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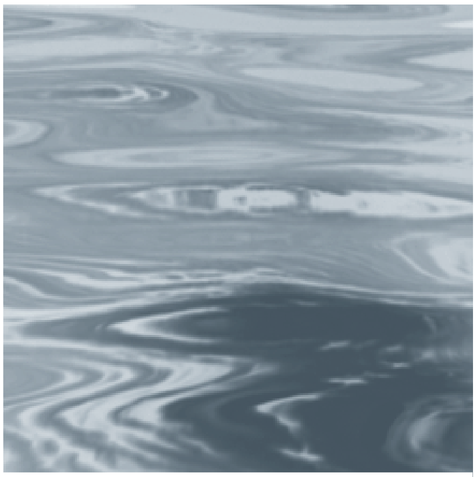
The effect of urban expansion on groundwater as a renewable resource in the Gaza Strip



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Volume 5, Number 8
April 2005

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The effect of urban expansion on groundwater as a renewable resource in the Gaza Strip

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Abstract

The required quantity of drinking water in the urban areas of the Gaza Strip has rapidly increased in recent years as a result of the rapid growth in population. This growth has been largely due to the Palestinian returnees from Arab countries following the Oslo Agreement in 1993 between the Palestinian Liberation Organization (PLO) and Israel. Because the region is essentially semi-arid, with mean annual rainfall of about 300mm occurring in only 5 months of the year and high evaporation, surface water resources are non-existent and the coastal groundwater aquifer in Western Gaza is solely relied upon as the source of drinking water. Being a coastal aquifer, adequate recharge and careful management of abstraction are important to prevent the saltwater intrusion problems commonly associated with groundwater mining. The sandy soil texture of the Gaza Strip, with its high infiltration capacity, should ensure that much of the annual rainfall percolates to recharge the aquifer; however, this prospect has been threatened by the increased urbanization - expansion of cities and refugee camps over the surrounding sand dunes, destruction of agricultural lands, soil compaction and tiling of roads and squares - which has increased the overland run-off at the expense of infiltration and groundwater recharge. As a result, an increasing amount of the rainfall is being lost to the sea as runoff, a situation made worse by the region's topography, which generally slopes towards the sea. The purpose of this paper is to present the current state of the water resources situation in the Gaza Strip and then outline some simple, sustainable paradigms for controlling the runoff at source so that more of it could be channeled towards groundwater recharge, the increased urbanization notwithstanding. It will be argued that unless these steps are taken and enshrined in the planning policy of the Gaza Strip, the problem could get worse.

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Introduction

Today, nearly half of the world's population live in cities. In developing countries such as the Gaza Strip, people are deserting rural areas while the population is rising rapidly in the urban centres (Al-Haddad, 2003). Physical planning and planning policy for the Palestinian areas of the Gaza Strip had, during the period of occupation, rested with the Israeli government. The situation continued until the early 1990's when such functions were transferred to the Palestinian Authority (PA), following the peace process between the PLO and Israel. The new Authority was therefore not only faced with the difficult task of accommodating the rapidly growing population but also with coping with the intense pressures placed on the limited land and other natural resources as a consequence.

At the inception of the PA, only rudimentary governmental planning institutions were functioning. Neither national, regional nor any other form of overall planning existed and only the largest municipalities had anything resembling planning units. This, coupled with the Israeli actions towards the Palestinian cities, meant that planning by the PA tended to be of an emergency nature. In short, the technical and administrative facilities available to the PA at inception fell far short of those needed for a modern planning institution to cope with the enormous tasks of planning for the rebuilding and development of Palestine (Ali Shaat, 2002).

The Gaza Strip has limited water resources and ground water is just about the only resource that can be used to support the future urban expansion. However, the development of this groundwater resource has to take place against the backdrop of the stringent restrictions imposed by the Israeli government on the Palestinians concerning the development of their resources and infrastructure. No development is allowed within 0.5 kilometres of the eastern and southern borders of the Gaza Strip. More than 30% of the land area of the Gaza Strip is considered to be security zones; Palestinains need special permission to enter these areas and in these areas, all the resources - including water - are reserved for the use of the Israelis.

The main aquifer in the Gaza Strip is part of what is known as the coastal plain aquifer. This aquifer covers the whole area of the Gaza Strip and extends over a distance of 120 km. It has a width of 7 to 20 km (PNA, 2002). The aquifer is replenished mainly from the infiltration of rainwater but this infiltration has gradually decreased due to the random urbanisation. This has led to a reduction of agricultural lands and an increase in the runoff towards the sea, leaving little water available for the recharge of the aquifer. According to a recent estimate (El-Kharuby, et al., 2003), the water shortage in the Gaza Strip is approximately 25 millions m^3 a year; this will double in 10 years time if the urbanisation continues at current pace, with its effect on infiltration and groundwater recharge.

