-Awadi & Al-Dossary, 2010).

- **Literature Review**

Since the climate aridity is a severe concern in the context of global climate change, research has been done for the assessment of aridity index, by using climate indices such as temperature, precipitation, and rainfall to estimate and evaluate the aridity level worldwide. (Deniz, Toros, & Incecik ,2010) studied climatic indices over Turkey by using De Martonne Aridity Index and Pinna Combinative Index. The study concluded that Pinna Combinative Index estimated 9% of the study area were found under drought but the extreme locations found by De Martonne Aridity Index. Meanwhile, there is a significant relation was found between the results for both indexes. According to (Andrade, Contente, & Santos 2021) that the assessment of aridity conditions is a key factor for water management and future adaptation plans. For the Iberian Peninsula three aridity indices were used De Martonne Aridity Index, Pinna Combinative Index and Erinc Aridity Index. Two Representative Concentration Pathway (RCP) were analysed RCP 4.5 and 8.5 for the short-range future from 2011 -2040

and medium range from 2041 -2070. The study concluded the increase in aridity or dry conditions until 2070 mainly under RCP 8.5. This outcome is coherent with the strong statistically significant correlation found between these three induces and the climate mean total annual precipitation. (Derdous, Bouguerra, Tachi, & Bouamrane, 2020) analysed the spatial and temporal evolution of De Martonne and The Pinna Combinative Aridity induces in north Algeria from 1980 -2018. For the calculation of aridity indices temperate and precipitation data series have been used. The De Martonne and The Pinna Combinative aridity indices were found highly correlated; however, a more varied distribution of climate types in the study area was obtained with the De- Martonne index then with The Pinna Combinative and the results could be used in planning and manging water resources in the study area.

(Vladut and Licurici, 2020) calculated De Martonne Aridity Index at annual, seasonal and monthly level and The Pinna Combinative Index for the region of Olteria (Romania) from 1961-2015 to emphasize the evaluation trend of aridity. The study illustrates that the De Martonne aridity index for seasonal values as follow, summer and autumn are the most sensitive seasons, where autumn is the driest season and summer is the most prone to aridity season. As for the monthly values August is the driest month followed by July and September.

- **Data and Methodology**

Aridity index is defined as numerical indicator of degree of dryness of the climate at a given location and it classified the type of climate in relation to water availability (Deniz, Toros, & Incecik, 2010). Statistical and Mathematical approaches used to investigate and track any changes in the past, recent and future values. Therefore, the data was sort, formed and calculated for the purpose of aridity index calculation. The data set analysed and processed for the calculation of the mean monthly, seasonally, and annual values of both precipitation and

mean, maximum temperature from the period 1992 – 2020 from Kuwait international airport meteorological station (KIA).

○ **The De Martonne Index**

The De Martonne Index was calculated for the study area based on temperature and precipitation data for the period 1992 -2020. The De Martonne Aridity Index considered as one of the oldest aridity dry\Humaid that helps to identify condition of different regions and the best well-known, widely used in applied climatology studies (Pellicone, Caloiero, & Guagliardi, 2019).

On an annual time, scale, the index is calculated according to the following formula (Pellicone, Caloiero, & Guagliardi, 2019):

$$I_{DM} = \frac{P}{T + 10}$$

Where P is the annual amount of precipitation (mm), and T is the mean annual air temperature (°C). Types of climates according to the De Martonne index were the Arid is $I_{DM} < 10$, Semi – aired is $10 \leq I_{DM} < 20$, Mediterranean is $20 \leq I_{DM} < 24$, Semi-humid is $24 \leq I_{DM} < 28$, Humid is $28 \leq I_{DM} < 35$, Very humid is $35 \leq I_{DM} \leq 55$ and Extremely humid $I_{DM} > 55$ (Derdous, Bouguerra, Tachi, & Bouamrane, 2020).

