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Projection of Future Climate by Multi-Model Median Approach under GIS Environment along the Gaza Strip, Palestine

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Abstract
Climate changes over the Gaza strip area as a semi-arid area is a major factor that affects the developing strategic plans for water sector. This study aims to determine the future climate changes over Gaza strip. Fossil energy intensive (A1F1) with high sensitivity is the emission scenario that was used for the prediction process. The median assembly approach was used to get the representative results from multi General Circulation Model (GCM) outputs. The predicted mean annual temperatures for years 2020, 2050 and 2080 were 20.66 °C, 22.48 °C and 25.08 °C respectively, While 0.85 °C, 2.67 °C and 5.28 °C were the mean annual changes from baseline period for years 2020, 2050 and 2080 respectively. The predicted mean annual precipitation for years 2020, 2050 and 2080 were 294.68 mm/year, 243.70 mm/year and 170.82 mm/year respectively, Hence -7.48, -23.98 and -46.37 mm/year were the predicted mean annual precipitation changes from baseline period for years 2020, 2050 and 2080 respectively. The mean annual sea level rise for baseline period was 1.097 cm, in the other hand 9.04 cm, 28.84 cm and 59.85 cm were the predicted mean sea level rise values for years 2020, 2050 and 2080 respectively.
Keywords: Climate Change, Gaza Strip, Climate projection, GCM, Emission scenario.

1. Introduction

Gaza Strip is a very narrow and high populated area along the coast of the Mediterranean Sea. The Area of Gaza strip is About 365 square kilometer and its length is approximately 45 km along the coastline. The Gaza Strip is located on the south-eastern coast of the Mediterranean Sea, between longitudes 34° 2” and 34° 25” east, and latitudes 31° 16” and 31° 45” north **Figure (1)**. The Gaza Strip is located in the transitional zone between the arid desert climate of the Sinai Peninsula and the semi humid Mediterranean climate along the coast (EMCC, 2012). The Gaza topography is characterized by elongated ridges and depressions, dry streambeds and shifting sand dunes. The ridges and depressions generally extend in a NNE- SSW direction, parallel to the coastline. They are narrow and consist primarily of sandstone (Kurkar). In the south, these features tend to be covered by sand dunes. Land surface elevations range from mean sea level to about 110 m above mean sea level. The ridges and depressions show considerable vertical relief, in some places up to 60 m. Surface elevations of individual ridges range between 20 m and 90 m above mean sea level (Aish, 2004). Soil in the Gaza Strip is composed mainly of three types: sands, clay, and loess. The sandy soil is found along the coastline extending from south to outside the northern border of the Strip, at the form of sand dunes. The thickness of sand fluctuates from 2 meters to about 50 meters due to the hilly shape of the dunes. Clay soil is found in the north eastern part of the Gaza Strip. Loess soil is found around Wadis, where the approximate thickness reaches about 25 to 30 m. The general land use of the Gaza Strip is divided into agricultural areas, built-up areas, and governmental areas.

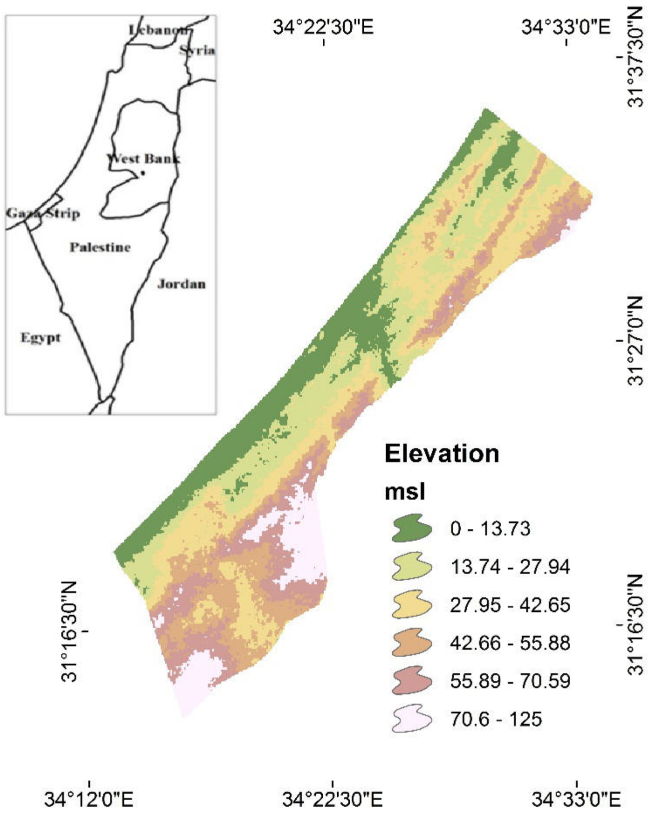

Figure 1: Location map and elevation of the Gaza strip.

Climate is usually defined as the mean weather and in broad sense; it is the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands millions of years (IPCC, 2008). As a result of emission of gases in the atmosphere, the human activities that could possibly change the climate include, industrial activities, development of extensive cities, pollution of water ways and cities, creation of thousands of dams and lakes, conversion of grassland or forest to cropland, and agricultural activities (IPCC, 2008). The Intergovernmental Panel's4th Assessment Report (AR4) (2008) on Climate Change (IPCC) provided a global context for climate change, and included the outputs from a number of global climate models (GCMs) under different greenhouse gas emission scenarios. Global climate change is interrupting the water circulation balance by changing rates of precipitation, recharge, discharge, and evapotranspiration. The world now already started to be affected due climate change impacts. Many problems start rising now, seasons are shifting, rainfalls are decreasing, temperatures are climbing so the water demand is hugely affected, and sea levels are raising causing seawater intrusion phenomena in many places. If we do not act now, climate change will permanently alter the lands and waters we all depend upon for survival (IPCC, 2008). Studies show that developing countries such as Palestine are more vulnerable to climate change and are expected to suffer more from the adverse climatic impacts than the developed countries (IPCC, 2001). Most of the Mediterranean countries are now in a risky situation according to current climate projections and its impacts on the hydrological budget and extremes. While there is scientific consensus that climate induced changes on the hydrology of Mediterranean regions are presently occurring and are projected to amplify in the future, very little knowledge is available about the quantification of these changes (Game et all, 2013).