In this paper, an attempt is made to assess the urban expansion in the Gaza Strip and its effect on groundwater recharge. It will be argued that for the groundwater to continue to be sustainable and meet the demand, the unbridled urbanisation of the highly porous sand dunes must be checked. As possible ways of achieving this, the paper describes some mitigation measures largely based on source control of rainwater runoff and encouraging its infiltration to recharge groundwater. The challenges for these proposed solutions are discussed within the overall context of urban planning policy for the Gaza Strip.

Brief history of urban development in the Gaza Strip

The urban development of the Gaza Strip has been strongly influenced by the political situation. Consequently, there have been three phases of urban expansion from 1948 up to now:

- **Pre-1948**: Before the 1948 war and establishment of Israel, the rural population of the Gaza Strip represented 32% of the total population, and most of the residents were the original Gaza Strip population. The area presently called the Gaza Strip was formerly part of the sub-district of Palestine during the British mandate period (see Figure 1). It was one of 18 sub-districts with a total area of 1111.5 km^2 (El-Dabag, 1987).

- **The Egyptian period from 1948 to the 5th June 1967**: The Gaza Strip with its present, much reduced area of 365 km^2 (see Figure 2) first came into existence 50 years ago in 1948, after the Israeli-Arab war. During this epoch, this Palestinians' area of the Gaza Strip was under Egyptian rule while the rest of the region was under Israeli occupation. The occupation was characterised by movements of Palestinian refugees towards the Gaza Strip, who settled in refugee camps attached to the original urban areas. As a consequence, the urban population increased rapidly, while the rural population declined to a mere 10% of the total population, which is a third of its original population.

- **The Occupation period from 10th June 1967 to 25th April 1994**: The Gaza Strip fell completely under the Israeli occupation, with approximately 14% of the region being declared as military zones. Urban planning and housing projects were taken over by the Israeli military administration whose overriding criteria were Israeli security issues and the use of all available resources of the Gaza Strip for the benefit of the Israeli occupying forces. Indeed, the military zones contain the most high-yielding, high-quality water aquifers in the Strip (see Figure 3) and its control meant that Gaza Strip citizens were deprived of the groundwater resources on which they depend. To compound the situation, dams were built to change the flow direction of Wadi Gaza to be used for the Israeli's use.

Since the truce with Israel in 1994,the urban population has increased rapidly due to the return of Palestinians from neighbouring Arab countries. Most of the returnees prefer to settle in the urban areas due to the culture and experience that they had gained while in exile. As shown in Table 1, the built up area has been projected to almost double its 1997 area by the year 2010.

All of this is placing enormous pressures on the infrastructures including water resources, and the increased built-up area occasioned by the new housing units, which represent a major land use change, is bound to affect the relative magnitudes of the water balance components of the hydrological cycle. The increased water abstraction from the aquifers to meet the rising water demands is already leading to significant depression of the water table, pollution from saltwater intrusion and general deterioration in the water quality. For example, as shown in Figure 3, chloride and nitrate concentrations have reached 1200


Lebanon
Syria
Mediterranean Sea
West Bank
Gaza Strip
Jordan
Israel
Egypt
Saudi Arabia
Red Sea
Figure 1

