# THESIS

## SUSTAINABLE DEVELOPMENT OF GROUNDWATER FOR GAZA STRIP IN PALESTINE




Submitted by

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## ABSTRACT

Gaza strip is a semi arid region encompassing an area of 365 $km^2$. It is bordered by the Mediterranean Sea in the northwest and the Negev Desert in the south and southeast and Egypt southwest. Israel (Palestinian Occupied Territories 1948) borders the Gaza Strip in the northeast. It consists of five Governorates: North, Gaza, Middle, Khanyounis, Rafah.

The Gaza Strip is a land under great pressure in terms of water resources. It is extremely densely populated, with its population of more than 1,500,000 inhabitants, and a population density of about 2500 persons per square kilometer. The groundwater environment in Gaza has been under great strain for some time and now in crisis one from which its people suffer severely today. Moreover, the water crisis creates agricultural, economic, social, and political instabilities that have regional ramifications. Most of the existing problems are a direct and indirect result of Israeli Occupation policy.

Water is presently accessed through pumping by more than 3500 irrigation and municipal wells with a total estimated annual extraction of about 150 million cubic meters (MCM) and the natural recharge of the aquifer is estimated to be about 118 MCM/year. The gap between the aquifer recharge and the resource overexploitation is worsening the groundwater regime in Gaza.

This study was framed to determine present and future groundwater recharge and withdrawal requirements in both quantitative and qualitative aspects for the Gaza strip

area. It also aimed to assess groundwater flow pattern under different future recharge and discharge conditions and to ascertain risk of sea water intrusion in the area. MODFLOW with MT3D package groundwater flow modeling software was used to evaluate the groundwater flow and contaminant transport for the area. The groundwater modeling require a huge amount of data and field inspections .and limited data could be gathered; therefore calibration of groundwater and solute transport model could not be carried out. Thus results and inferences presented in this study may be considered as generally applicable only.

The initial data of hydraulic heads and chemical concentrations of year 2005 have been used for the running of the non calibrated model. The distribution of the water discharge on different Gaza Governorates was judged with accordance to different issues: population, the number of legal wells, and the agriculture intensity of every governorate. While the recharge data was available for the entire area of the Gaza coastal aquifer, it have been analyzed on a percentage basis and divided among different model zones.

The modeling results show continuous declination of the ground water level by 6-10 m over next 30 years with value as low as 4 m below average mean sea level (amsl) at some places. This could result in risk of sea water intrusion of 3-5 Km in the area of coastal regions. The ground water quality in turn deteriorates due to the large difference between the amount of natural recharge and the groundwater abstraction in different Gaza Strip Governorates. The modeling results show clear groundwater quality degradation for majority of areas in Gaza strip. It shows elevated values of chloride (salinity), nitrate, and

total dissolved solids. These elevated values are highly above the WHO recommendations of the potable water quality. This study has revealed that groundwater in Gaza aquifer is not sustainable as the water table depth in the strip is continuously declining and the stress is ever-increasing. If the pumping continues at these unsustainable rates, it will destroy the aquifer's capacity to resist sea water intrusion from the Mediterranean and saline lateral inflow from the east of the Gaza strip, thereby making it totally unsuitable for human consumption or for irrigated agriculture within the next few decades.

In order to protect the Gaza aquifer from its getting impaired or permanently lost and to ensure sustainable groundwater supplies, groundwater management measures in the strip are absolutely required. Several sustainable management projects are very important to achieve the sustainability of Gaza groundwater resources like changing the irrigation techniques and cropping pattern to lower the water consumption for irrigation purposes, to evaluate alternative water resources such as large scale desalinization plants, water demand reduction measures should be used in municipal areas to decrease municipal water demand as well sewage quantum, rules , legislations and practical implementations should be employed to prevent the illegal wells phenomena to reduce irrigation water extraction, remedial measures and public awareness programs should be initiated to reduce the use of pesticides, sewage and industrial waste infiltration.