(Gampe et all, 2013) used a remote sensing approach, to provide benchmarks for the validation of their hydrological model results, in Gaza Strip which has a data scarce area, is presented to. Evapotranspiration patterns are derived from land surface temperature (LST) and normalized difference vegetation index (NDVI). The resulting mean annual evapotranspiration of ~ 450mm seems reasonable, however likely to overestimate the real actual evapotranspiration, hence can serve as a benchmark for model validation. The final modeled evapotranspiration of ~ 400mm shows similar inter annual distributions and therefore acceptable results.

Also, (Ashour et all, 2012) analyzed the potential impacts of the temperature and precipitation changes as two main characteristics of climate change in addition to water salinity on the agricultural water demand. Changes in humidity concentration were not evaluated, nor were the changes in wind velocity and solar radiation. The study was carried out on 5 representative crops (Olive, Palm, Grape, Citrus and Guava) that cover around 83% of the orchard farms in Gaza Strip, considering eight simulated climate change conditions.

This paper aims to study and investigate the future climate change over the Gaza Strip based on the output of one or more global climate model (GCM).

2. Materials and Methods

Climate is usually defined as the "mean weather", or more precisely, as the statistical description of the weather in terms of the means and variability of relevant quantities over periods of several decades (typically three decades as defined by World Metrological Organization (WMO)). These quantities are most often surface variables such as temperature, precipitation, and wind, but in a wider sense, the "climate" is the description of the state of the climate system (IPCC, 2008). The Intergovernmental Panel on Climate Change (IPCC) developed long-term emissions scenarios in 1990 and 1992. These scenarios have been widely used in the analysis of possible climate change, its impacts, and options to mitigate climate change. This was followed by a decision by the IPCC Plenary in 1996 to develop a new set of emission scenarios (IPCC, 2000). Future greenhouse gas (GHG) emissions are the product of very complex dynamic systems, determined by driving forces such as demographic development, socio-economic development, and technological change.

The future projections are highly uncertain. Actually the emission scenarios are like alternative situation about how the future might be and it is very useful toll to examine how the driving forces may influence the future emission (IPCC, 2000). Four different storylines were developed to describe the relationships between emission driving forces and the evaluation process. Every storyline represents different demographic, social, economic, technological, and environmental developments, which may be viewed positively or negatively according to the process (IPCC, 2000). Four qualitative storylines yield four sets of scenarios called "families": A1, A2, B1, and B2. The storyline of each scenario family describes one possible demographic, politico-economic, societal, and technological future. Within each family, one or more scenarios explore the global energy industry and other developments and their implications for greenhouse gas emissions and other pollutants (CARA, 2006). The A1 storyline and scenario family describe a future world of very rapid economic growth, global population that peaks in the mid-21st century and declines thereafter, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building, and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. The A1 scenario family has three groups that describe alternative directions of technological change in the energy system (A1FI: fossil energy intensive, A1T: non-fossil energy sources and A1B: is a balance across all sources, a future world of very rapid economic growth, low population growth, and rapid introduction of new and more efficient technology) Major underlying themes are economic and cultural convergence and capacity building, with a substantial reduction in regional differences in per capita income. In this world, people pursue personal wealth rather than environmental quality. Energy supply is balanced among fossil fuel and non-fossil energy sources (CARA, 2006). The A2 storyline and scenario family describe a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing population. Economic development is primarily regionally oriented and per capita, economic growth and technological change are more fragmented and slower than other storylines (CARA, 2006). The B1 storyline and scenario family describe a convergent world with the same global population that peaks in mid-century and declines thereafter, as in the A1 storyline, but with rapid change in economic structures toward a service and information economy, and with reductions in material intensity and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social and environmental sustainability, including improved equity, but without additional climate initiatives (CARA, 2006). The B2 storyline and scenario family describe a world in which the emphasis is on local solutions to economic, social and environmental sustainability. It is a world with continuously increasing global population, at a rate lower than A2, and with intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 storylines. While the scenario is oriented around environmental protection and social equity, it focuses on local and regional levels (CARA, 2006). *"A1FI leads to the highest atmospheric CO2-concentrations, while B1 gives the lowest "(*CARA, 2006).

Numerical models (General Circulation Models or GCMs), representing physical processes in the atmosphere, ocean, cryosphere and land surface, are the most advanced tools currently Available for simulating the response of the global climate system to increasing greenhouse gas concentrations; While simpler models have also been used to provide globally- or regionally-meand estimates of the climate response. Only GCMs, possibly in conjunction with nested regional models, have the potential to provide geographically and physically consistent estimates of regional climate change which are required in impact analysis (IPCC, 2011). GCMs depict the climate using a three dimensional grid over the globe, typically having a horizontal resolution of between 250 and 600 km, 10 to 20 vertical layers in the atmosphere and sometimes as many as 30 layers in the oceans. Their resolution is thus quite coarse in relation to the scale of exposure units in most impact assessments (IPCC, 2011). Moreover, many physical processes also occur at smaller scales, such as those related to clouds, and cannot be properly modeled. Instead, their known properties must be meand over a larger scale in a technique known as parameterization. This is one source of uncertainty in GCM-based simulations of future climate. Others relate to the simulation of various feedback mechanisms in models concerning, for example, water vapor and warming, clouds and radiation, ocean circulation and ice and snow albedo. For this reason, GCMs may simulate quite different responses to the same forcing, simply because of the way certain processes and feedbacks are modeled (IPCC, 2011).

