

The Gaza strip

The last “ghetto”: an organised deprivation and a denied urban development

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a desk study

Occasional paper No. 8

January 2009

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Summary

Foreword

The Gaza strip:the last “ghetto”: an organised deprivation and a denied urban development

The Gaza strip: an autonomous dependent territory.....	5
Evolution of the population.....	7
Available land.....	9
Water abstractions and effects on the water table.....	12
Wells.....	12
Agricultural wells.....	18
Consequences of the abstractions.....	20
Influence of other sources of contaminants.....	24
Effect on health.....	24
Measure taken	25
Desalination of brackish water.....	26
Waste water treatment plants in the Gaza strip.....	31
Waste water disposal.....	35
Sludge disposal	36
Toxic metal contamination in wastewater and in sludge.....	37
Energy in the Gaza strip.....	37
Closure of the Gaza strip and incursions.....	41
Days of closure.....	42
TIM (Temporary International Mechanism)	43
Infrastructure project on halt.....	44
The 2008-2009 war on Gaza.....	46
Conclusions.....	49

List of Abbreviations

CAMP	Coastal Aquifer Management Project
Cl₋	Chloride
CM	Cubic Meter
CMD	Cubic Meter per Day
CMWU	Coastal Municipalities Water Utility
GRWC	Gaza Regional Water Carrier
Km²	Square Kilometers
ICRC	International Committee of the Red Cross
l	Liters
l/c/d	Liters Per Capita Per Day
LEKA	Lyonnaise des Eaux-Khatib & Alami
m	Meters
m³	Cubic meters
m³/d	Cubic Meter Per Day
m³/h	Cubic Meters Per Hour
mamsl	meters above mean sea level
MCM	Million Cubic Meters
mg/l	Milligrams per liter
MCM/Yr	Million Cubic Meters Per Year
MOG	Municipality of Gaza
NO₃⁻	Nitrate
PA	Palestinian Authority
PCBS	Palestinian Central Bureau of Statistics
PMU	Project Management Unit- Finland Project
PWA	Palestinian Water Authority
RO	Reverse Osmosis
TDS	Total dissolved solids (in mg/l)
UFW	Unaccounted For Water
USAID	United States Agency for International Aid
USD	United States Dollars
WHO	World Health Organization
WWTP	Waste water treatment plant

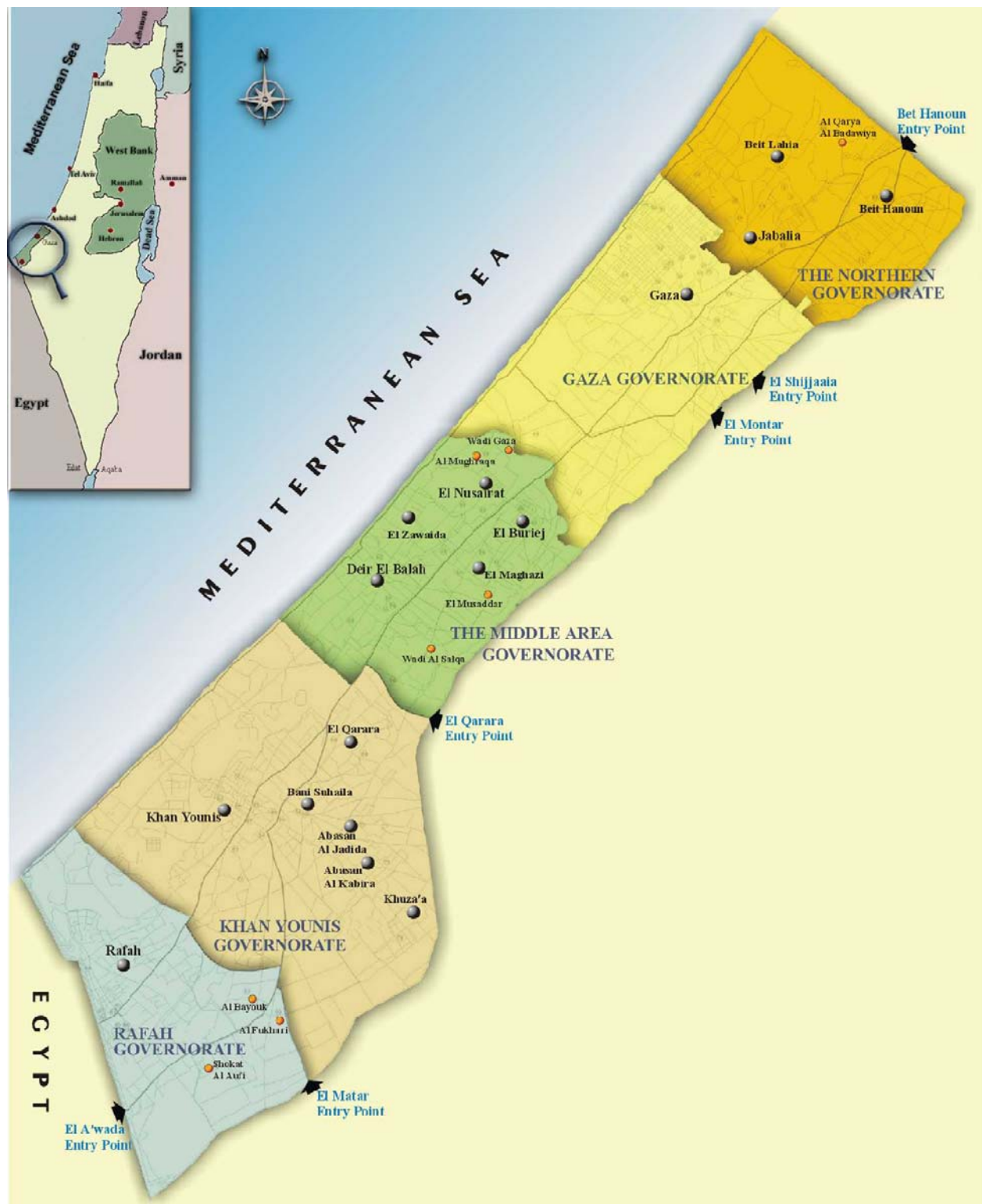


Figure 1 Map of the Gaza strip, governorates boundaries and municipalities

Foreword

This desk study has been prepared taking into account documents obtained from different authors and contacts established during the period of the research and during previous visits to the area. During the past two years not only the access to the strip has been very difficult, but as well access to verified information within the strip. The factional tensions and the fragile security environment with the looming danger of hostage taking resulted in severe movement restrictions, reduced monitoring and data collection. Nevertheless we have been ascertained by Gazans and reviewers with recent and prolonged on-ground experience that the data outlined in this paper would give a good idea of the overall situation in the field with regard to access of the people to indispensable goods and with regard to the perspectives they are facing.

The hardship endured by the inhabitants of the strip since the occupation and more precisely during the years after the unilateral disengagement by the Israeli in 2005, when a collective punishment has been enforced by the occupant, has reached unbearable proportions.

The last 6 months of 2008 have been particularly difficult for the Gazan, but they did not know that it could be worst. On 27th of December the war on Gaza brought unprecedented suffering and destructions, with a disproportionate use of force by the Israeli Defence Forces, causing more than 1000 deaths and over 4500 wounded, mainly children and women.

Civilian, hospitals, protected schools, UN compounds, humanitarian workers, public buildings, private houses have been targeted during poorly chosen targets, in blatant breaching of international laws and agreement.

The behaviour of the occupants in this operation have been described as war crimes and as such should be investigated by an independent facts finding commission to determine if there is room for indictment of those who were responsible for.

But one has not to forget how the Gazan have been punished collectively during the period of the truce agreed between the two parties, when they were confined in a ghetto inside the strip.

The damage caused on the infrastructure by the recent war has not yet been assessed but is likely to be enormous. Anyway, the International Community, blatantly silent during the war conducted with the usual impunity by Israeli, will pay for the repairs, with the majority of items purchased in Israel, some sort of compensation for the fears endured by its population.

What about the inhabitants of Gaza? Will they be compensated too?

The Gaza strip: an autonomous dependent territory

The Gaza strip is emblematic for different aspects. Since the unilateral pullout of the IDF and of the settlers in 2005, it is the first “autonomous territory” under complete Palestinian political control. There are no more check points, no more exclusive roads, the movement are free within the strip, with the exception of the security area, a 1 km large buffer areas all along the border and the access of the seashore, authorized only in a few points.

The word “autonomous” is somehow misleading as the dependence of the territory from the outside world is enormous. Particularly from Israel, who has retained a close control of the people, with the control of the Gaza strip/West Bank population registry, as almost any changes in the registry require the approval of Israel. It has retained the control of the air and of the territorial waters, of any movement across the border, of any import or export of goods through the different crossings and maintain the control of the tax system (see www.btselem.org/ the Gaza strip/Scope of Israeli control of the Gaza strip and related papers).

Israel can at any time decide to close the borders with the strip at all entry points, leave some open, restrict the movement of the transport trucks, control the power supplying the grid, directly or indirectly with the control of the fuel supply to the GECO (Gaza Electricity company). It controls the type of goods entering the strip and any movement across the borders, even between the border shared with Egypt, in its southern bounds.

The movements of any boat along the coast are restricted and the airport, built with funds from the EU, has been completely damaged during the main incursions of the IDF.