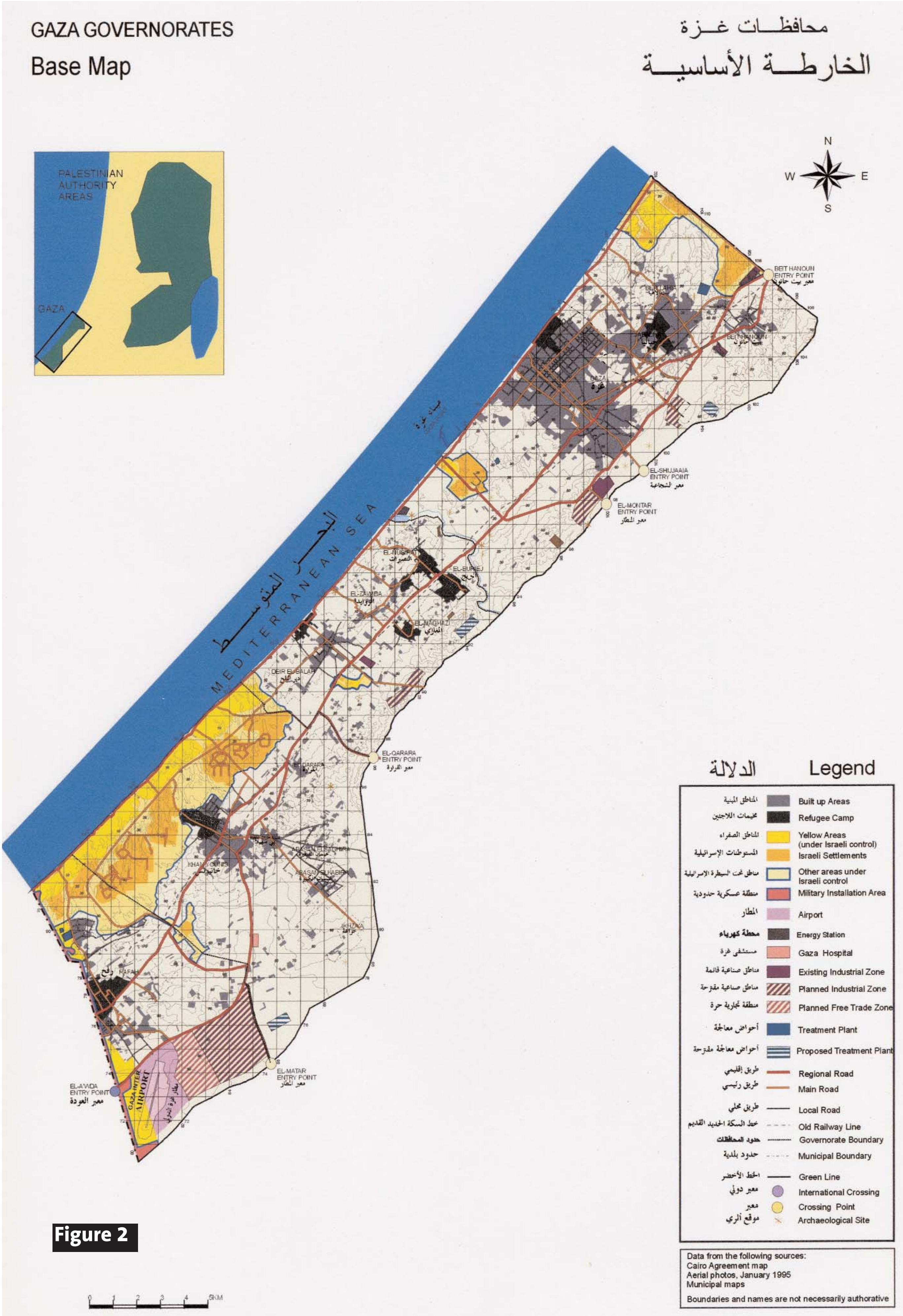
GAZA GOVERNORATES
Base Map
محافظـــات غــزة
الخارطـــة الأساسيـــة
PALESTINIAN AUTHORITY AREAS
GAZA
N
W
E
S
MEDITERRANEAN SEA
البحـــر المتوســـط
BEIT HANOUN ENTRY POINT
معبر بيت حانون
EL-SHUJAAIA ENTRY POINT
معبر الشجاعية
EL-MONTAR ENTRY POINT
معبر المنطار
EL-QARARA ENTRY POINT
معبر القرارة
EL-MATAR ENTRY POINT
معبر المطار
EL-A'WDA ENTRY POINT
معبر العودة
GAZA INTER AIRPORT
EL-NUSEIRAT
EL-BUREIJ
EL-ZAWAIDA
EL-MAGHAZI
DEIR EL-BALAH
EL-QARARA
KHAN YOUNIS
KHUZA'A
RAFAH
الدلالة
Legend
Built up Areas
Refugee Camp
Yellow Areas (under Israeli control)
Israeli Settlements
Other areas under Israeli control
Military Installation Area
Airport
Energy Station
Gaza Hospital
Existing Industrial Zone
Planned Industrial Zone
Planned Free Trade Zone
Treatment Plant
Proposed Treatment Plant
Regional Road
Main Road
Local Road
Old Railway Line
Governorate Boundary
Municipal Boundary
Green Line
International Crossing
Crossing Point
Archaeological Site
Data from the following sources:
Cairo Agreement map
Aerial photos, January 1995
Municipal maps
Boundaries and names are not necessarily authorative
0 1 2 3 4 5KM

Figure 2

mg/l and 300 mg/l respectively in some areas, much higher than WHO recommended standards.