The De Martonne aridity index for specific season was calculated using the following equation (Baltas, 2007)

$$I_{DM} = \frac{4 P_s}{T_s + 10}$$

Where I_{DMsi} is seasonal value of the De Martonne aridity index at station i and the over bar P_s and T_s are mean seasonal precipitation and temperature, respectively, for each season at station i .

The De Martonne aridity index calculated using the following equation was to find the climate characteristic of a particular month (Gebermedhin, Kahsay, & Fanta, 2018). When the monthly De Martonne aridity index value is lower than

20, the lands need irrigation in that month (Gebermedhin, Kahsay, & Fanta, 2018).

$$I_{DM} = \frac{12 P_m}{T_m + 10}$$

○ The Pinna Combinative Index

This index describes the regions and seasons where irrigation is necessary since it takes in to account the precipitation and temperature of the driest months (Tabari, Talae, Nadoushani, Willems, & Marchetto, 2014)

$$I_P = \frac{1}{2} \left(\frac{P}{T+10} + \frac{12P_d}{T_d+10} \right)$$

where P and T are the annual mean values of precipitation and air temperature, respectively, and P_d and T_d are the mean values of precipitation and air temperature of the driest month, respectively. When the value of the I_P is less than 10 ($I_P < 10$), the climate is classified as dry and when the value of I_P varies between 10 and 20 ($10 \leq I_P \leq 20$) the climate is characterized as semi-dry (> 20) (Baltas, 2007).

○ Erinc Index

Erinc aridity index is a ratio between the annual mean maximum temperature T_{max} and total yearly precipitation amount of the region P , where I_m is the aridity index the mean annual maximum temperature is represented with T_{max} in °C and the annual precipitation represented with P in mm (Al-Zamili & Al-Lami, 2020). Erinc aridity index classified into six climatic zones in the Hyper – arid is < 8 , Arid is $8 - 15$, Semi – Arid is $15 - 23$, Dry Sub Humid is $23 - 40$, Humid is $40 - 55$, and Very Humid is > 55 (Al-Zamili & Al-Lami, 2020).

$$I_m = \frac{P}{T_{max}}$$

- **Aridity Indicators Result**

The result is based on calculations of De Martonne, The Pinna Combinative aridity index and Erinc. According to the annual calculation of De Martonne index the average value for the study period is 15 as a semi – Arid climate zone. The lowest value of the annual index is 11 as a semi – Arid from 2010 and the highest value 22 is recorded only in 2018 as a Mediterranean table 1. The mean distribution of the monthly De Martonne aridity index is demonstrated in the following table 2. November, December, and January are characterized by semi – arid climate with ranging between 12- 13 as index value. While in February, March, April, and May are considered as arid climate with values ranging between 6 to 1. The lowest values index recorded during the summer months and the binging of autumn June, July, August, September, and October as Arid climate with 0 as the value. The seasonal analysis for De Martonne aridity index demonstrated in figure 1, during the winter the value of the index varies from 1 to 11 as arid and semi – arid. The spring aridity conditions based on that the values ranging between 0 up to 11 as arid and semi. The summer season is mostly dominated by arid climate conditions with 0 as a value since the summer is the driest season based on the average values of the arid index. Although the autumn season is characterized by the arid and humid climate conditions with values range between 0 up to 55 in 2018.

The Pinna Combinative aridity index ranged from 11 to 16 as a dry climate for the period of the study 1992 to 2020 with exception for the year of 2018 where the values is barely near 20 table 1. The Erinc Index ranged from 1 to 10 KIA for most of the years are presented as Hyper- Arid and Arid table 1. More diversified distribution of climate is obtained by using the Dr Martonne aridity index than using both Erinc index and the Pinna Combinative aridity index. Such a conclusion is given that the De Martonne aridity index is more suitable for the

analysis of aridity in arid and desert areas since it shows the actual range and the annual, monthly, and seasonally difference between the aridity values.