Retaliation following rocket bombardments from the strip is carried out with disproportionate and excessive use of the force, targeting security sensitive buildings or people and causing damage to the infrastructure, mainly to the electrical equipment, but also causing planned collateral damage to other installations essential for the survival of the civilian population, like drinking water pipelines, water reservoirs, sewage network etc. and to private and public properties. Incursions of the Israeli Defence forces (IDF) into the strip are almost always resulting in more “shaved” land where properties and agricultural land are secured from any use by the Palestinians (*Operation summer rains, June 2006 and more recent operation Cast Lead, December 2008*).

We will not embark here in a detailed analysis of the provisions of the different bodies of law applicable to the context, like the provisions embodied in the different Geneva conventions or in those drafted during the different agreements defined during the roadmap to peace, which will eventually be reached in a still hypothetical future.

We will try to carry out an analysis of the main resources available for the survival of the people and of the environmental problems such a territory is facing.

The exponential increase of the population, which will reach more than 2 millions in 2025, the limited space and resources available and the tight control exerted by the hegemony state, in this case Israel, will inevitably lead to a human and environmental catastrophe if the current state of oppression is maintained.

The fate of Gaza is the fate of many cities around the world, where in a confined area an equilibrium must be found between the population, its economic activity to foster a better life, and the resources available within a limited space, like the availability of land, water, power, etc.

The restrictions imposed by Israel and somehow triggered by political problems within the Palestinians themselves, do oblige the Gazan to stretch their ingenuity to their last end, in order to organize and maintain the fragile equilibrium between all the parameters governing the land where they live.

Israel does not make things easy and the "positive conditions" policy, quoted by A.Gray (A. Gray, *Positive conditions: the water crisis in Gaza*, August 2006, www.countercurrent.org) in her paper still applies. "Israel will create in the course of the next 10 or 20 years conditions which would attract natural and voluntary migration of the refugees from the Gaza Strip and the West Bank to Jordan." (Yitzak Rabin, former Labour Party Prime Minister)

As a consequence of the victory of Hamas in January 2006 elections, there has been an increased escalation in Israel attitude toward this democratic elected "terrorist" organisation.

Most if not all the very much needed complex engineering projects are on a standstill, like those supported by USAID, the EU and the other different donors. Their completion will have to wait until a better political climate will be established within the strip and within the international community, including Israel. However if a lot is depending from Israel, a few things could still be done within the strip. Several projects, aimed to improve the environmental situation of the strip until better conditions will be prevailing, like those undertaken with the assistance of the ICRC, with the temporary improvement of the wastewater disposal, or those carried out by other organisations, like UNICEF, are certainly contributing to delay the predicted environmental catastrophe and give to everybody time to reach a better climax, essential for the resumption of the planned and ongoing projects, presently on hold.

UNICEF has also drilled more than 30 new wells, operated at lower outputs, in an attempt to avoid a further deterioration of the aquifer, allowing to shut down those of extreme poor water quality. Some improvements have also been carried under emergency aid from the World Bank, mainly in the drinking water distribution network.

However, the past and the current incursions will not change the evolution of the environmental situation even if in some areas it may contribute to worsen it, particularly when aerial strikes may hit essential infrastructures, like electricity grids or water pipelines or pumping stations, despite the claims by the IDF (Israeli Defence Force) that extreme care is observed in the choice of the targets.

Past incursions have shown that little care is paid to avoid damage to pipelines or other essential built-up structures. Moreover, damage is sometimes, if not always, carried out deliberately, with little concern or rather intended consequences for the inhabitants, claiming that it is unavoidable, like any collateral damage claiming a high number of victims among the civilian population.

A ceasefire will probably be reached as usual. However, the International Community must increase its efforts to oblige Israel to comply with any future agreement and, in the same time oblige HAMAS to change its radical standing toward Israel.

The International Community has been relatively tolerant on Israel and has allowed Israel to maintain the strip under a tight control, similar to what has been done in the world War II ghettos and allowed its army to carry out military operations which can be defined without any doubts as war crimes, with a high number of civilians being killed or wounded, in a total disrespect of the laws of war and of the provisions of International Humanitarian Law.

It is time now to act swiftly to allow the strip to operate in a normal way, like in any similar situation around the world.

Israel may bare the cost of it in an initial period, as some shelling will most probably still occur in the nearby land, but that may be the price to pay for years of occupation, which has pushed the Palestinians in the hand of the most radical groups and it will now take time to bring them back to any form of organised control.

Among the measures to be implemented an independent and free port must be allowed to operate, where fuel and other essential goods will transit, like in any normal state, with all the concerns required to maintain the security of Israel. Other exchanges will have to be governed by international trade agreements, like the supply of electricity and eventually water.

At the same time Gazan will have to take up the challenge of the management of the territory and of its resources, which have been left to the goodwill of the occupying power. No serious attempt made at implementing any water management strategy led to an increase of the registered wells from 1200 in 1967, to 2100 in 1993 and to about 4000 nowadays.

Since 1995, a lot of efforts were made to give to the administration the necessary legal tools to manage the available resources, like for water, with the creation of the Palestinian water authority (PWA, 1995). A comprehensive study of the aquifer (CAMP, Coastal Aquifer Management Programme from 1999 to 2004) has been commissioned and the results are still the backbone of any attempt to manage the resource. By 2006, under its impulsion and with the support of Finland, through the Project Management Unit, the Water Master Plans for the different governorates have been prepared. The Wastewater Master Plan, the Land Development one have also been made available, but the political turmoil prior to the arrival to power of Hamas in 2006 has frozen almost all the projects.

In this paper we describe the global situation of the strip and will try to analyse what is possible to do to immediately and when the current crisis will be over, in order to improve the situation of the inhabitants and pave the way for the future development of the strip. Some projects, carried out in a context of emergency, to cope with the immediate problems and to gain time for more definitive ones, have already been implemented.

Other, essential for the future of the strip, will have to be resumed as soon as possible, and cannot wait indefinitely. The future of the strip and of Israel is also linked with what is happening in the Gaza strip and in the West Bank. Neglecting the fundamental rights of the Palestinian will only lead to the predicted environmental catastrophe and increase the suffering of both sides, through the unfortunately well known spiral of violence that has prevailed during the last 50 years.

Evolution of the population

The Gaza strip is one of the most densely populated areas of the world. In 2005 its population has reached almost 1'400'000 inhabitants and its increase is following exponential patterns, with projections for 2025 close to 2 millions of people, or just a little lower, depending on the different scenarios used for the estimation of the evolution.

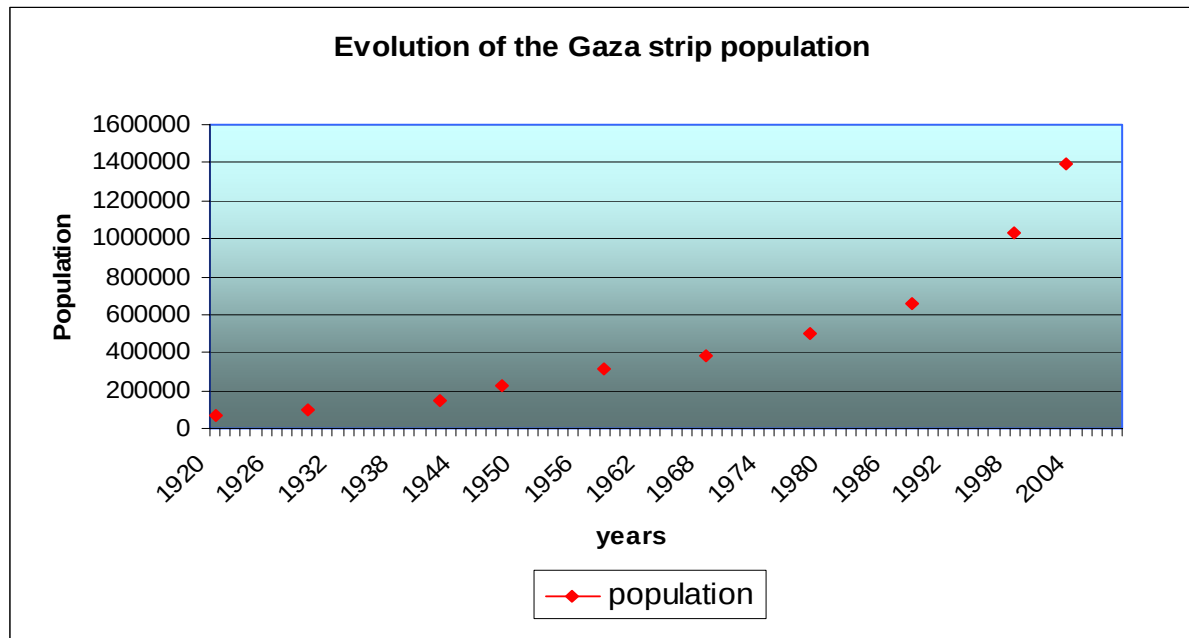


Figure 2 Evolution of the Gaza strip population from 1920 to 2004 (data from ARIJ).