Table 1: Current and projected housing units for the Gaza Strip (MOPIC, 1998).

Year	Built up area (km^2)	Number of houses
1997	54.25	152,851
2005	68.49	203,681
2010	94.65	297,111

Groundwater protection through catchment management

The important groundwater areas are located in the northern and southern areas of the Gaza Strip. These areas are divided into two categories, namely those areas where the groundwater is as yet relatively unpolluted by human activities and where the salinity is very low, and those where the groundwater is mined and heavily polluted by saltwater intrusion (see Figure 3). The continued growth of the population and increase in built up areas over the sandy dunes in the good aquifer areas will reduce both the infiltration of rainwater and groundwater natural recharge, thus threatening ground water quality and quantity.

Given the above, delineating and protecting recharge areas for the groundwater aquifers must be a priority for the Gaza administration, but such an attempt is bound to conflict with the new urban development strategy of the PA whose overriding priority is the provision of housing units to accommodate the refugees. It is therefore no surprise that the Gaza Strip, with its existing borders and increasing population, will find it hard to evolve an environmentally sound urban expansion but there is no shying away from the fact that this is precisely what is needed.

At present, the only protected areas are those locations in the Israeli settlements of the Gaza Strip, which were originally selected by the Israelis to control Palestinian water resources through a number of military laws, e.g. 1-98/1967, 2-158/1967 and 3-291/1968, thereby guaranteeing adequate water provision for the Israelis. While these areas will be gradually handed back to the Palestinians as part of the Oslo Agreement, signed in 1993, other areas of protection would be needed in order to achieve the level of groundwater recharge to reverse the degradation currently evident in the Gaza Strip.

Based on the soil texture (Figure 4) and chloride concentration (Figure 3) maps, the following areas offer the most promise for groundwater protection and are proposed:

- The sandy dunes area in the south-western part of Gaza (Rafah/ Khan younis)
- An-Nuseirat beach, Wadi Gaza and Netzarim (Israeli settlement)
- Beit Lahia, Beit Hanun and Jabalia sandy dunes.

Unfortunately, the randomised urban expansion to accommodate the Palestinian refugees that took place during the Israeli occupation included these areas. Moreover, the Israeli settlements built after the 1967 war were founded on the best groundwater aquifers of the Gaza Strip. Today there are 19 such settlements in the Gaza Strip, occupying around 13% of the total area. Apart from the Israeli policy, which has tended to restrict freshwater availability to the Palestinians, the Palestinian planning institutions were also faced with accommodating the planning problems generated by international donors. Table 2 shows the donated housing projects, which are also located within the proposed groundwater protection areas. While these donation projects will become a core of the future urban expansion, they nonetheless will contribute to further reduction of the proposed protected areas. This calls for an