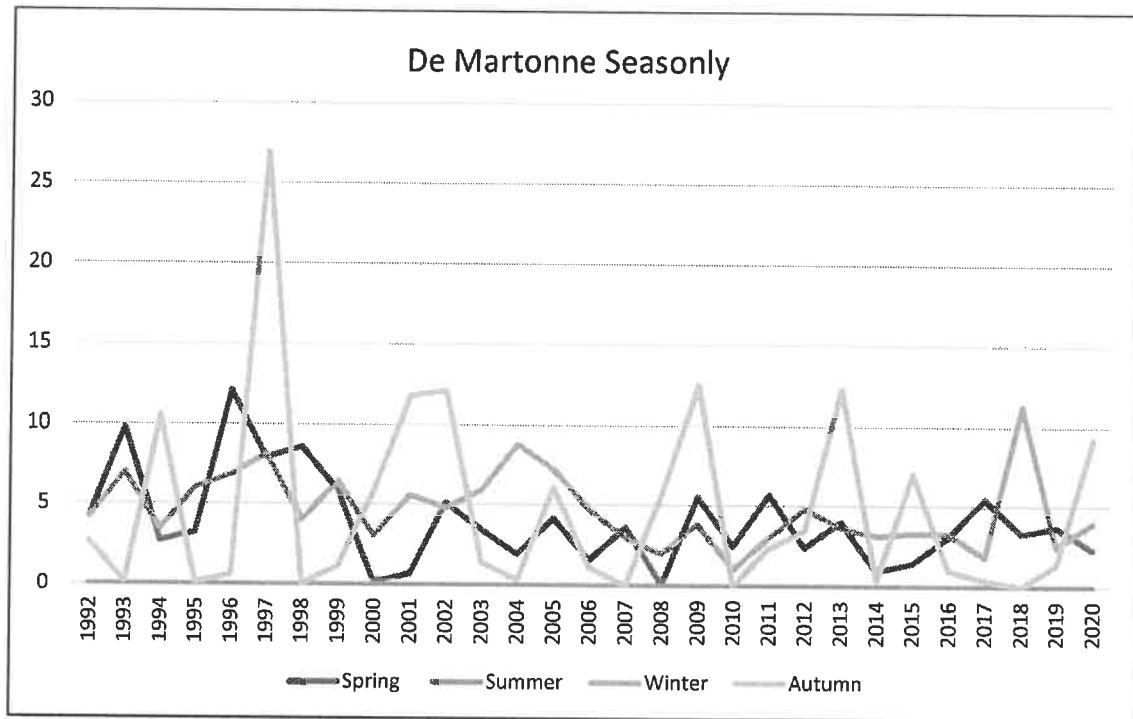


Figure 1: De Martonne seasonally analysis from 1992 to 2020. Source Kuwait international airport meteorological station (KIA) from the Directorate General of Civil Aviation Department of Meteorological – Climate Division.

- **Current and Future Changes in Temperature, Precipitation in the Aridity Index**

This section represent climate change projection for the selected area regarding temperature and precipitation and the aridity index values. The selected area climate, past, present, and future was analysed relative to temperature and precipitation patterns. Based on temperature over 1992 to 2020 the average annual at KIA is 26.84 °C but, on monthly basis there is a substantial variation exists. During the summer months June, July, and August the month July considered as the peak of the hottest temperature with average temperature 39.21 °C , as well during the winter months December, January, and February the month

of January is the peak of the coldest months with average temperature 13.46 °C figure 2.