The evolution has been dramatic in the last 20 years, when its population increased from about 600'000 to about 1.4 millions in 2005, when the last census was carried out, reflecting the high birth rate, up to about 4 % and even more in some of the refugee camps. (*Updated population projections from 1997 census, Palestinian Central Bureau of Statistics, 2005*). The next figure show this trend, which is likely to continue in the coming years, until better conditions

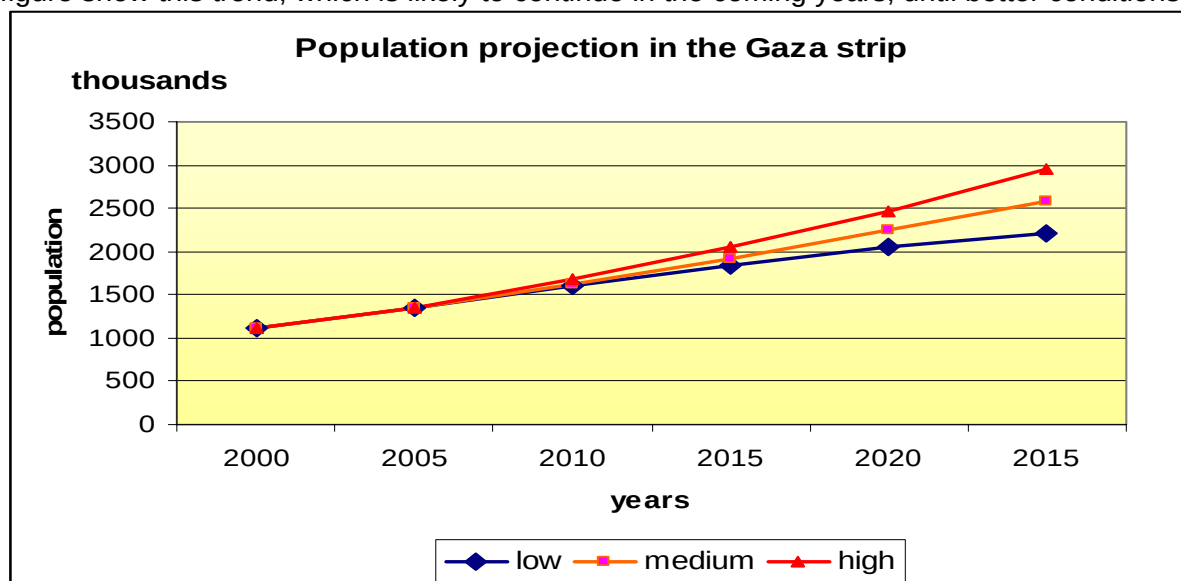


Figure 3 Population projection in the Gaza strip based on data on 2005 and relative growth rates (data from ARIJ)

within the Gaza strip may eventually prevail, leading to a decrease in the birth rate and consequently to the population growth.

The birth rate growths patterns are however different between the 5 governorates, even if they remain relatively high everywhere. The global trend since 1920 is dramatic and the projections are even more appalling. In 2025 the strip will have to accommodate more than 2 M of people and in the worst case scenario up to 3 M. The next figure shows the population projections outlined in a study on the urbanisation of the strip, carried out by the Applied Research Institute of Jerusalem (*Analysis of Urban Trends and Land Use Changes in the Gaza Strip between 2001 and 2005*, ARIJ, J. Isaac et al., 2006, www.arj.org), where not only the growth trends have been analysed but also their consequences on the land available to cope with such an increase.

A distinction between the availability of land most suitable or less suitable for housing or other built-up areas has been made using high resolution satellite images. Thematic maps have been produced to assist planners and allow them to define which area would be best for any type of future urban development.

However, owing to the current closure of the strip, with Israeli restricting among other goods declared strategic for the security of Israel, any import of cement and other building material, for constructions of housing or other built-up facilities had to be put on hold.

The unilateral disengagement carried out in 2005 has made about 28 km² of land available, previously used by the settlements, but a huge security zone is still restricted from any access. It is not clear how much of the “shaved areas”, up to a total of 44.3 Km², has been made accessible after the disengagement, as some of this area was restricted for the construction of a security wall around the colonies and the remaining to secure a buffer security zone close to border, which is still restricted of access.

Available land

The next figures give a general idea of some of the areas foreseen for development, where the existing built-up areas, those reserved for agricultural activities and the surface allotted to the few industrial areas can be seen. It is striking to see how the built-up area have already encroached on those reserved for agricultural activities, with an horizontal urbanisation where a vertical one would be the must. This is also supported by the increase of the mean built-up area per capita observed in the strip from 2001 and 2005, from 48 to 57 m²/p (*Analysis of Urban Trends and Land Use Changes in the Gaza Strip between 2001 and 2005*, ARIJ, J. Isaac et al., 2006, www.arj.org) when funds were made available from Arab countries, for the construction of houses for people expelled from the shaved areas or from demolished houses. In the built up areas population densities are high as they are in cities, up to about 19'000 people/km² in Gaza town and just slightly lower in the other urban agglomerations (see ref ibid). However, the densities are extremely high in all the refugee's camps, where they reach about 50'000 people /km², with one close to 95'000 people/km² (Beach camp). This is close to what is observed in other parts of the world when people are living in temporary camps, as refugees or as internally displaced people (IDP), where densities up to 1000 people /hectare are common, particularly when no planning attempts have been initiated (G. Sartori et al., *Monitoring of Urban growth of Informal Settlements and population estimation from aerial photography and satellite images*, www.thirstycitiesinwar.com). However, in this case we are dealing with tents or with makeshift shelters and not with houses built in concrete, with laid infrastructure like roads, pipelines and electricity. Despite the difficulty to live in such an environment we are still far from what is observed in some of the worst slums of the world, those of the town of Nairobi, where densities up to 1500-2000 people /hectare

(Kibera) are easily measured, with almost no space for anything between the corrugated iron shelters, poor access to water and almost no sanitation.



Figure 4 Approximate areas reserved for future development by activities. Built up areas have been digitized from Google Earth in 2005 (ARIJ). Reserved area are from Ghbn et al.

The percentage of the built-up areas in the whole strip has increased from about 16.9 % in 2001 to about 21.1 % in 2005 but even if the demand for new houses and for any urban development is high it is likely that nothing has changed between 2005 and 2009, mainly due the restrictions imposed by Israel on building materials and for any new area restricted for security reasons.

It is not clear at the time of writing what will happen within the areas temporarily occupied during the recent ground offensive, but it is likely that further areas will be shaved and many more houses demolished.

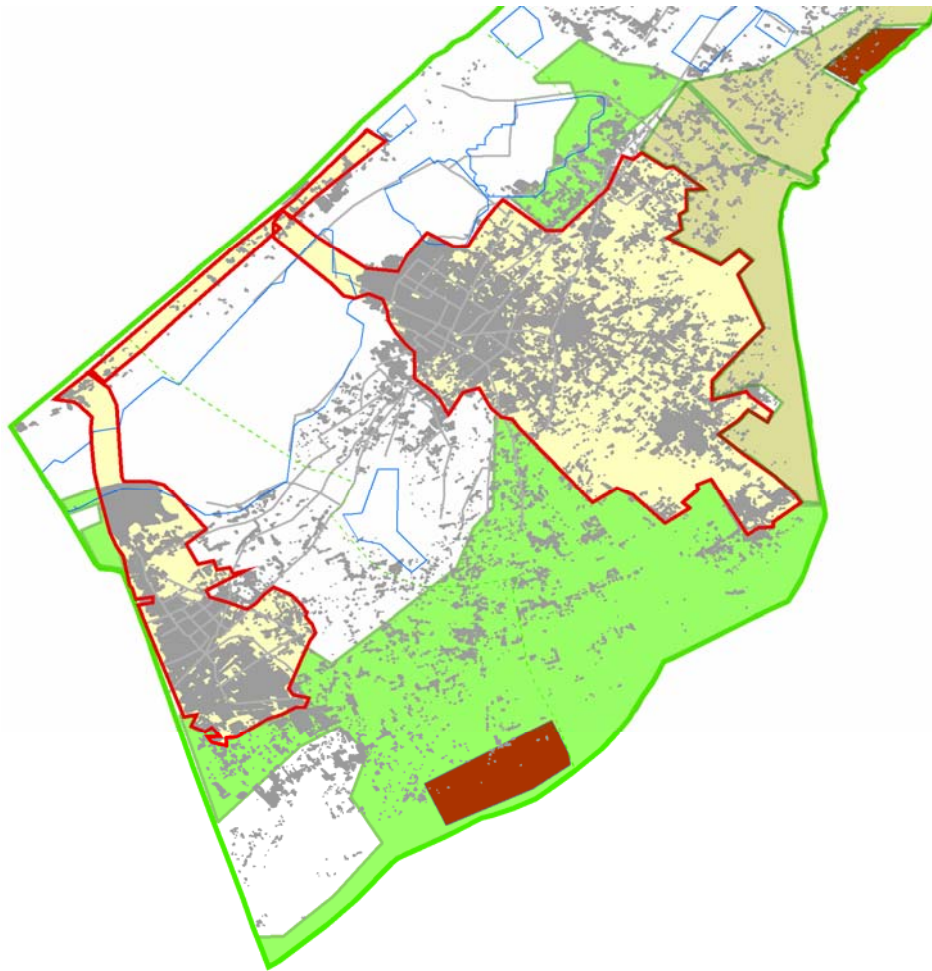


Figure 5 Evolution of the built-up areas in the southern governorates.

Water abstractions and effects on the water table.