Changes in climate are calculated in reference to a baseline period and this reference baseline period is a necessity in developing climate scenarios. It serves to characterize the sensitivity of the exposure unit to present-day climate and usually serves as the base on which data sets that represent climate change are constructed. According to (IPCC, 1994), baseline period should be representative of the present-day or recent mean climate in the study region and of a sufficient duration to encompass a range of climatic variations, including several significant weather anomalies (e.g., severe droughts or cool seasons). The WMO defines a very popular climatological baseline period of 30 years that encompasses the period of 1961 – 1990 as a 'normal' period. This period provides a standard reference for many impact studies. However, observations during this time period in some regions may exhibit anthropogenic climate changes relative to earlier periods. Sources of baseline data include a wide variety of observed data, a combination of observed and model-simulated data (reanalysis data), control runs of GCM simulations, and time series generated by stochastic weather generators.

The Fifth Assessment Report (AR5) of the United Nations (UN) Intergovernmental Panel on Climate Change (IPCC) is being released in four parts between September 2013 and November 2014, superseding the 2007 Fourth Assessment Report (AR4) as the most comprehensive review of climate science and policy. These assessment reports and related updated scientific publications assist national governments in their communications with the UNFCCC and help them review their GHG emissions and plans for mitigation, potential impacts, and adaptation. General circulation models (GCMs) that describe the relationships between and dynamics of oceans and the atmosphere that together create our global climate are important fundamental tools used to assess changes in climate. Various research institutes develop their own models and report results for agreed inputs (such as RCP8.5) on a publicly accessible website (CMIP5). Various methods are then used to downscale these datasets to enhance resolution to more regional and local scales for application in climate-risk assessments. SimCLIM is integrated modeling software that ingests many of these downscaled datasets using the median (the 50th percentile, not the average) to generate ensemble results. Use of the median eliminates more extreme model results, providing a more balanced perspective of climate change for the locales in question across the range of GCM projections (URICH et all, 2014).

SimCLIM is a flexible software package that links data and models in order to simulate the impacts of climatic variations and change, including extreme climatic events, on sectors such as agriculture, health, coasts, or water resources. SimCLIM is a user-friendly “open-framework” system that can be customized and maintained by users. It contains tools for importing and analyzing both spatial (monthly, seasonal) and time-series (hourly, daily or monthly) data (Climsystem, 2011). SimCLIM-for-ArcGIS add-in enables ArcGIS users to produce spatial images of climate change in a very easy, quick, straight-forward process. The add-in is based on 20 years of development of the standalone SimCLIM tool, marketed by CLIM systems, uses outputs from global climate models, produced for the IPCC (Intergovernmental Panel for Climate Change), more specifically for the 4th assessment report1. The add-in allows for evaluating uncertainties stemming from different emission scenarios, different climate sensitivities, and different climate change models. Projections of future climate, and changes compared with the baseline climate can be produced (CLIMsystem, 2011). In this paper SimCLIM for ArcGIS. Tables (1 and 2) List of GCMs providing patterns for SimCLIM-for-ARCGIS, Available from the CMIP3 database which is managed by the Program for Climate Model Diagnosis and Intercomparison (PCMDI) (CLIMsystem, 2011).

Table 1: Forcing factor (CLIMsystem, 2011).

Privation	Forcing Factor
G	well-mixed greenhouse gases
BC	black carbon
LU	land use
O	ozone
OC	organic carbon
SO	solar irradiance
SD	sulphate direct
MD	mineral dust
V	volcanic aerosol
SI	sulphate indirect
SS	sea salt

Table 2: GCMs providing patterns for SimCLIM-for-ARCGIS (CLIMsystem, 2011).

No.	Originating Group(s), Country	Model	SIMCLIM name	Horizontal grid spacing (km)	Forcings used in model simulation
1	Bjerknes Centre for Climate Research, Norway	BCCR	BCCRBCM2	~175	G, SD
2	Canadian Climate Centre, Canada	CCCMA T47	CCCMA-31	~250	G, SD
3	Meteo-France, France	CNRM	CNRM-CM3	~175	G, O, SD, BC
4	CSIRO, Australia	CSIRO-MK3.0	CSIRO-30	~175	G, O, SD
5	CSIRO, Australia	CSIRO-MK3.5	CSIRO-35	~175	G, O, SD
6	Geophysical Fluid Dynamics Lab, USA	GFDL 2.0	GFDLCM20	~200	G, O, SD, BC, OC, LU, SO, V
7	Geophysical Fluid Dynamics Lab, USA	GFDL 2.1	GFDLCM21	~200	G, O, SD, BC, OC, LU, SO, V
8	NASA/Goddard Institute for Space Studies, USA	GISS-E-H	GISS—EH	~400	G, O, SD, SI, BC, OC, MD, SS, LU, SO, V
9	NASA/Goddard Institute for Space Studies, USA	GISS-E-R	GISS—ER	~400	G, O, SD, SI, BC, OC, MD, SS, LU, SO, V
10	LASG/Institute of Atmospheric Physics, China	FGOALS	FGOALS1G	~300	G, SD
11	Institute of Numerical Mathematics, Russia	INMCM	INMCM-30	~400	G, SD, SO
12	Institute Pierre Simon Laplace, France	IPSL	IPSL-CM40	~275	G, SD, SI
13	Centre for Climate Research, Japan	MIROC-H	MIROC-HI	~100	G, O, SD, BC OC, MD, SS, LU, SO, V
14	Centre for Climate Research, Japan	MIROC-M	MIROCMED	~250	G, O, SD, BC OC, MD, SS, LU, SO, V
15	Meteorological Institute of the University of Bonn, Meteorological Research Institute of KMA, Germany/Korea	MIUB-ECHO-G	ECHO---G	~400	G, SD, SI
16	Max Planck Institute for meteorology DKRZ, Germany	MPI-ECHAM5	MPIECH-5	~175	G, O, SD, SI
17	Meteorological Research Institute, Japan	MRI	MRI-232A	~250	G, SD, SO
18	National Centre for Atmospheric Research, USA	NCAR-CCSM	CCSM—30	~125	G, O, SD, BC, OC, SO, U
19	National Centre for Atmospheric Research, USA	NCAR-PCM1	NCARPCM1	~250	G, O, SD, SO, V
20	Hadley Centre, UK	HADCM3	UKHADCM3	~275	G, O, SD, SI
21	Hadley Centre, UK	HADGEM1	UKHADGEM	~125	G, O, SD, SI, BC, OC, LU, SO, V