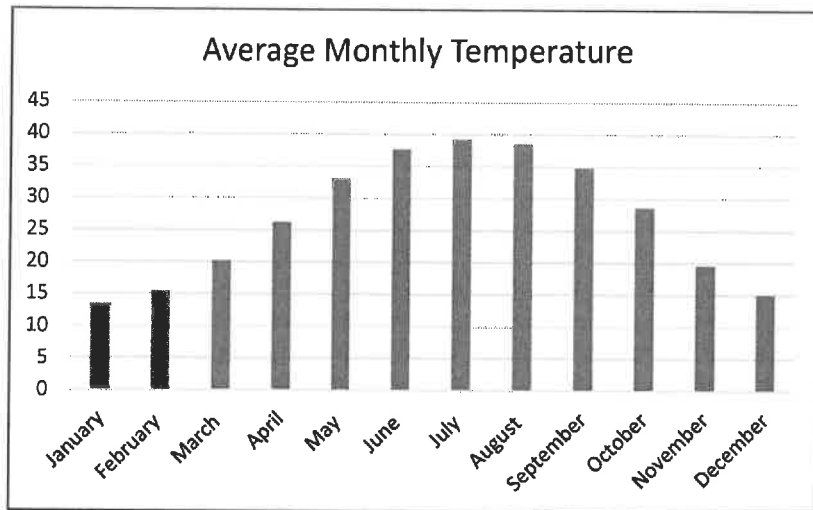


Figure 2: Average Monthly Temperature from 1992 to 2020. Source: Kuwait international airport meteorological station (KIA) from the Directorate General of Civil Aviation Department of Metalogical – Climate Division.

The average annual precipitation is 128 mm per year during study period 1992 – 2020. On monthly basis, precipitation is concentrated during winter and autumn months. During the peak of precipitation season in November the average precipitation is 29.65 mm, while in December 26.30 mm and January with average 24.57 mm. In contrast, during summer months, the average amount is zero figure 3.

For the assessment of future changes in aridity index values were made by using “Grouped Model Intercomparison Projected Phase 5” (CMIP5) data supported by Intergovernmental panel on climate change (IPCC) fifth assessment report (World Bank Group, 2021). Include four Representative Concentration Pathway (RCP) The RCPs include a stringent mitigation scenario (RCP2.6), two intermediate scenarios (RCP4.5 and RCP6.0) and one scenario with extremely

high Green House Emission (GHG) emissions (RCP8.5) (World Bank Group, 2021).

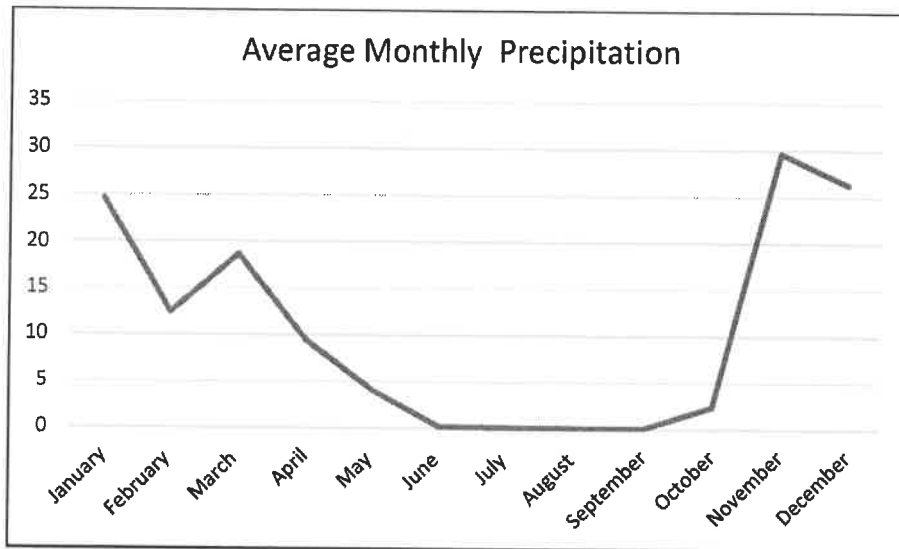


Figure 3: Average Monthly Precipitation from 1992 to 2020. Source: Kuwait international airport meteorological station (KIA) from the Directorate General of Civil Aviation Department of Meteorological – Climate Division.

The estimated data of multi model output based on 1986- 2005 as reference period. The future analysis period will be divided into different time frames such as 2040 – 2059, 2060 – 2079 and 2080 – 2099 (World Bank Group, 2021).