In Gaza water is supplied from the underground aquifer, for the domestic use and for the agricultural needs. Before the unilateral disengagement, water was also supplied in minor quantities by Mekorot, the Israeli utility, up to 5 MCM/year. The total abstraction of water for drinking purposes has been estimated by various authors to about 60 MCM/y (60 Millions of cubic meters/y). Water is also used for irrigation and many agricultural wells have been sunk into the aquifer, to supply irrigated fields or greenhouses using water conservation techniques. The number of these agricultural wells has increased dramatically from about 2000 in the nineties to more than 4000. The amounts withdrawn from the aquifer for this purpose are estimates to be close to 90 MCM. The need for domestic water to supply a growing urban population has resulted in an increase of the number of municipal wells from 95 to over 115, a significant increase, due to the important abstraction of such wells. Over pumping has led to a depletion of the water table and discharge of partially treated waste water has also deteriorated the increasingly poor quality of the water. Chloride and nitrate concentrations are exceeding the recommended levels of the WHO, prompting the PWA to define higher temporary standards, with chloride up from 250 mg/l to 500 mg/l and with nitrate up from 50 mg/l to 70 mg/l. Many wells were also sunk within the areas occupied by the Israeli settlements but no precise data are available for these latter and they are probably out of use and re-drilling will have to be considered. Data on existing wells have been compiled when the Master Plans for the different governorates (Rafah, KhanYounis, Deir el Balah, Gaza town and Beit Lahia) have been prepared by different consultancy firms under the supervision of the PMU (Project Management Unit) working under the Palestinian Water Authority.

Well aware of the problem within the aquifer, most of the recommendations were to drill new wells in area where it was considered that the quality of the underground water was still acceptable and to condemn some old wells where the quality of the water abstracted was so deteriorated that it would jeopardise the whole quality of the water distributed by the utilities. To improve the quality or least to avoid a further deterioration of it, blending of the water with high quality water from Mekorot was also considered and it was proposed to increase the yearly amounts delivered to the northern areas to 5 MCM/year (13700 m3/day) and even more, if possible.

Following the pull out at the end of 2005 the situation has dramatically changed. No more water from Mekorot reaches the Gaza strip, with the exception of a few villages in the East-Southern border of the strip and only a few of the planned wells could be drilled.

Wells

As outlined previously the number of wells drilled within the Gaza strip is important. As such the number of wells is of relative importance if the amounts withdrawn are less important than the natural or artificial recharge of the aquifer. Unfortunately this is not the case in Gaza and the total abstraction is by far exceeding the natural recharge of the aquifer, which is from direct rainfall and from underground flow from the Hebron hills, toward the sea.

Figure 6 shows the location and the type of wells used to withdraw water from the aquifer within the Gaza strip. The wells have been classified as municipal wells, agricultural wells, piezometres, abandoned and domestic. The location and the abstractions of the municipal wells have been reported using the data available from Master plans and from other publications dealing mainly with water quality.

For comparison purposes with other similar situations a 1 km² grid has been used to divide the whole strip. Using GIS it is possible to select the wells per Km² and retrieve the data attached. The number of wells/km² is obtained and the volume abstracted per km² can be computed from the database.

The number of wells / km² is only an indication on how the drilling is managed. In principle there is a regulatory police allowing the sinking of a well, based on the potential of the aquifer and taking into account the possible impact of a well on the neighbouring ones and vice versa. A radius around every well should be in principle respected. However, what is important is the foreseen withdrawal, which depends on the hydraulic potential of the aquifer and of the quality of the water. Owing to the necessity to get access to water these basic principles may not have been respected..

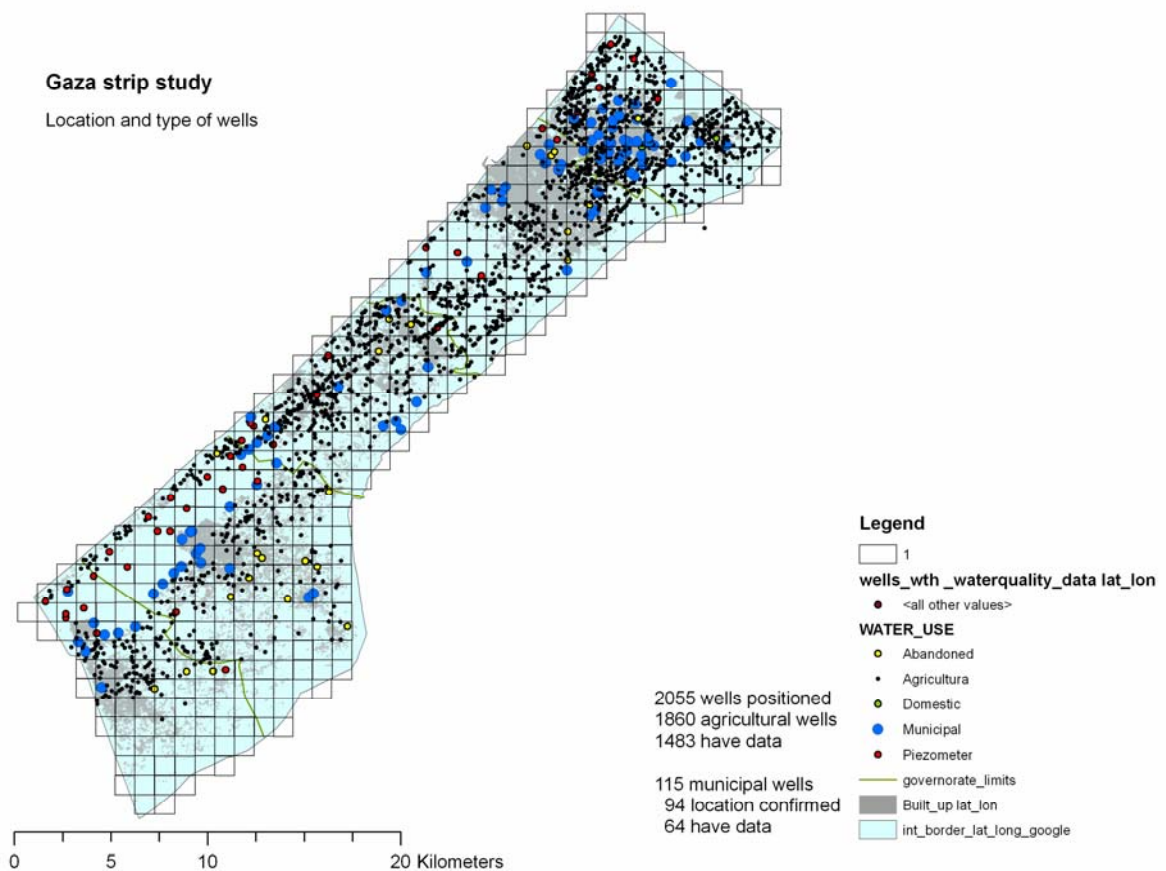


Figure 6 Location and type of wells within the Gaza strip. Total number of wells: 2055.(data from ARIJ)

The quantities abstracted per Km² are of paramount importance, as they give an indication of the potential effect on the water table of the prevailing pumping and may allow the regulatory institutions to define what will be the amounts than can be pumped, in order to maintain a sustainable abstraction from the aquifer, while meeting the needs of the population.

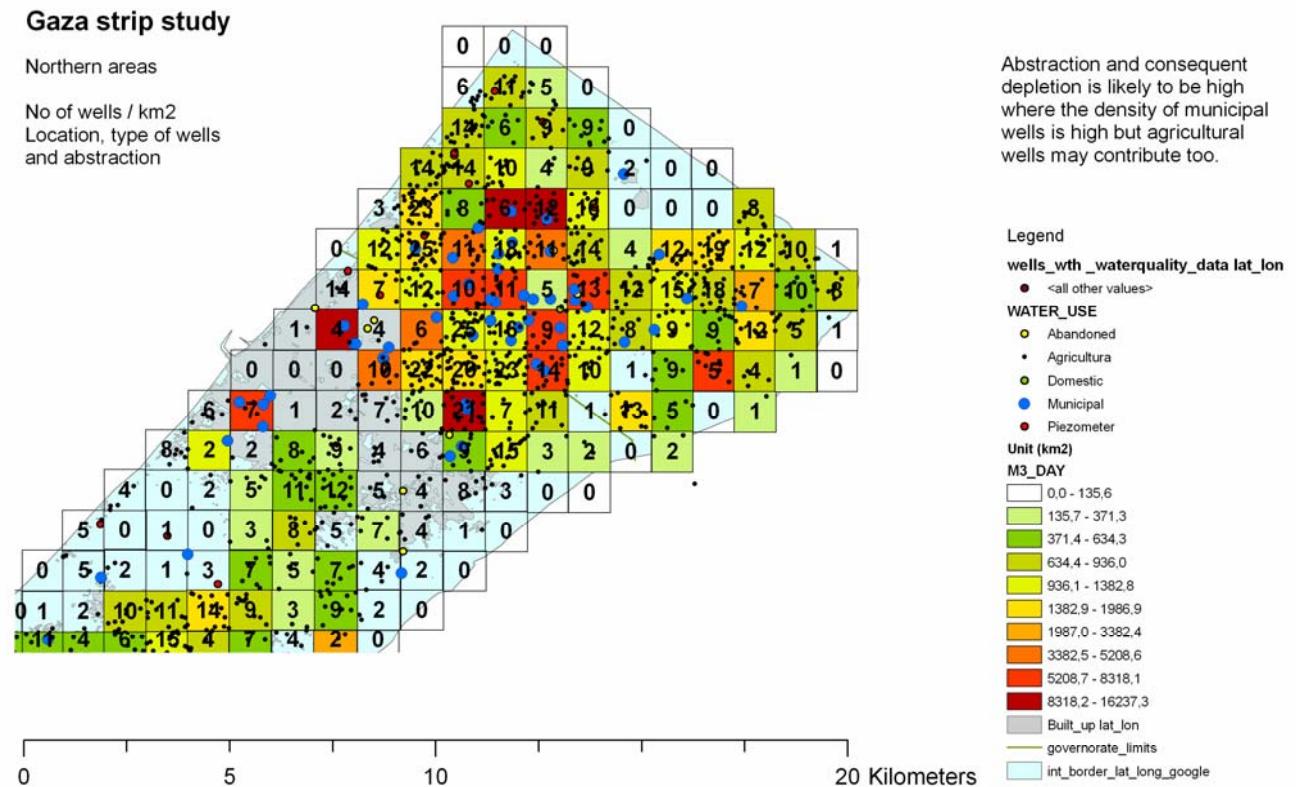


Figure 7 No. and type of wells/km2 in the Northern areas of the Gaza strip.