The International Energy Agency (IEA) has released unpublished estimates of 2010 global carbon dioxide (CO_2). Between 2003 and 2008, emissions had been rising at a rate faster than the IPCC worst case scenario. However, the global recession slowed the emissions growth considerably, and in fact they actually declined slightly from 29.4 billion tons (gigatons, or Gt) CO_2 in 2008, to 29 Gt in 2009. However, despite the slow global economic recovery, 2010 saw the largest single year increase in global human CO_2 emissions from energy (fossil fuels), growing a whopping 1.6Gt from 2009, to 30.6 Gt (the previous record annual increase was 1.2 Gt from 2003 to 2004). As illustrated in **Figure (2)**, in 2009, we had dropped into the middle of the IPCC Special Report on Emissions Scenarios (SRES) scenarios, but the 2010 increase has pushed us back up toward the worst case scenarios once again. According to all of that A1F1, the scenario with high sensitivity is much closer to what the world is doing. That is why A1FI - high will be used in the climate future projection processes in this paper.

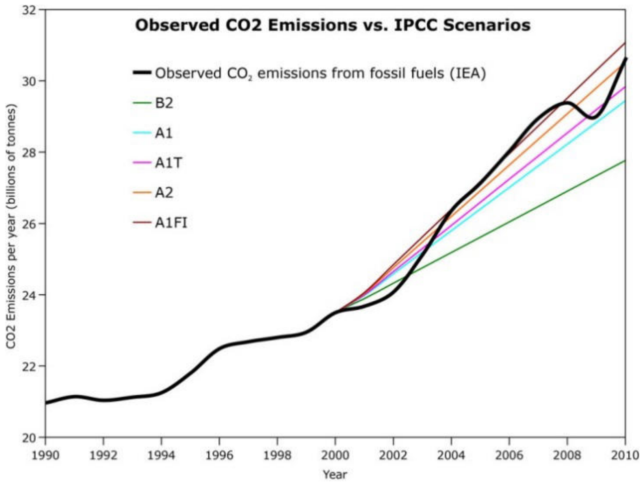

Figure 2: IEA global human CO_2 annual emissions from fossil fuels estimate vs. IPCC SRES scenario

projections.

Many equilibrium and transient climate change experiments have been performed with GCMs (Kattenberg et al., 1996). Several research centers now serve as repositories of GCM information (IPCC, 2001). In the Gaza strip, taking the output of just one GCM is not very close to what we want because it is the first time that a future projection will be made for this area, and it's not accurate to take any GCM instead of other one. Outputs from different GCM vary widely, especially for precipitation. We only can judge the performance of a GCM in relation to other GCM's. The accepted approach for our area is to use an ensemble of multiple GCM's, and when the median approach is used (taking the median of the GCM outputs, instead of the mean), the all used 21 Available GCM's is the way to go. SimCLIM software can do that and provide a pre-calculated ensemble for ArcGIS-toolbar.

The precise modeling of climate change is limited, in our study, we will use SimCLIM model over three time interval (2020, 2050, and 2080) and A1F1 emission scenario with high sensitivity in order to project the future climate for the Gaza strip and the process will be conducted as shown in **figure (3)**.

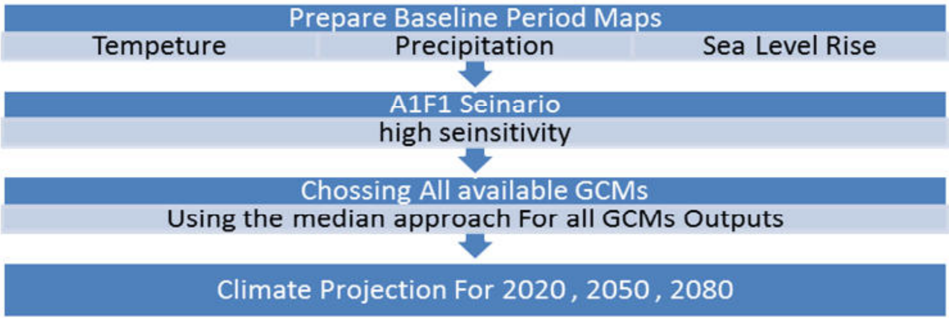

Figure 3: Climate change projection process.

3. Results and Discussions

According to Gaza strip hydrological cycle the winter season is from October to March during six months, the summer season is from April to September. **Figure (4 - 6)** show the baseline maps mean temperature for the winter, summer and annual mean temperature for the baseline period, respectively. The maximum temperature for the baseline map is in august (26.29 ^{o} C) and the minimum temperature is in January (12.50^{o}C), for the summer season the mean temperature is 23^{o} C and for winter is 16.56 ^{o} C that leads to 19.8 mean annual temperature for the baseline period. Temperatures standard deviation in the monthly baseline raster maps for each cells increase in the winter season and decrease in the summer season so that we can say that in the winter season there is a real special difference in temperature. The reason for this difference is the location of the Gaza strip between Asia and Africa and the semiarid characteristics for this area. Figures (7 - 9) show the baseline maps mean Precipitation for the winter, summer and annual mean precipitation for the baseline period, respectively. The maximum precipitation for the baseline map is in January (135.39 mm) and the minimum precipitation is in Jun (Zero mm) , for the summer season the mean total precipitation is 11.479 and for winter is 307.036 that leads to 318.521 mean total annual precipitation for the baseline period. Precipitation standard deviation in the monthly baseline raster maps for each cells increases in the winter season and decreases in the summer season. However, it fluctuates in the winter season so that we can say in the winter season there is a real spatial difference in precipitation. In addition, the reason for this difference is the location of the Gaza strip between Asia and Africa and the semiarid characteristics for this area.