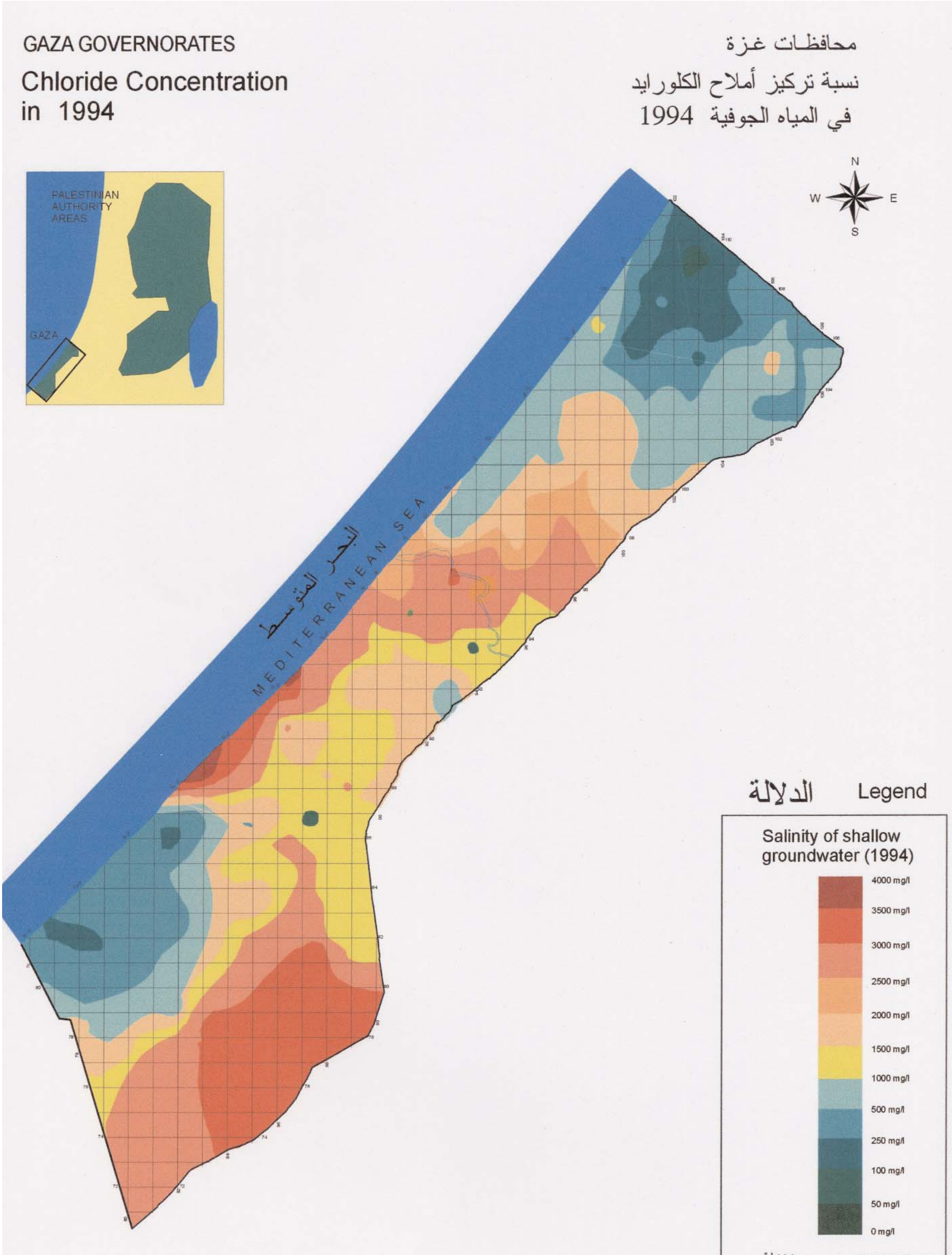
GAZA GOVERNORATES
Chloride Concentration in 1994
محافظات غزة
نسبة تركيز أملاح الكلورايد
في المياه الجوفية 1994
PALESTINIAN AUTHORITY AREAS
GAZA
N
W
E
S
البحر المتوسط
MEDITERRANEAN SEA
الدلالة
Legend
Salinity of shallow groundwater (1994)
4000 mg/l
3500 mg/l
3000 mg/l
2500 mg/l
2000 mg/l
1500 mg/l
1000 mg/l
500 mg/l
250 mg/l
100 mg/l
50 mg/l
0 mg/l
حدود دولية
International Border
الخط الأخضر
Green Line