The following figure 4 and table 5 illustrates the changes on average annual temperature and projected change in temperature for the selected area over the period of 2040 to 2099 under different RCP scenarios. During the study period 1992-2020 the average temperature for winter months December, January and February is 14.69 °C meanwhile, the future projection showed an increase from 0.10 up to 3.36°C. Additionally, in summer months June, July, and August during the study period the average temperature is 38.48 °C while the future projection

showed an increase from 0.69 °C to 4.66 °C. Changes in precipitation is one of the most important potential outcomes of global warming KIA experience rainfall on average 128 mm per year figure 3 and monthly average between 29.65 mm to 18.66 mm from November to March. Future variation in precipitation is examined by using CMIP5 under all RCPs showed decrease in precipitation from November to December by – 6.8% under all RCPs while the chance for prediction increases by 19 to 25% from January to April Figure 5 and table 5.

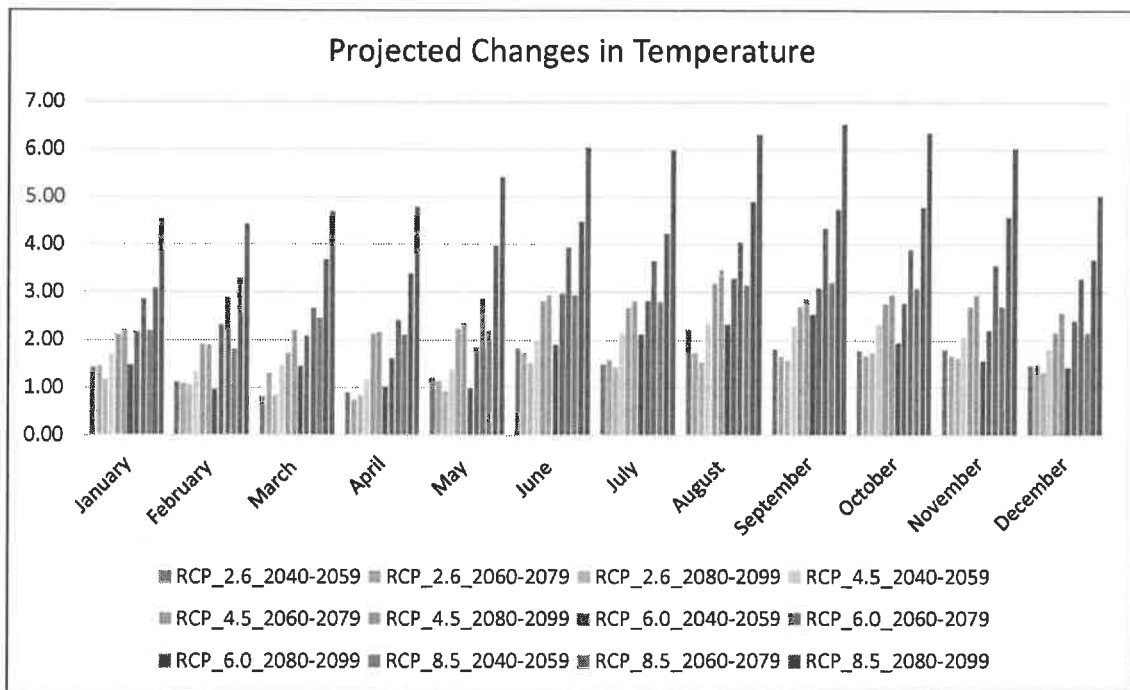


Figure 4: Projected Monthly Temperature Changes. Source: (World Bank Group, 2021)