The number of wells/km2 and the quantities abstracted per Km2 for the Northern area are shown in the following figure and represented graphically with increasing intensities of the colours.

The next figure shows the results obtained for the whole strip, where the areas causing problems have been marked with a circle.

115 municipal wells have been located within the whole strip. However, withdrawals for only 64 municipal wells have been recorded. Pumping hours and flow rates have been used to compute the total abstractions. In about 15 % of the dataset, pumping hours were not available and 24h pumping rates have been used.

The total amount of water withdrawn from the 64 municipal wells is close to 66 MCM/year and the amount pumped from the 1483 agricultural wells, for which data were available, is reaching 49 MCM/year.

The amounts computed from the flow rates of the pumps and from pumping hours are likely to be higher than the real ones, as the pumps are pumping directly into the network and do not work at their best efficiency.

The reported range for the amounts of water pumped by the municipal wells is close to 60 MCM/year, with those for the agricultural wells close to 90 MCM/year. The inconsistency is due to the difficulty to get access to data, particularly recent data. New wells have been drilled, even if it not clear if those of poor water quality have been shut down.

It is quite easy to observe that the levels of the abstractions are important where the density of the municipal wells/ km2 is high, combined with a high number of agricultural ones, even if the latter do not have the same impact.

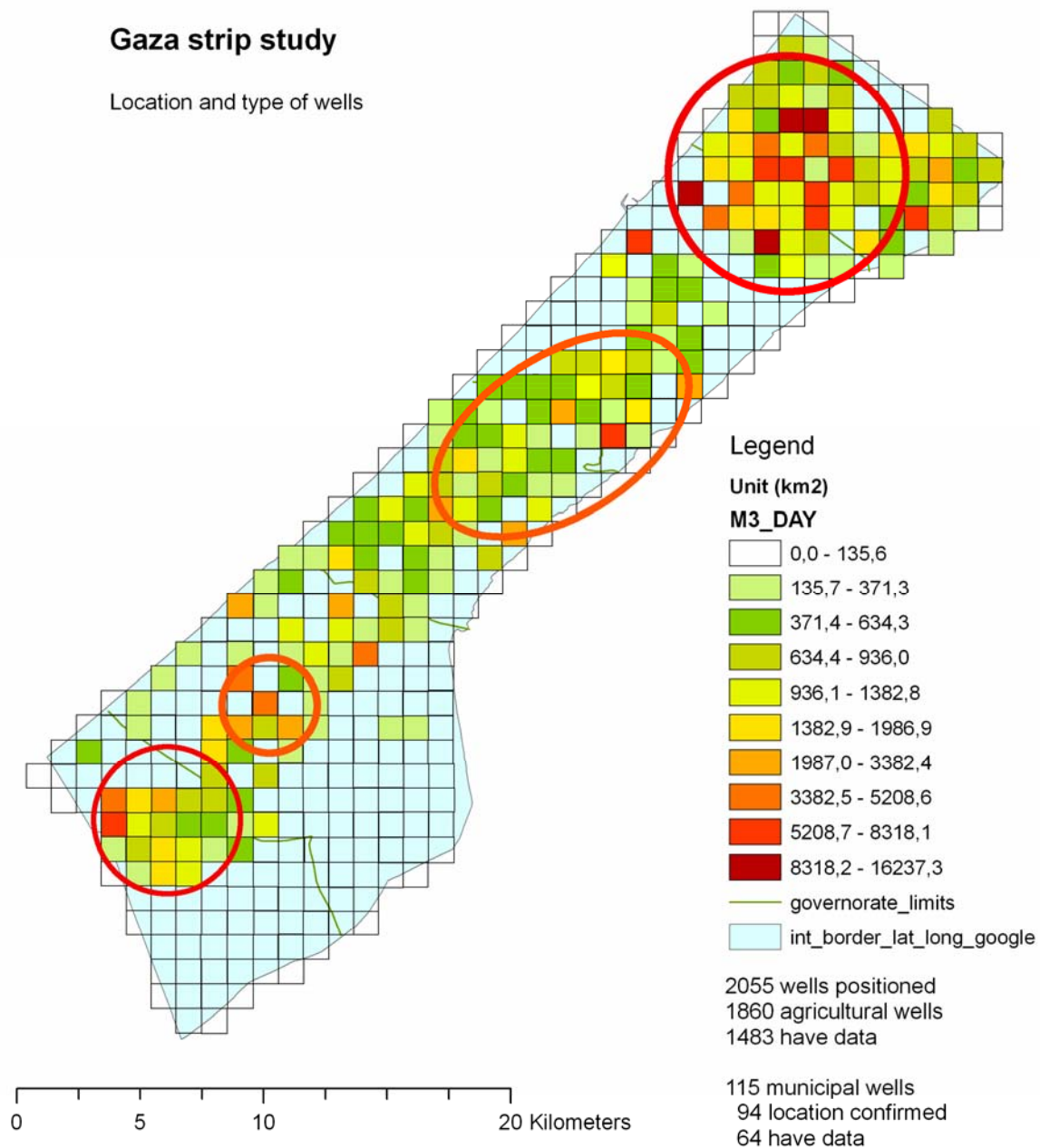


Figure 8 Average no. of m3 abstracted /km2 by all type of wells, mainly municipal and agricultural, in the Gaza strip from the available data set (ARIJ) completed with data from the different Governorates Master plans.

The Coastal Water Municipal Utility, the entity created from the Water boards of the municipalities of each governorate, is fully aware of the problem and is keen to limit the abstractions of the municipal wells to a manageable temporary limit, until more permanent solutions will be implemented, like the RWDP /(Regional Water Desalination Plant). Unfortunately due to the political instability the foreseen completion in 2005 of the RO plant, planned to produce up to 60'000 m³/day in the initial phases, had to be postponed to 2010 and it is most likely that the "statu quo" prevailing end of 2008 will last for a while.

Among other temporary solutions, it has been proposed to limit the abstractions of some of the wells supplying Gaza town to 115 m³/h for not more than 20 hours/day, instead of the 24 hours, but again, this was a solution taking into account the supply of good quality water from Mekorot, outlined in most of the Master plans. In the governorate of Khan Younis (*KhanYounis Master plan*) it has been proposed to limit the abstraction of any new municipal well to 70 m³/ for a maximum of 16 hours of pumping / day, for a total abstraction of about 1120 m³/ day and to shut down the wells with a high concentration of chloride and nitrate, in order to minimize the effects on the water quality and limit the depletion of the water table, linked with the over pumping.

Drilling of new wells in areas not too much affected by the depletion of the water table or at least with acceptable water quality data has also been proposed. The following table summarizes the present situation of the supply of drinking water for the different governorates and the main solutions outlined in the Masters plans to fill the foreseen shortages, based on increased population pressure.

Table I. Water production within the different governorates

Coastal Municipalities Water Utilities (CMWU)

Data from Master Plans (2006)

Governorate	Munic.	Population		Wells	Est. l/c/d	UFW ⁽²⁾	New wells ⁽¹⁾	Produced m ³ /d	Billed m ³ /day
		2005	2010						
N. Gaza	5 ⁽⁴⁾	281727	370070	24 + 3 ⁽³⁾	85-110	20%	17	48223	24247
Gaza	1	486803	587186	30 +1	150	30%	?	75342	52789
Deir el Balah	7	213058	269011	26	68-80	20%	16	30300	24247
K.Younis	6	272326	344788	17 + 6	100	20%	?	45300	36240
Rafah	3 + 1	190292	238045	8	?	?	5	16986	11890 ⁽⁶⁾
	24	1'444'206	1'809'100	115			38	199165 ⁽⁵⁾	137523

¹⁾ production estimated for 70 m³/h during 16 hours for 42560 m³/day

²⁾ mostly assumed as 50 % UFW have been computed for NGaza gov.

³⁾ 3 wells supplying UNRWA ref. camp.

⁴⁾ Sheikh Zayed city included

⁽⁵⁾ 199165 m³/d corresponds to 72.7 MCM / year

⁽⁶⁾ no data for UFW billed equal produced x 70% (assumed)

The total amounts produced are close to 200'000 m³/d (73 MCM/year) but only part of it is really billed. Some values for the billed water were not available and were computed using the estimated UFW (unaccounted for water) listed in the Master plans. It is likely that the

UFW are higher than 30 %, with leaks and illegal connections difficult to spot, even if since 2002, some efforts have been done to limit their importance.

Any incursion or bombardment is likely to increase these losses, with the unavoidable damage to the pipelines, when they are not specifically targeted. Years of efforts to contain the losses are wiped off in a few days and a lot of water is lost again before reaching the consumers.