Figure 3

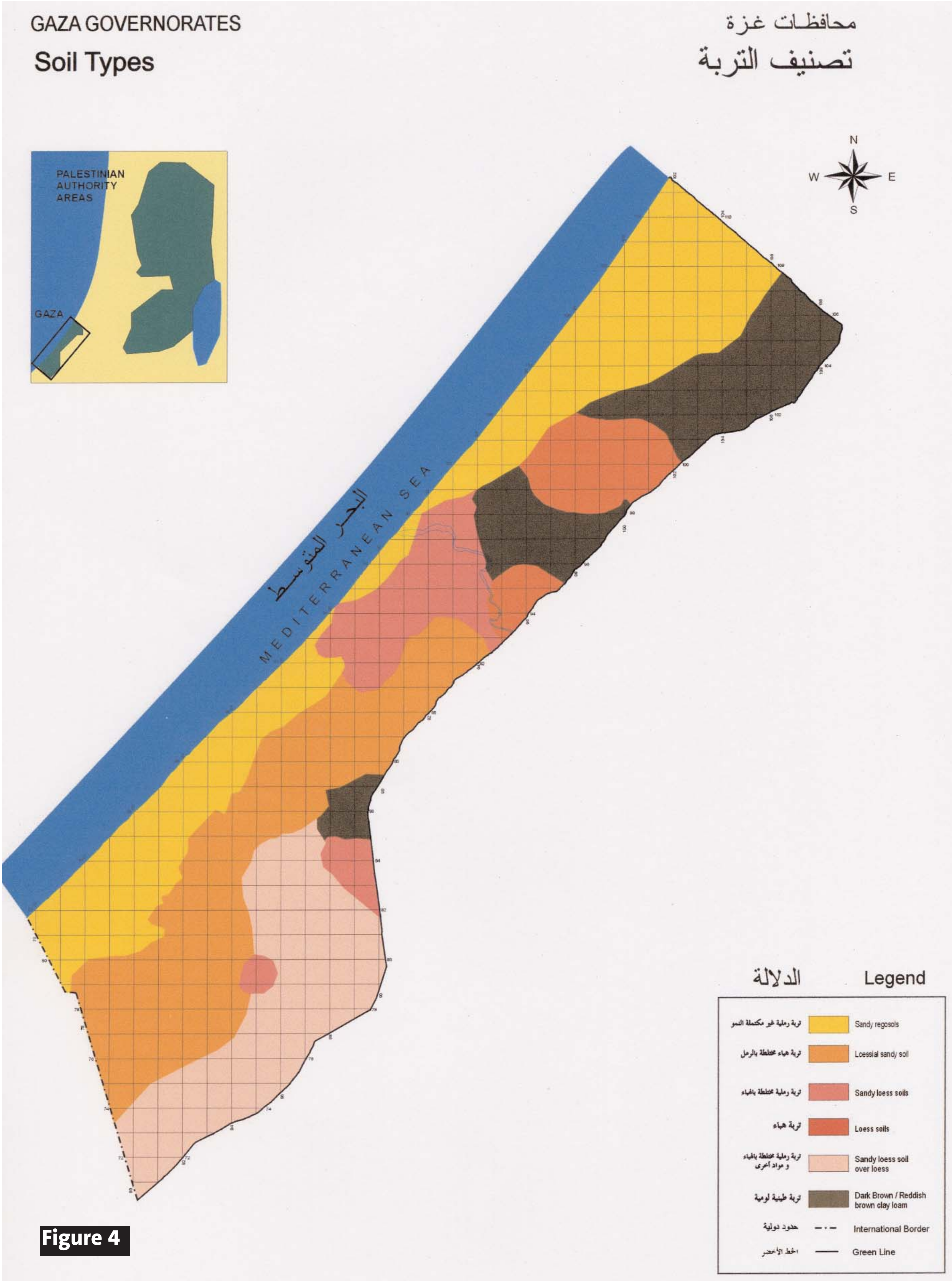
GAZA GOVERNORATES
Soil Types
محافظات غزة
تصنيف التربة
PALESTINIAN AUTHORITY AREAS
GAZA
N
W
E
S
البحر المتوسط
MEDITERRANEAN SEA
الدلالة
Legend
تربة رملية غير مكتملة النمو
Sandy regosols
تربة هياء مختلطة بالرمل
Loessial sandy soil
تربة رملية مختلطة بالهياء
Sandy loess soils
تربة هياء
Loess soils
تربة رملية مختلطة بالهياء و مواد أخرى
Sandy loess soil over loess
تربة طينية لومية
Dark Brown / Reddish brown clay loam
حدود دولية
International Border
الخط الأخضر
Green Line

Figure 4

alternative strategy for accommodating the increased population in the Gaza Strip, which will spare the scarce groundwater resources.

One option is to concentrate future developments in the eastern region of the Gaza Strip. The eastern side of the Gaza Strip is clay soil (see Figure 4) with a low infiltration rate. The area was used in the past as agricultural land for cultivation of citrus fruit. However, according to the Ministry of Agriculture, the land cultivated for citrus fruit has reduced considerably by up to 60% recently due to dwindling financial returns from its sales but also more importantly the high cost of water for its irrigation. It is therefore only reasonable that future urban expansion should be restricted to the eastern region of the Gaza Strip, leaving the highly porous sandy dunes of the southern and northern regions as basins for recharging the groundwater aquifers.

Table 2: Donated housing projects within proposed areas for groundwater protection (MOPIC, 1998).

Project	Area m^2	Location
Rafah housing	8,760	Rafah Sandy dunes
Castle towers project	5,908	Khan younis
An- Nuseirat towers project	21,460	An Nuseirat
Al-Karama towers project	22,127	Jabalia
Police Housing project	18,000	Beit Hanoun
Al-Awda housing project	148,000	Jabalia
Ebad ElRahman project	-	Beit Lahia

Assessing potential for runoff recharge

Available information

During the Israeli occupation, Palestinians were not allowed to participate in any form of planning, as development was entirely controlled by the Israeli civil administration. Moreover, the use of remote sensing and GIS was forbidden by military rules. Thus, Israel's withdrawal from areas of Palestinian jurisdiction and from the Palestinian civil affairs after signing the Interim Agreement on the West Bank and Gaza Governorates on September 28th 1995 left no basic data, infrastructure, or technical expertise and basic equipment.