The projection of future temperatures in 2020 shows that the absolute mean temperatures in the summer season will be in the range of 23.77^{o}C to 24.16^{o}C. The warmest area for summer season in the Gaza strip is the south-east area and the colder one is the Gaza city area. On the other hand for winter season, the absolute mean temperatures will be in the range of 16.82 ^{o} C to 17.67 ^{o} C. The warmest area for winter season in the Gaza strip is north-east area and the coastal middle area and the coldest area for winter season is south-west area. Figure (10) shows the annual mean projected temperatures for 2020, and as shown in it the mean annual temperatures range from 20.35o c to 20.88 o c. The south-west area is the coldest area in the Gaza strip for 2020, and the warmest areas are east-middle area and coastal south area. In addition, the minimum temperatures are at January and it ranges from 14.30oC to 13.20oC with raster map mean temperatures 13.89oC and 0.3oCstandard deviation. The maximum temperature is at august and it ranges from 27.27oC to 26.77oc with raster map mean temperature 27.02 o c and 0.10oC standard deviation. The projection of the future temperatures in 2050 shows that the absolute mean temperatures in the summer season will range from 25.76oC to 26.15oC. The warmest area for summer season in the Gaza strip is the south-east area and the colder one is the Gaza city and west village area. In other hand for winter season, the absolute mean temperatures will range from 18.49^{o}C to 19.334 ^{o}C. The warmest area for winter season in the Gaza strip is north-east area and the coastal middle area.

Furthermore, the coldest area for winter season is south-west area. **Figure (11)** shows the mean projected annual temperature for 2050.

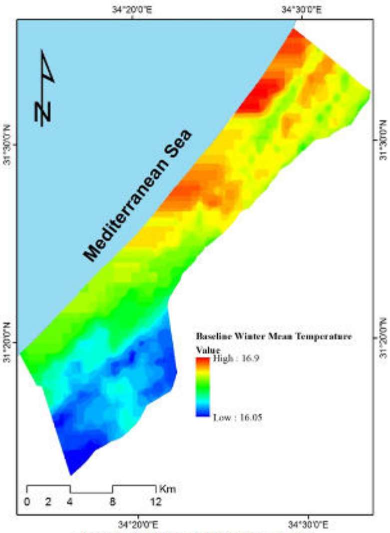

Figure 4: Winter mean temperature (1972 – 2002).

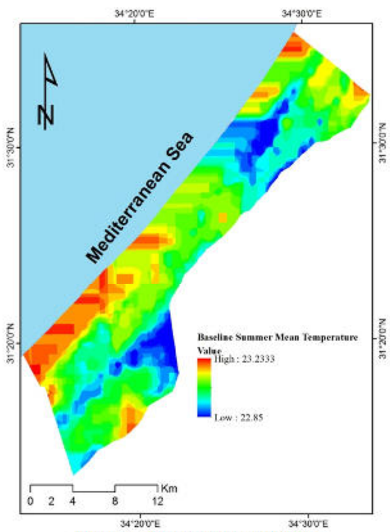

Figure 5: Summer mean temperature (1972 – 2002).

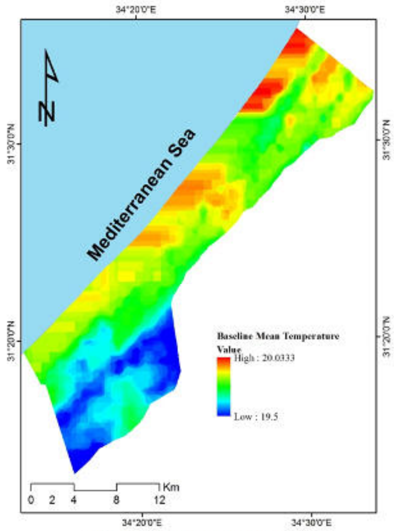

Figure 6: Mean annual temperature (1972 – 2002).

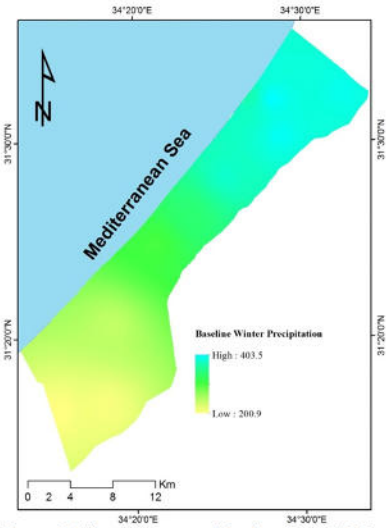

Figure 7: Winter mean precipitation (mm) (1972 – 2002).

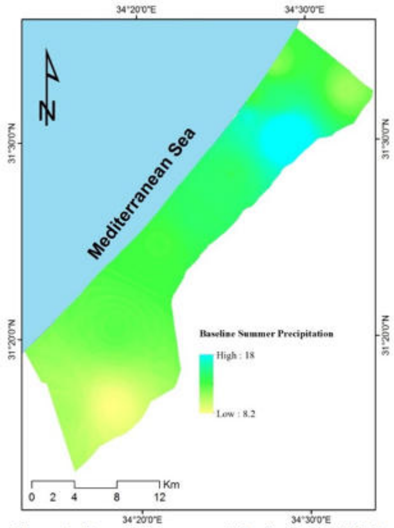

Figure 8: Summer mean precipitation (mm) (1972 – 2002).