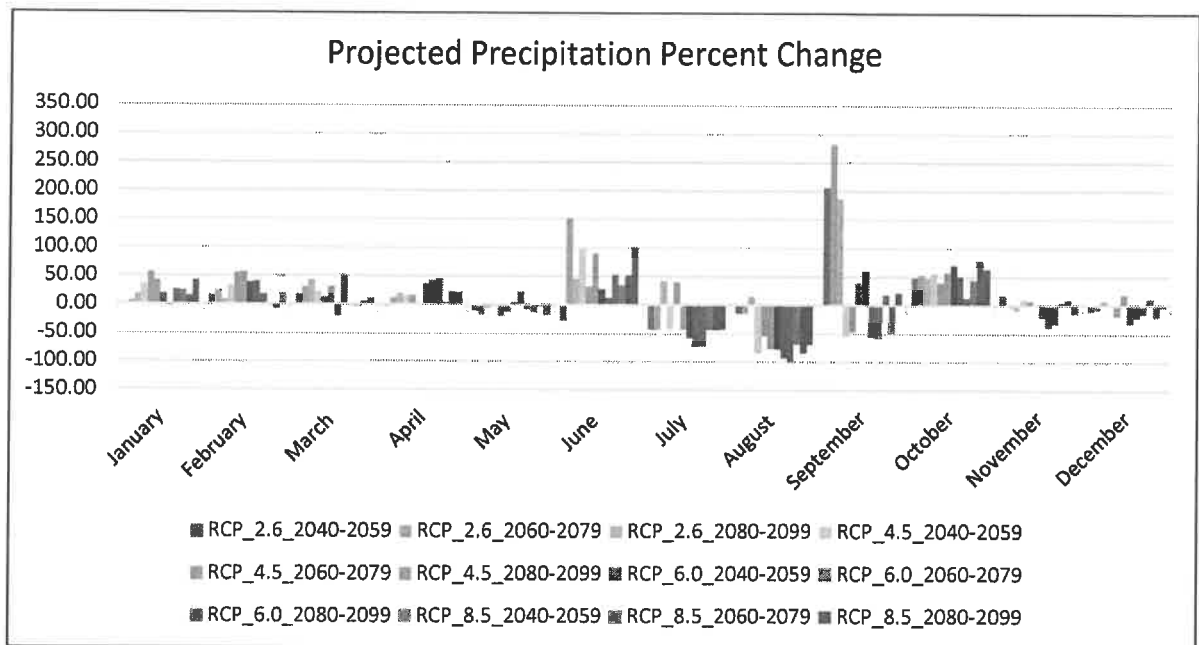


Figure 5: The projected change in precipitation under all RCPs. Source: (World Bank Group, 2021)

o **Future Changes in the Aridity Index**

This section presents the projecting changes of climate and aridity condition by using De Martonne, The Pinna Combinative Index and Eric indices that determine the climatic conditions based on future projection of temperature and precipitation for the selected area. The analysis results have shown that warming is projecting in the selected area and indicate a notable warming in future under the following scenarios RCP 2.6 – 4.5 – 6.0 and 8.5 with no detected changes in the De Martonne annual, the Pinna Combinative Index as well as Eric aridity values compare between the recorded data from 1992- 2020 and the future projected data under RCPs scenarios figure 6 and table 6.