To create for the first time the Palestinian maps of the Gaza Strip, Arc view 3.1 GIS was used to connect the register data with the real geographic locations. Moreover, digitizing the aerial photograph maps gave statistical information about the number of the houses, the roof area, the paved streets and squares. The results were compared with the numerical data from the municipalities and village councils and good agreement was obtained. As would be shown in the next sub-section, an accurate estimate of the impervious area of the basin is required for estimating the runoff generated by the urban areas.

Storm water quantities

As stated previously, the increasing urbanization in the Gaza Strip represents a significant land use change, which will affect the major components of the overall water balance within the Gaza Strip. The recommended safe yield of the coastal aquifer in the Gaza Strip is 55 million cubic metres a year (PNA, 2002) and it would be good if a significant proportion of this could be returned to the aquifers through natural recharge. However, while urbanization will increase overland runoff, this will be at the expense of infiltration and groundwater recharge making the attainment of this objective difficult. The relative magnitudes of these impacts are better predicted using an integrated surface water-groundwater management model. However, even the most basic of such models will require significant data to calibrate, validate and verify (see Nawaz et al., 1999). These data are not available for the Gaza Strip; so while the use of a comprehensive modelling tool might be desirable, it is certainly a matter for the future as far as the Gaza Strip is concerned.

As an interim solution, an attempt was made to estimate the quantities of water that can potentially be available from rainwater runoff for groundwater recharge using a simple water balance approach. To estimate the annual runoff volumes, the basic water balance equation is used:

$$Q = CAP$$

where Q is the annual runoff, A is the basin area, P is the annual rainfall and C is the runoff coefficient. The runoff coefficient is a measure of imperviousness of the basin and will increase as urbanization increases. For highly urbanised catchments, C can range between 0.6 – 0.85 (Steel, 1985).

Gaza's topography gradually slopes downwards from east to west with the elevation varying between 20 metres above sea level in the west to 100 metres above sea level in the east. Thus, without any intervention, much of the rainwater in the urbanised areas will simply run straight into the sea, without giving enough time for infiltration to the ground water. One plausible intervention is directing this runoff into the sandy soil in the dunes area along the southern seashore and allowing the water to infiltrate into groundwater. The sand dunes are 30-50 m above sea level, cover a total area of 70 km^2 in a width of 2-3 km. Moreover, lucite soil, which is a mixture of sand and loam, is widespread in the middle of the Gaza Strip (see Figure 4). The other possibility will be to collect the rainwater at the household level. These two options for re-using the rainwater runoff are now described in more detail.

Scenario 1- Large Scale Collection in Infiltration Basins: Collecting rain water on a large scale, using surfaces like asphalted streets or conduits and tiled roads and squares to collect the water and storing it in large ponds for the sole purpose of infiltration is common in many parts of the world. The selected locations of the infiltration ponds should be planned according to the topography and the basin area, having estimated the runoff volume to be stored. Using the equation on page 17, the total amounts of collected rain water from the built up areas are shown in Table 3, based on the Gaza Strip's annual rainfall estimate of 300mm. This option is quite feasible if the rainwater can be safely collected and diverted to the infiltration basins formed in the sand dunes. In modern communities around the world with developed storm drainage systems, this would pose no serious logistical problems. However, such systems are practically non-existent in the urban areas of the Gaza Strip with the consequence that whenever intense rainfall occurs, the water will quickly flow from the flat or pitched roofs to the streets, often mixing with silage flow or untreated sewage. Such flows soon become a nuisance with potential health hazards or major flooding problems (LYSA, 1995).

Other problems with the large scale infiltration basin option are the potentially large amount of the water that could be lost through evaporation and the large land area required for the infiltration basins, particularly where infiltration rates are low or the runoff water has too much sediments which plug the infiltration paths. The infiltration capacity of the Gaza Strip soil ranges from 1.4 to 3.0 m/day (Al-Najar, 1996), but this could rapidly decrease for the infiltration basins if the runoff water has a lot of sediment. One solution to the problems of sediment would be to have a series of infiltration basins, with the leading basin not being used for infiltration but merely for settling out the sediment.