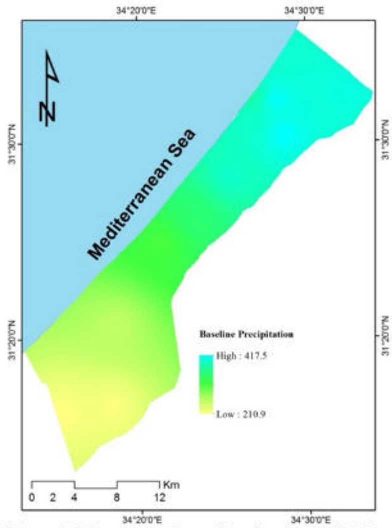

Figure 9: Mean annual precipitation (mm) (1972 – 2002).

In addition the mean annual temperatures range from 22.18° C to 22.77° C, the south-west area is the coldest area in the Gaza strip for 2050 and the warmest area areas are east-middle and coastal south area. The minimum temperatures are at January and they range from 14.71° c to 15.81° c with raster map mean temperatures 15.39°C and 0.296°C standard deviation. The maximum temperature is at august and it ranges from 28.85°C to 29.35°C with raster map mean temperature 29.10°C and 0.0951°C standard deviation. The projection of future temperatures in 2080 shows that the absolute mean temperatures in the summer season will range from 28.61°C to 28.99°C. The warmest area for summer season in the Gaza strip is the south-east area; and the colder one is the Gaza city and west village area. On the other hand, for winter season, the absolute mean temperatures will range from 20.88°C to 21.70°C. The warmest area for winter season in the Gaza strip is north-east area and the coastal middle area. Moreover, the coldest area for winter season is south-west area. Figure (12) shows the annual mean projected temperatures for 2080. In addition the mean annual temperatures range from 24.80°Cto 25.30°C, the south-west area is the coldest area in the Gaza strip for 2080 and the warmest area areas are east-middle and coastal south area. Furthermore, the minimum temperatures are at January and it ranges from 16.87°C to 17.97°C with raster map mean temperatures 17.55°C and 0.296°C standard deviation. The maximum temperature is at august and its ranges from 31.82°C to 32.32°C with raster map mean temperature 32.07°C and 0.098°C standard deviation.

The projection of future precipitation in 2020 for the absolute precipitation in the summer season will range from 7.70 mm to 16.89 mm. The maximum precipitation area for summer season in the Gaza strip is the Gaza city area, and the minimum one is the south-west area. On the other hand, for winter season the absolute precipitation will range from 165.90 mm to 373.50 mm. The maximum precipitation area for winter season in the Gaza strip is northern area, and the minimum precipitation area for winter season is south-west area. Figure (13) shows the annual projected absolute precipitation for 2020. In addition, the projected precipitation ranges from 195.33 to 366.32mm. The south-west area has the minimum absolute precipitation value in the Gaza strip for 2020 and the maximum absolute precipitation value will be in southern and middle areas. The minimum precipitation is at June and its equal zero mm ; the maximum precipitation is at January and its range from 55.33 mm to 126.78 mm with raster map mean precipitation 91.08 mm and 21.31 mm standard deviation. The projection of future precipitation in 2050 shows that the absolute precipitation in the summer season will range from 6.66 mm to 14.52 mm. The maximum precipitation area for summer season in the Gaza strip is the Gaza city area; and the minimum one is the south-west area. On the other hand, for winter season the absolute precipitation will range from 153.87 mm to 307.66 mm. The maximum precipitation area for winter season in the Gaza strip is northern area, and the minimum precipitation area for winter season is south-west area. **Figure (14)** shows the annual projected absolute precipitation for 2050. Moreover, the projected precipitation ranges from 162.03 mm to 319.63 mm. The south-west area has the minimum absolute precipitation value in the Gaza strip for 2050 and the maximum absolute precipitation value will be in southern and middle areas. The minimum precipitation is at June and its equal zero mm; the maximum precipitation is at January and it ranges from 47.49 mm to 108.34 mm with raster map mean precipitation77.93 mm and 18.150 mm standard deviation. The projection of future precipitation in 2080 shows that the absolute precipitation in the summer season will be range from 5.16 mm to 11.15 mm. The maximum precipitation area for summer season in the Gaza strip is the Gaza city area and the minimum one is the south-west area. On the other hand, for winter season the absolute precipitation will range from 108.08 mm to 215.08 mm. The maximum precipitation area for winter season in the Gaza strip is northern area. In addition, the minimum precipitation area for winter season is south-west area. **Figure (15)** shows the annual projected absolute precipitation for 2080. Moreover, the projected precipitation range from 114.44 mm to 224.31 mm, the south-west area has the minimum absolute precipitation value in the Gaza strip for 2080, and the maximum absolute precipitation value will be in the southern and middle areas. The minimum precipitation is at June and its equal zero mm , the maximum precipitation is at January and its range from 36.29mm to 81.99 mm. with raster map mean precipitation 59.13 mm and 3.61 mm standard deviation.

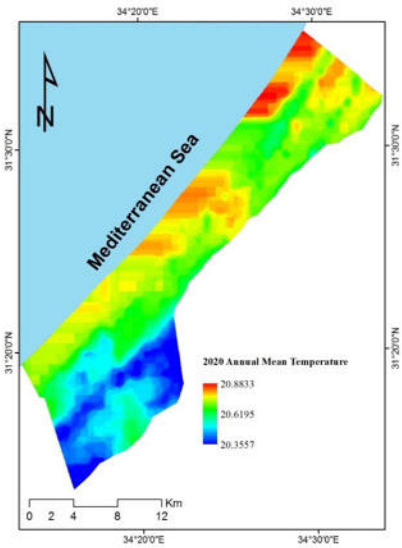

Figure 10: Mean annual projection temperature for 2020.

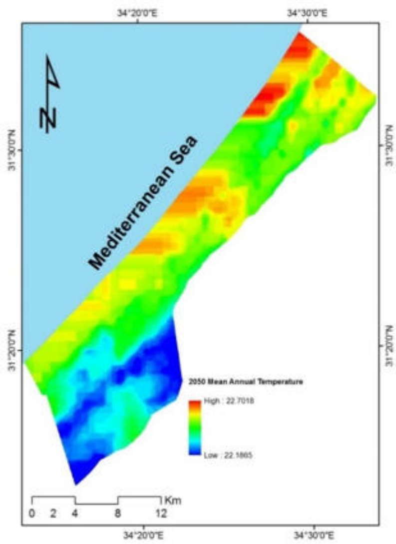

Figure 5. 11: Mean annual projection temperature for 2050.