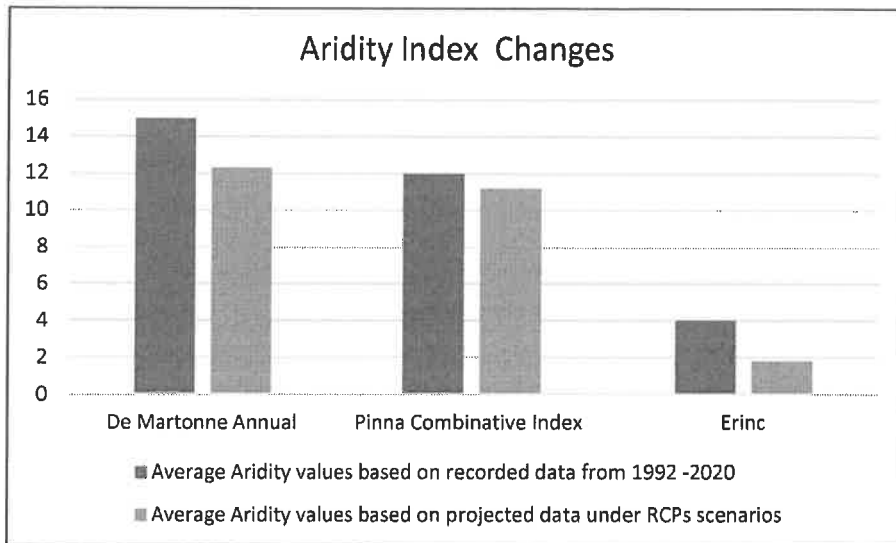


Figure 6: Current and projected aridity values. Source: Kuwait international airport meteorological station (KIA) from the Directorate General of Civil Aviation Department of Meteorological – Climate Division and World Bank Group 2021.

- **Conclusion**

For the description and analysis of the aridity index and future projections of aridity indices changes for the study area the De Martonne, The Pinna Combinative Index, and Erinc Index were analyzed. The values were calculated for the period of 1992 -2020. To help understand, describe, and examine the current aridity values as well as the future projections due to climate change.

According to the De Martonne, the annual aridity index gives the values for Semi-Arid from 1992 until 2020 and Mediterranean for only 2018. For seasonal De Martonne aridity index, during winter and spring the values varying from 0 to 11 as arid and semi-arid climate. Meanwhile, in the summer the value of index is 0 as this season considered as the driest and the hottest in the country. Then, autumn season as characterized by the arid and humid climate conditions with values ranging between 0 up to 55. Finally, the De Martonne aridity monthly index represent two types of climate conditions in the study area appearing as during

November, December, and January as a semi- arid and during February, March, April, May, June, July, August, September, and October as Arid – climate. Using the Lang Index and Pinna Combinative Index identified the climate during the study period as hyper – arid climate and dry climate. The analysis results have shown that warming is prominent in the selected area and indicate a notable warming in future under the following scenarios RCP 2.6 – 4.5 – 6.0 and 8.5 with increase from 0.69 °C to 4.66 °C during summer and 0.10 up to 3.36°C throughout winter. As well, under all RCPs showed decrease in precipitation from November to December by – 6.8% under all RCPs while the chance for prediction increases by 19 to 25% from January to April Along with no clear changes in the De Martonne annual aridity values as well as the Pinna and Erinc.

In the end, climate change is expected to have profound effect on the state of Kuwait, where freshwater resources are limited and mostly depend on desalinated water which is the most common source of freshwater (Environment Public Authority, 2019). With climate change projects the increase in temperature thus will be increasing in dust storms events and experiencing more frequent drought events that would increase the water demand for irrigations and other domestic needs such as the increase in electric power usage for indoor air cooling this demand will require more energy consumption to fulfil (Environment Public Authority, 2019). Increasing in dust storms, drought, high wind speed and lack of vegetations and rise in temperature will play significant role to land degradation conditions which will directly affect Kuwait food security. Kuwait arid climate is intensified by low annual rainfall which will leads to an increase in drought occurrences, in the meantime, the climate change may increase the length, frequency and severity of these events which will force existing water issues. Also, the rainfall season in Kuwait tends to be unpredictable and often characterized by heavy storms that might cause flash floods and will increase the

impact on agriculture, infrastructure, and water resources (Environment Public Authority, 2019).

Table 1: De Martonne, The Pinna Combinative and Erinc Index Annual Index from 1992 to 2020. Source: The researcher based on Kuwait international airport meteorological station (KIA) from the Directorate General of Civil Aviation Department of Metalogical – Climate Division

Years	De Martonne Annual	The Pinna Combinative Index	Erinc Index
1992	14	12	3
1993	17	14	6
1994	14	12	3
1995	16	13	5
1996	17	14	6
1997	18	14	7
1998	14	12	3
1999	16	13	5
2000	13	12	2
2001	14	12	3
2002	15	13	4
2003	16	13	4
2004	18	14	6
2005	17	14	6
2006	14	12	3
2007	13	11	2
2008	12	11	1
2009	14	12	4
2010	11	11	1
2011	13	12	3
2012	15	12	4
2013	15	12	4
2014	13	11	2
2015	14	12	3
2016	13	12	3
2017	12	11	2
2018	22	16	10
2019	13	11	2
2020	14	12	3