As shown in Table 3, the total amount of runoff water would represent a significant return of the annual withdrawal of 55 million cubic metres but, given the problems associated with infiltration basins outlined above, it is unlikely that all the runoff volumes will reach the groundwater. As an alternative to basin infiltration, the water could be directly injected into the aquifer;

however, for this to be feasible, the injected water must be ultra pure. The issue of injection wells is not within the purview of this paper.

Scenario 2: The implementation of scenario 1 at the present time is potentially beset with numerous problems, notably that it requires a separate storm water collection system, whereas the majority of the sewerage systems in the Gaza Strip are combined, conveying both sewage and storm water, except for some densely populated refugee camps. Thus, while desirable and offering a better potential for redressing the groundwater recharge problem in the Gaza Strip, Scenario 1 is not practicable for existing settlements but should be considered for new expanded urban areas.

The second option is rather more limited in scope and involves the individual housing units harvesting rainwater from the house roofs and storing it in small reservoirs (cisterns) near or under the house for domestic use. This type of collection system is already established in the West Bank (the other part of the Palestinian territories), as an old practice to obtain water in the villages un-served by a formal water supply system. The total amount of water collectible in this way using the equation described on page 17 is also presented in Table 3. This is based on the average roof area per housing unit of 90 m^2 and the total number of housing units shown in Table 1 (see also Hudhud and Najar, 1993). For the roofs, the runoff coefficient in the equation can be taken as unity. As expected, the runoff volume from scenario 2 is much lower than for the previous scenario. Furthermore, this scenario would not contribute to the long-term objective of redressing the over-pumping of the Gaza Strip aquifer. Nonetheless, it would go a long way in meeting some of the current annual water shortage of 25 million cubic metres and should therefore be considered as part of the housing licensing process by the relevant institutions.

Table 3: Estimates of annual rainwater runoff in Gaza

Year	Collected rainwater (Million m^3)	
	Scenario 1 Large scale Built up area	**Scenario 2** Small scale Roofs of houses
1997	10.61	3.71
2005	12.33	4.95
2010	18.50	7.22

Conclusions and recommendations

The current status of the environmental situation in the Gaza Strip has made it urgent to address the integration of future physical development and a natural resources protection requirement, within the framework of a land use plan. It should be a multi-sectoral plan, attempting to coordinate and balance future development needs against environmental concerns and preservation of the regions natural resources.

The most effective and sustainable strategy for managing the precious groundwater resources in the Gaza Strip is to maintain its adequate recharge by collecting the storm water that currently runs to waste from its urban and paved areas. A fully integrated and functional storm collection and road drainage system is required for this to be successful and should be pursued as a priority by the PA. At the same time, the existing infiltration basins should be rehabilitated and new basins established in the areas identified in this paper. While this option might be for the future, it is important that for the present the municipalities of the Gaza Strip make it mandatory for inhabitants who want to build a house to install rainwater harvesting facilities, including a cistern.

References

Al Haddad, B; The application of remote sensing and GIS in urban planning, in: M. Ziara et. al., (eds), the proceeding of the international conference of engineering and city development. Gaza, 2003, p.p. U13-U20

Ali Shaat. Spatial planning challenges in Palestine. In Proceeding of the 5th SUPS. AlSharjh 2002

Al-Najar, H; Reuse of saline waste water in Gaza city. M.Sc thesis. IHE Delft, 1996.

El-Dabag, H.; Our country Palestine. Palestinian studies, Beirut. 1987

El-Kharoubi, A.; Risk-in informed strategic planning approach for infrastructure: water sector case study in Gaza city. in: M. Ziara et. al., (eds), proceedings of the international conference of engineering and city development. Gaza, 2003, p.p. I35-I46.

Hudhud, A., and T. Najar; Rain water collection systems in the West Bank, B.Sc graduation project. An Najah University 1993.

LYSA. Assessment of water and sewerage public services in the Gaza Strip. PECDAR, 1995

Ministry of Planning (MOP). Facts and numbers, annual report. Gaza 1999.

MOPIC, Emergency resources protection plan. 1996.

Nawaz, N. R., Adeloye, A. J. and M. Montaseri; The impact of climate change on storage-yield curves for multi-reservoir systems. Nordic Hydrol., 30(2), 129-146., 1999.

Palestinian Central Bureau of Statistics. Vol. 2, Issue 4, 2002.

Palestinian National Authority (PNA). Water National Plan final report. Vol. 1 Ramallah 2002.

Steel E. W., Terence J McGhee; Water supply and Sewerage. 5th edition. McGraw-Hill.1985

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