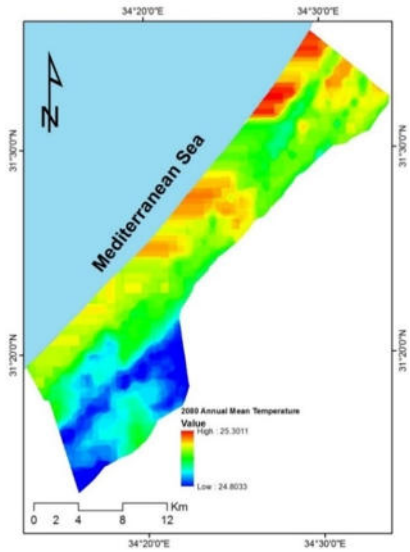

Figure 5. 12: mean annual projection temperature for 2080.

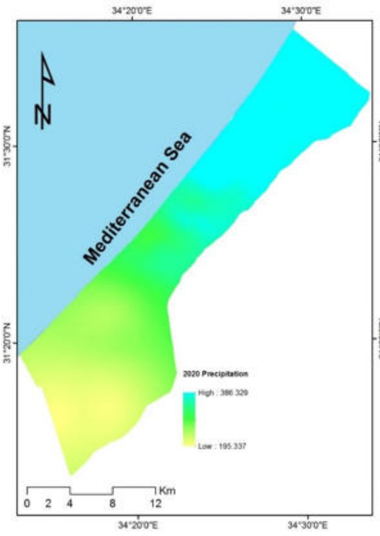

Figure 13: Annual projection precipitation for 2020.

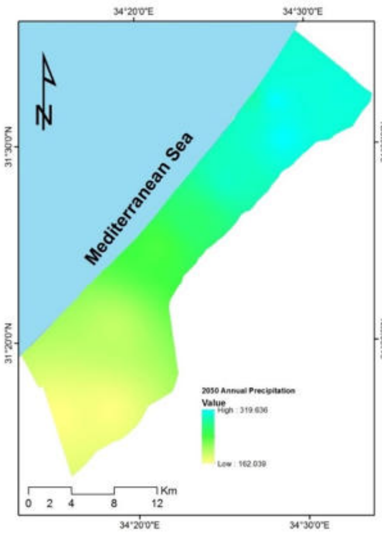

Figure 14: Annual projection precipitation for 2050.

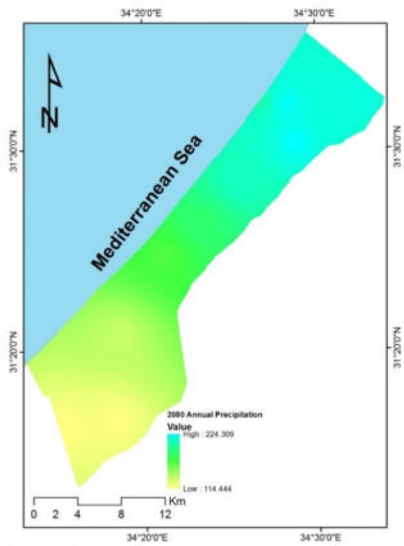

Figure 15: Annual projection precipitation for 2080.

Figures (16 & 17) show all of monthly mean projected temperature and precipitation respectively these two charts illustrate all of projected years from baseline to 2080.

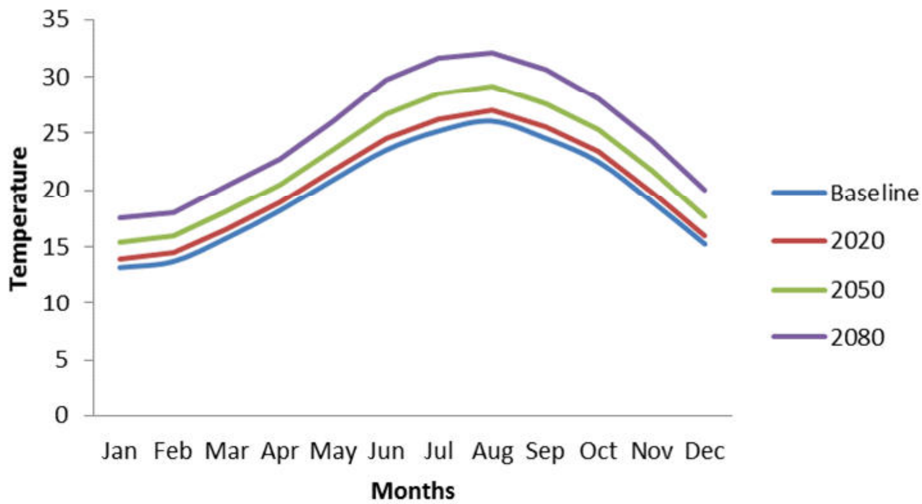

Figure 16: Projected temperature.

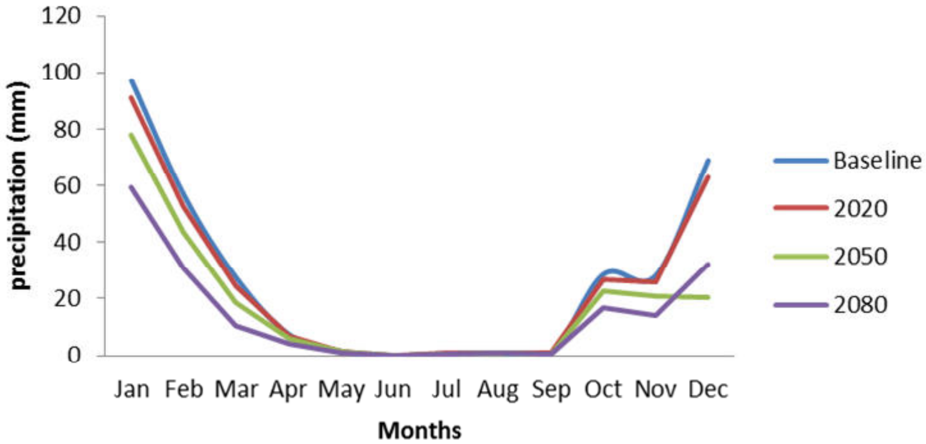

Figure 17:Projected precipitation.