Table 2: De Martonne Monthly from 1992 to 2020. Source: The researcher based on Kuwait international airport meteorological station (KIA) from the Directorate General of Civil Aviation Department of Metalogical – Climate Division

Months	Monthly De Martonne
January	12.5
February	5.8
March	7.7
April	3.2
May	1.2
June	0.1
July	0.0
August	0.0
September	0.0
October	0.7
November	12.5
December	12.9

Table 3: Projected Increase in Temperature. Source (World Bank Group, 2021)

Scenario	The projected increase in Temperature °C	Projected Period
RCP 2.6	0.8 – 2.22	2040 – 2059
	0.75 – 1.73	2060 – 2079
	0.83 – 1.73	2080 - 2099
RCP 4.5	1.16 – 2.34	2040 – 2059
	1.17 – 3.19	2060 – 2079
	1.88 – 3.46	2080 - 2099
RCP 6.0	0.97 – 2.53	2040 – 2059
	1.62 – 3.29	2060 – 2079
	2.41 – 4.34	2080 - 2099
RCP 8.5	1.81 – 3.20	2040 – 2059
	3.08 – 4.90	2060 – 2079
	4.42 – 6.54	2080 - 2099

Table 4: The future projections of Annual De Martonne, Erinc Index and Pinna Combinative Index values. Source: The The researcher based on (World Bank Group, 2021) data

Scenario	De Martonne Annual	Erinc Index	The Pinna
RCP 2.6_ 2040-2059	12.4	1.9	11.2
RCP 2.6_ 2040-2059	12.4	1.9	11.2
RCP 2.6_ 2080-2099	12.5	1.9	11.2
RCP 4.5_ 2040-2059	12.5	2.0	11.2
RCP 4.5_ 2060-2079	12.3	1.8	11.2
RCP 4.5_ 2080-2099	12.4	1.9	11.2
RCP 6.0_ 2040-2050	12.3	1.8	11.1
RCP 6.0_ 2060-2079	12.3	1.8	11.2
RCP 6.0_ 2080-2099	12.0	1.6	11.0
RCP 8.5_ 2040-2059	12.2	1.7	11.1
RCP 8.5_ 2060-2079	12.2	1.7	11.1
RCP 8.5_ 2080-2099	12.1	1.7	11.0

Table 5: The average projected present change in precipitation under all RCP 2.6, 4.5, 6.0 and 8.5 Source: (World Bank Group, 2021)

Month	RCP_2.6_2040-2099	RCP_4.5_2040-2099	RCP_6.0_2040-2099	RCP_8.5_2040-2099
January	8.22	44.84	14.06	27.51
February	16.33	48.57	32.65	3.27
March	30.37	22.40	9.31	4.47
April	9.61	11.33	40.39	15.78
May	-11.27	-12.03	5.88	-10.59
June	56.83	73.58	30.38	62.64
July	-15.01	-15.10	-66.83	-43.18
August	-4.82	-71.55	-89.52	-74.23
September	225.46	-20.22	-17.07	-2.77
October	49.54	51.31	45.10	62.34
November	1.76	6.09	-29.80	-0.29
December	-3.06	1.16	-21.75	-3.79

Table 6: Current and projected aridity values. Source Kuwait international airport meteorological station (KIA) from the Directorate General of Civil Aviation Department of Metalogical – Climate Division and World Bank Group 2021

Aridity Index	Average Aridity values based on recorded data from 1992 -2020	Average Aridity values based on projected data under RCPs scenarios
De Martonne Annual	15	12.3
Pinna Combinative Index	12	11.2
Erinc	4	1.8

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