One of the problems identified by the different consultants is linked with the design of the pumping systems. Most of the pumps are directly connected to the network and their production is therefore not optimal, as they have to pump against a changing head. The solution proposed was to deliver directly to storage tanks, most to be built, from which the water was then pumped into the network. This would improve not only the production, but also decrease the energy consumption and improve the access to water. None of these proposals have yet been implemented, owing to political turmoil and the Israeli management of the crisis.

Data on municipal wells compiled from the Master Plans are quite complete for the North Gaza governorate, for the Gaza city and for Rafah governorates. Completing the characteristics of the wells for the remaining ones can be done easily. Up to now flow rates / hours are available for 82 of the 115 wells located on the map. Pumping hours are available only for 64 wells out of 102 but we can assume that most of remaining wells are operated for 20-24 hours/day and it will be easy to complete the available figures, if necessary.

What is evident is their importance in the depletion of the water table. Data from CAMP (Coastal Aquifer Management Program) show two depletion cones, one located in the Northern governorates and the other in the Rafah/Khan Younis areas. Their importance has increased in the recent years, with a decrease of the level of the water table below mean sea level (m.s.l) at a rate close to 0.4 m/year, with some locations showing even higher variations.

Unfortunately this is likely to continue and will even increase if the construction of the regional desalination plant, due to cope with the increased demand, is postponed again.

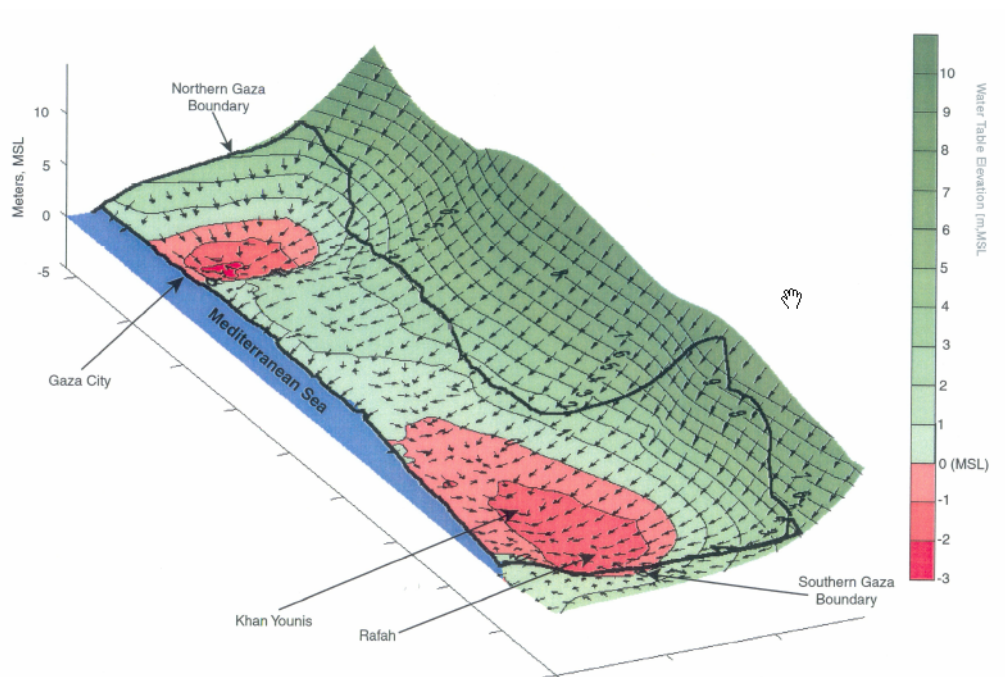
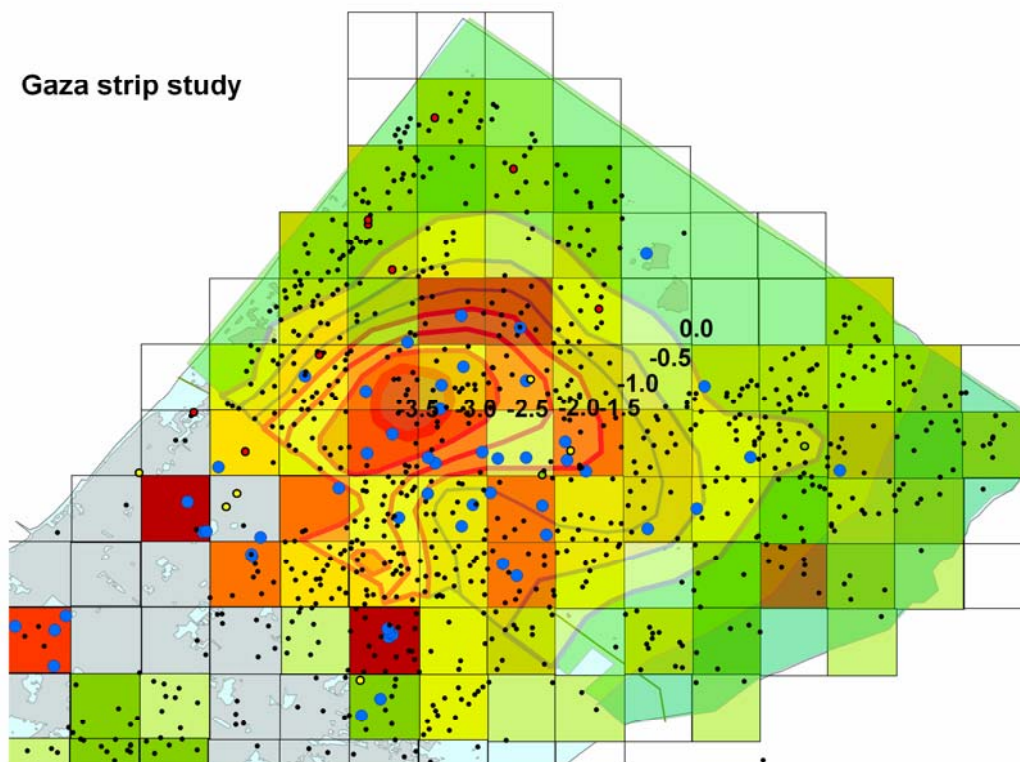


Figure 9 Simulated depletion of the water table and recharge flow direction (from CAMP)



Northern area: No of wells / km², Location, type of wells and abstraction and spatial depletion of the water table

Figure 10 Measured depletion from levels in shallow agricultural wells and location of the municipal and agricultural wells. -3.5 m level (below mean sea water level) is shown as a thicker red line.

The effect of the municipal wells is shown in the above figure, where the -3.5 m depletion is shown as a red line. Data are from the PWA (Palestinian water authority) collected in 2004, reported on a geo-referenced map showing the municipal wells as well as the agricultural ones. Similar maps have been produced for the whole Gaza strip and with the current abstraction and lack of other sources of water of better quality apart from Mekorot, the depletion will worsen, probably at a higher pace than outlined previously.

The urgently needed 60'000 m³/d would not only allow to cope with the increasing demand, but will also allow the utility to implement all the measures listed in the master plans, despite the drawback of the non-availability of the 5MCM from Mekorot (13700 m³/j), linked with the recent events. But producing 60'000 m³/d from RO requires quite a lot of energy (200 MWh or about 120 '000 litres of fuel/day) and in this field too the problems are not yet solved.

There were also about 40 wells which were used by the settlers prior the pull out. Their water quality is considered good as their withdrawal was limited to 30-40 m³/h for not more than 10-12 hours/day. As they were sunk quite away from the seashore, about 1.5 Km, and at about 500 m from each other, it is likely that their re-drilling will contribute to cope with the foreseen needs of the Gaza people, when the boreholes will be drilled and made operational. Under the present circumstances it is not likely that this will happen soon.

Agricultural wells

What is easy observable from the above figures is the high number of the agricultural wells. If the individual amounts withdrawn from these wells are much lower than what is currently pumped from the municipal wells, their effect on the global depletion of the water table can not be neglected, as the total amount is important and may be equivalent if not more than the total abstraction of the municipal ones.

Out of the 1860 agricultural wells listed in the database 1483 have withdrawal data, but none of them reaches the volumes abstracted by any municipal well by far. However, for the