The SimCLIM Sea-level Scenario Generator contains tabled year-by-year output from 'Model for the Assessment of Greenhouse Gas Induced Climate Change' (MAGICC), a simple global climate model, as forced by the six key SRES greenhouse gas emission scenarios are used by the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report. For each scenario, low, mid and high projections are provided for global-mean changes in temperature, sea level (thermal expansion only) and sea level (total, including ice melt). The corresponding values for atmospheric concentrations of carbon dioxide are also provided. For each emission scenario, three projections of estimated eustaticsea-level changes from 1990 to 2100 are provided, for three sets of sensitivity values (SimCLIM, 2011).

The global baseline period raster map for sea-level rise provided by SimCLIM, from this map we can figure that the minimum sea-level value is -0.140 cm and the maximum value is 2.180 cm with mean value 0.994 cm and standard deviation 0.322 cm. Moreover, by focusing on our study area the baseline period value for sea level rise is from 0.943 cm to 1.252 cm with mean value 1.097cm. By using SimCLIM and the emission scenario A1F1 with the median assemble for all Available GCM as previously discussed and by using the same discussed projection procedure, we can get figure (18) with the sea-level rise projection for all years until 2100 with three sensitivity cases low, mid and high sensitivity. It is considered in the discussed projection methodology. Three regression curves with its equations were developed for each projected sensitivity curve in order to make the projection processes very simple. For the three considered projection period 2020, 2050 and 2080.Table (3) illustrates the projected sea-level rise values for three sensitivity.

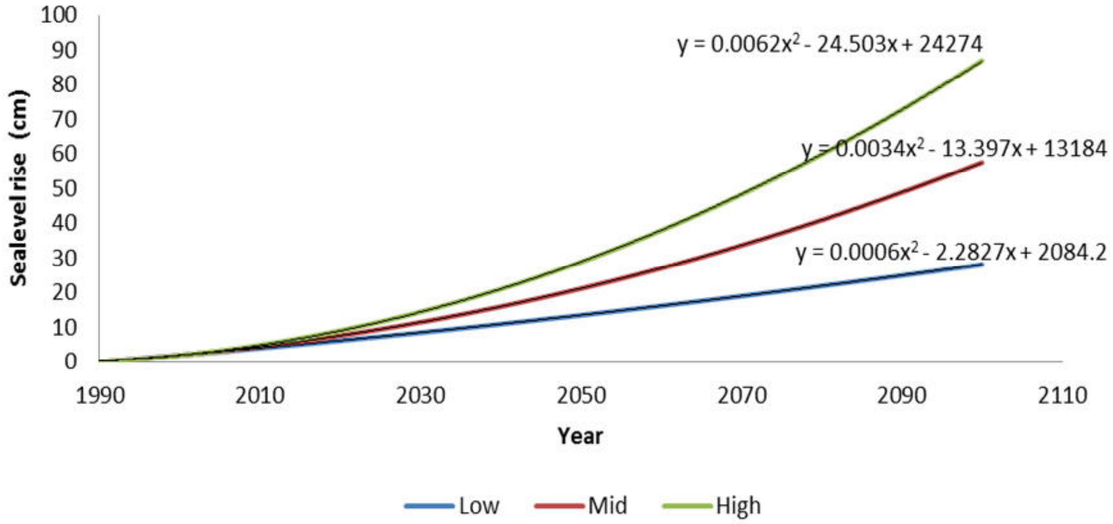

Figure 18: Sea-level rise projection.

Table 3: Projected Sea-level Rise values.

Year	Sensitivity		
	Low (cm)	Mid (cm)	High (cm)
2020	6.14	7.59	9.04
2050	13.48	21.16	28.84
2080	21.92	40.88	59.85

4. Conclusions

Climate change is already beginning to transform life on earth. Around the globe, seasons are shifting, rainfalls are decreasing, temperatures are climbing so water demands are increasing, and sea levels are raising causing seawater intrusion. If we do not act now, climate change will permanently alter the lands and waters we all depend upon for survival (IPCC, 2007). Studies show that developing countries such as Palestine are more vulnerable to climate change and are expected to suffer more from the adverse climatic impacts than the developed countries (IPCC, 2001). As such, predicting the future climate changes is essential for stratigic plannig activities. In this paper the annual mean values for temperature and precipitation for the priod from 1972 to 2002 were used as baseline for the modelling procedure. A1F1 with high sensitivity is the emission scenario that was used for the prediction process because it reflects the worst and current situation. The median assembly approach was used to get the representative results from multi GCM outputs. 20.66 °C, 22.48°C and 25.08°C were the predicted annual mean temperatures for years 2020, 2050 and 2080 respectively. 0.85 °C, 2.67 °C and 5.28 °C were the mean annual changes from baseline period for years 2020, 2050 and 2080 respectively. 294.68 mm/year, 243.7 mm/year and 170.819 mm/year were the predicted annual mean precipitation for years 2020, 2050 and 2080 respectively. -7.48 mm/year -23.98 mm/year and -46.37 mm/year were the predicted mean annual precipitation changes from baseline period for years 2020, 2050 and 2080 respectively. 1.097 cm was the mean sea level rise for baseline period for the Gaza strip location area. 9.04cm, 28.84 cm and 59.85 cm were the predicted mean sea level rise values for years 2020, 2050 and 2080 respectively.

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