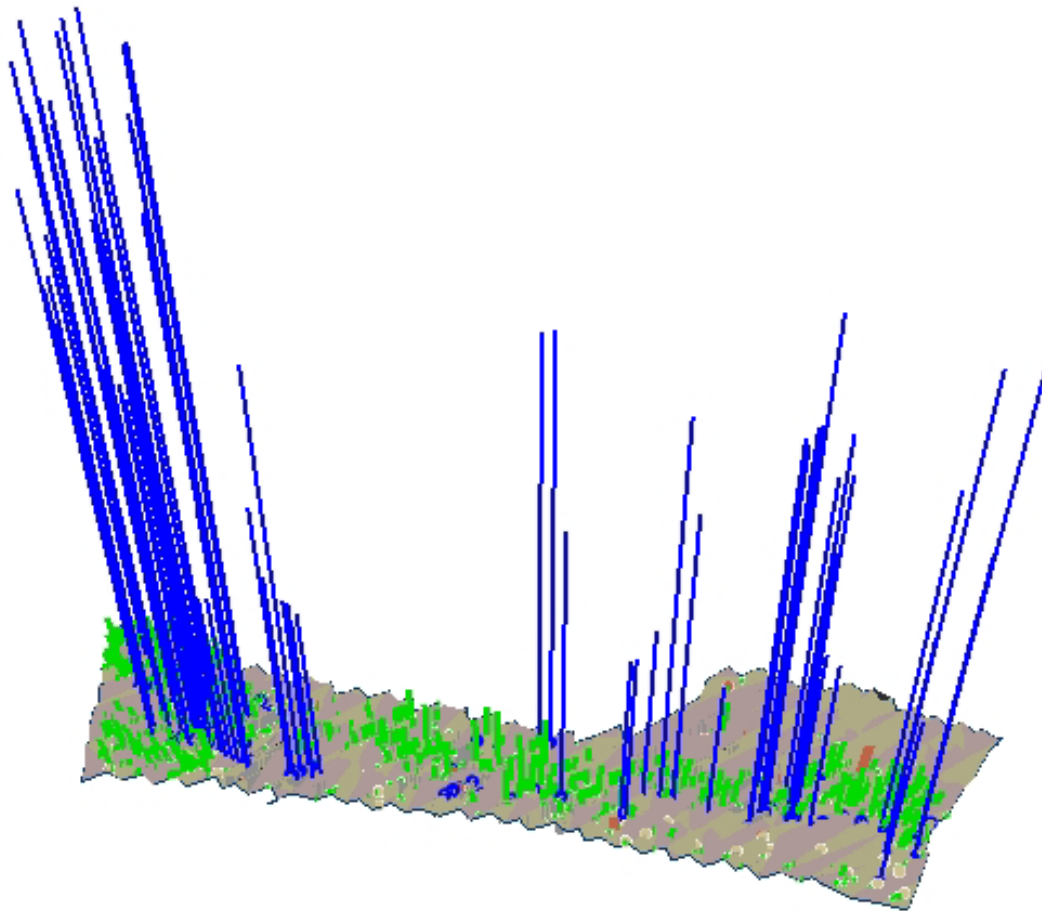


Figure 11 Relative importance of the different types of wells (blue municipal, green agricultural) expressed as daily pumping. Withdrawal computed from ARIJ database and from Master plans data. Data for Middle governorate not complete. 115 municipal wells located and 82 with data.

entire strip, the total annual abstraction of the 1483 wells, computed from the database was of about 49.3 MCM, which corresponds to 135'153 m³/day. Assuming that the remaining wells do abstract similar amounts, a simple proportional calculation gives the value of 132.9 MCM/year, which exceeds the amount pumped for drinking water purposes, and definitely has an impact on the underground aquifer.

The relative importance of the different wells is clearly shown in the above figure where the position and the amounts withdrawn by a/m two types of wells, have been reported. Data for the municipal wells are from the Master plans.

In this area there is a need to better understand the issue and eventually to prepare or to enforce, if any is existing, a regulatory frame to avoid wild drilling or sinking of wells, which will, despite the limited abstraction, slowly contribute to the global problem.

If an arbitrary figure of 10 m³/h and 16 hours of pumping is retained for the agricultural wells, 222 of the 1483 reported in the database do exceed the limit and their pumping should be decreased, particularly if there are located close to each other, within the reference surface unit of 1 km².

Consequences of the abstraction

As shown above from data collected from shallow wells, the level of the water table are more than 3 m below sea level in the Northern, in the Khan Younis and in Rafah governorates. The depletion begins already in the Deir el Balah area and increases in importance in the two Southern governorates. In principle the level of the water table increases regularly from the seashore and reaches the height of several meters above the sea level in the Eastern part of the strip. As stated above the observed depletion is mainly due to the over abstraction of the municipal wells but the agricultural wells play also an important part.

If the depletion of the water table is worrying, the deterioration of the water quality is another problem. Data on NO₃⁻ and on Cl⁻ concentrations have been collected since the eighties. If the evolution of the nitrate concentration can be explained by anthropogenic causes, mainly linked with the extensive use of fertilizers (manure) (*Shomar B. et al, Elevated nitrate levels in the groundwater of the Gaza strip: distribution and sources, Sci Total environ (2008), doi:10.1016/j.scitotenv.2008.02.054*) for agricultural production and also to the poor disposal of the sewage, the increase of chloride has a different origin.

Nitrate (NO₃⁻)

The spatial distribution of the NO₃⁻ concentration coincides relatively well with the depletion cones, where abstraction for domestic water is high, over the built up areas, but also where leaching from fields and greenhouses, where manure is used as a fertilizer, has a significant contribution to the increase. The high concentrations of nitrate in water must also be linked with the poor disposal of wastewater, mainly from cesspits not connected to the sewage network, otherwise it would be difficult to explain the observed spatial distribution. The next figures show the recent situation (2003) of the spatial distribution of the chloride and of the nitrate concentrations in the Northern governorate, from data collected from shallow agricultural wells.

From comparison with data available from ARIJ (1990) and from CAMP (1997) (see next figures) it appears that the nitrate concentration has increased significantly since 1990 to 1997, while it seem to have reached a steady state in 2003. Area with nitrate concentration above 400 mg/l where easily observed in the CAMP distribution map, but the foreseen increase has not really occurred in the northern areas, most probably due to improved disposal of waste water.

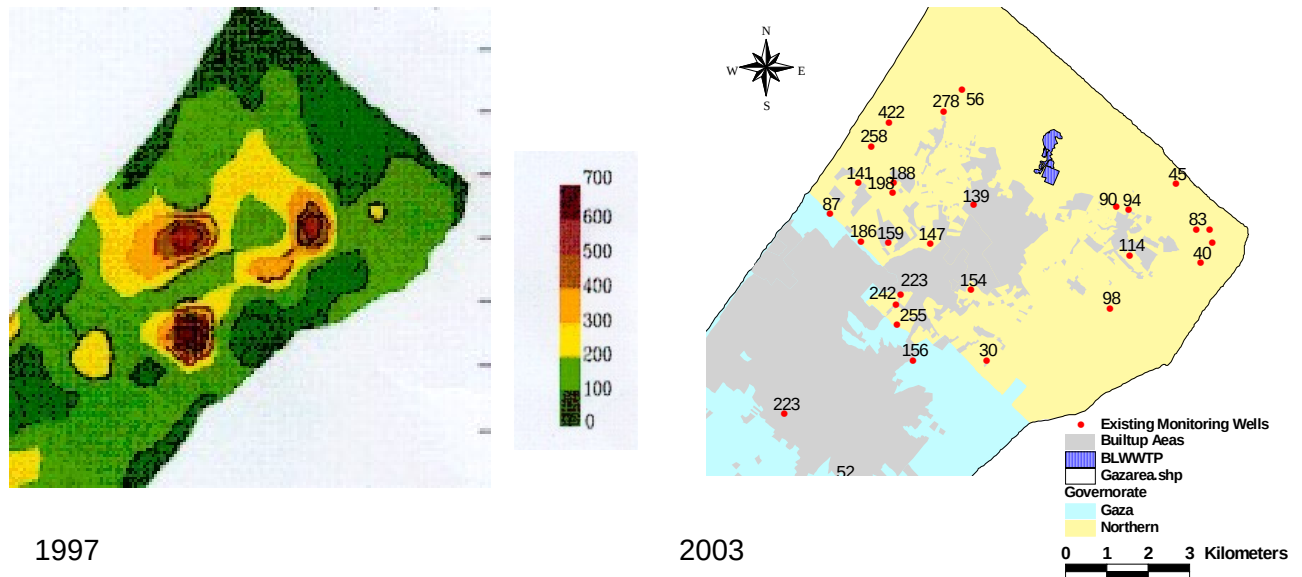


Figure 12 Nitrate concentrations (mg/l) for year 1997 (CAMP) and for 2003 (PWA) in the shallow aquifer in the northern governorate (from CAMP and Master Plan for the Northern Governorate)

In the southern areas, and more specifically in Rafah, the surfaces cultivated under greenhouses are important as it can be seen from the figure, digitized from Google Earth. Here again it may be difficult to distinguish between the different origins of the high nitrate concentrations.



Figure 13 Surfaces occupied by greenhouses in the Rafah areas, showing the importance of urban agriculture and its potential effect on the increase of nitrate in the underground water due to leaching. Surfaces digitized from Google^R Earth images (Digitalglobe)

Manure must play an important role but in the latest figure available (Shomar, 2006, *ibid*) showing the spatial distribution of NO_3^- within the Gaza strip, the link between manure and high nitrate levels is not evident as one would have expected. However it is also possible that other types of fertilizers may be used in the greenhouses, with manure mainly used in the open fields. The high levels of nitrate, up to 400 mg/l, observed in the municipal wells of Khan Younis, where the importance of the urban agriculture is low, with almost no greenhouses nor open fields, can only be explained by a waste water origin, or by more complex migrations of the nitrate ion within the underground, not yet understood and studied at present.

Chloride (Cl^-)

The chloride concentration in the underground water can be from different origins. Close to the coast it is most probably due to salty water intrusions, linked with over-abstraction and up-coning of the brackish/salty water from the lower layer of the saturated formation. High draw-downs in semi-confined aquifers may be common with pumps tapping into slightly more saline water. It is quite possible that the observed high concentration of Cl^- , within the coastal area of the Deir el Balah governorate is due to inland displacement of the saline/freshwater wedge. High concentrations at the eastern areas are due to geological formations and giving the direction of the recharge, from the Hebron hills toward the coast, a constant flow of chloride may continue to trigger the level upward.

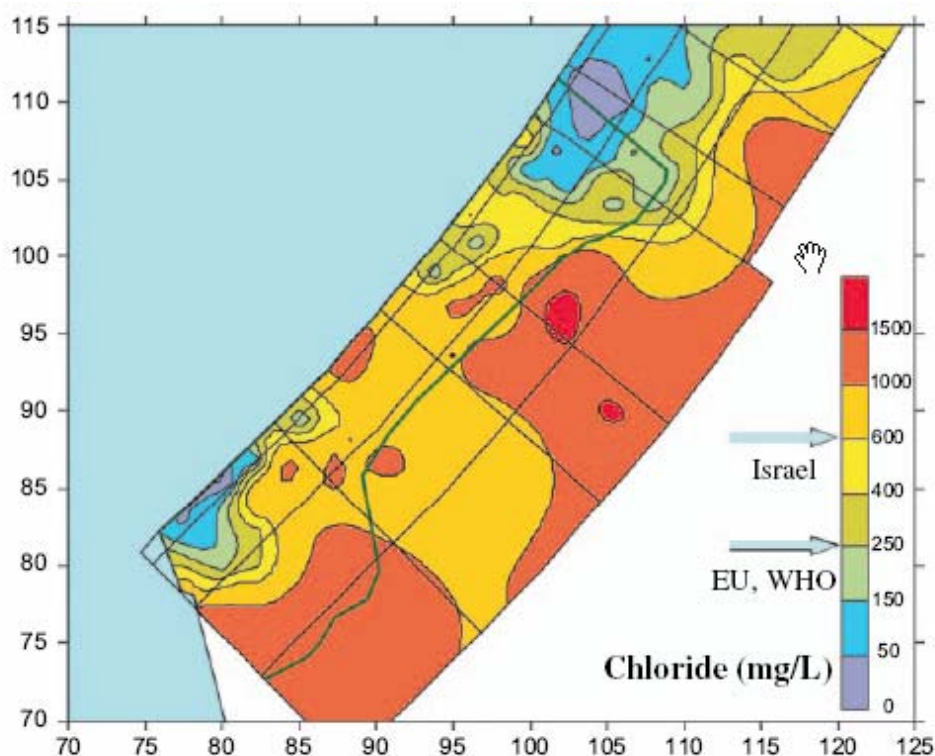
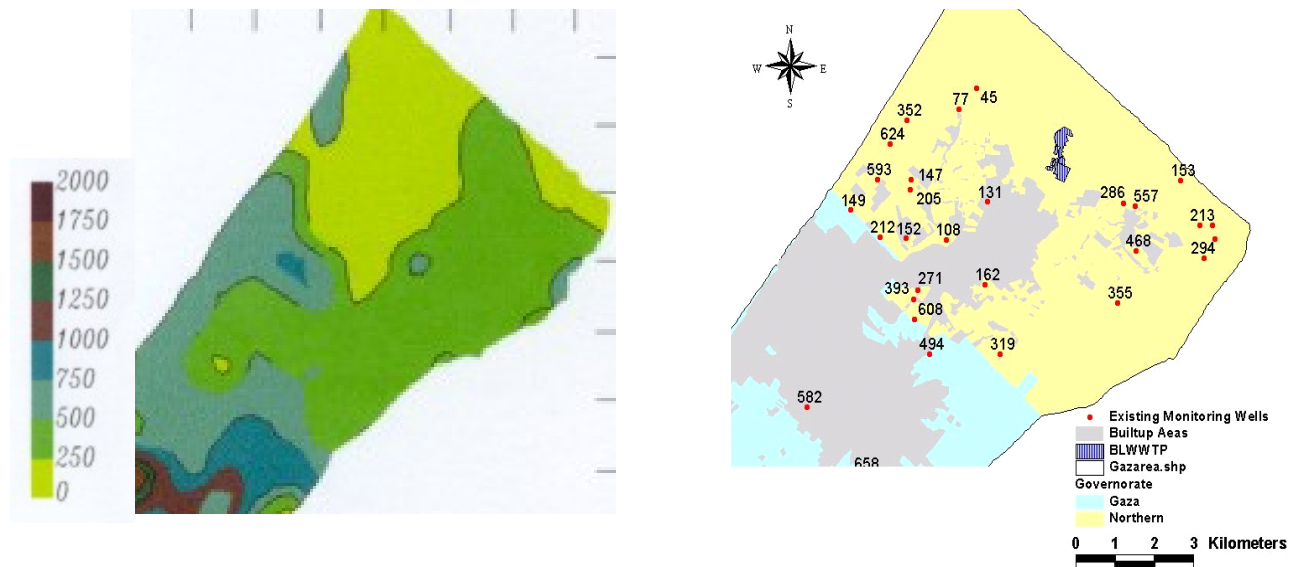


Figure 14 Evolution of the chloride concentration within the Gaza strip and on the eastern side of the aquifer. (Figure from Weinthal et al.)

The chloride concentration is higher in the eastern areas due to geological reasons, mainly linked with the presence of brine formations within the geological layers. Its concentration

decreases gradually toward the seashore where levels below 150 mg/l may be found.



1997 (CAMP)

2003 (PWA)

Figure 15 Chloride concentrations (mg/l) for year 1997 (CAMP) and 2003(PWA) in the shallow aquifer of the Northern governorate (from CAMP and Master Plan for the Northern Governorate)

As for nitrate, the chloride concentration has not increased substantially in the Northern areas, and, with a better disposal of waste and an increased use of desalinated water from the Regional Water Desalination Plant (RWDP), unfortunately yet to be built, we may even observe a decrease of the concentration of the chloride. However, for nitrate this decrease may not be observed as for this ion the concentrations within the water of the shallow wells are mainly due to its presence in manure used as fertilizer and its effect is diffuse and therefore more difficult to control.

In this area the chloride concentrations exceed the temporary standard of 500 mg/l set for drinking water by the PWA in only a few wells, at least in the water of the shallow wells.

In the municipal wells the situation is even more evident. According to analysis carried out in 2004 only 2 wells show high concentration of chloride and their importance to the global production is limited (Beit Hanoun, C 76, C79, 320 m³/d and 120 m³/d respectively).

The situation in the Southern governorates is quite different.

The next figure shows the evolution of the chloride concentration in 3 wells of the Southern governorate (Master plan for Rafah governorate). From levels close to 5-600 mg/l the concentration of chloride has risen to about 1200 mg/l, far above the admitted temporary standard of 500 mg/l, set by the PWA. Interestingly, the concentration in well P 83, located less East than the two others, has changed less dramatically, increasing from 600 to 800 mg/l., a significant but slight increase, if compared with the two other wells, for which monitoring has been carried out since the seventies. This also explains why there are only a few wells used for agricultural purposes in this region. To irrigate their fields, farmers are apparently tracking water from wells located in the Western side of the governorate, where

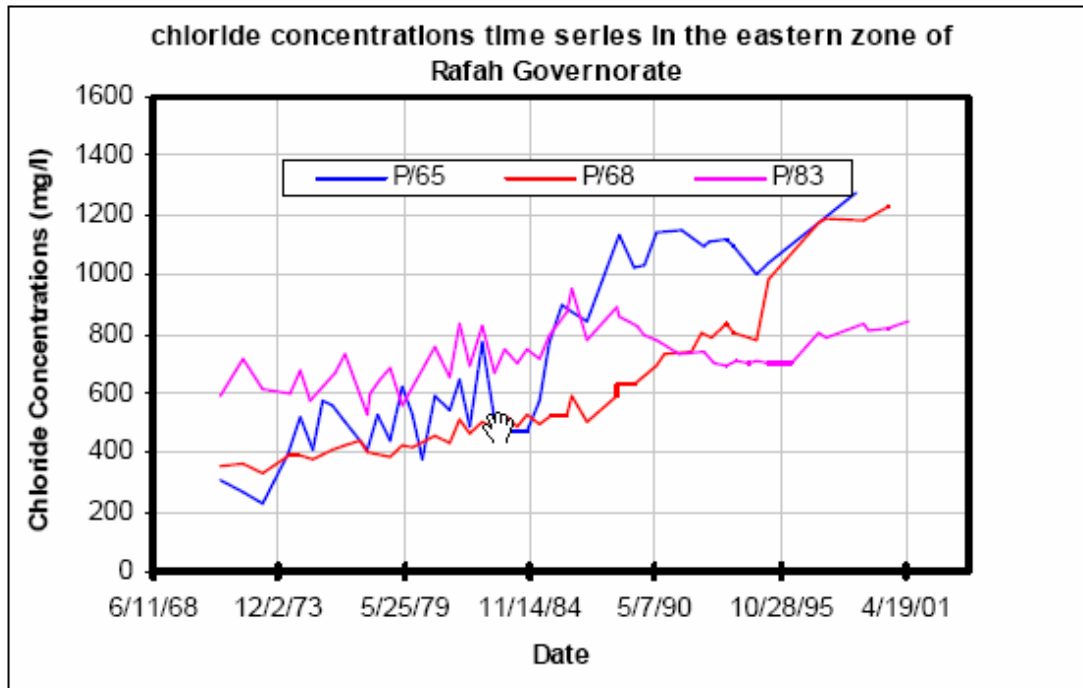


Figure 16 Evolution of the chloride concentration in 3 wells located in the eastern side of the Rafah governorate (Master plan for the Rafah governorate)

the water quality is much better, but the operation is of course economically quite costly, due to the distances involved.

Influence of other sources of contaminants

The deterioration of the water quality is also triggered by the brine disposal of the 5 desalination treatment plants using RO, which use brackish water. This is likely to increase the concentration of chloride close to the location of the disposal of brines, which ideally should be done to the sea. As the water is getting more and more saline, the inhabitants of the strip have begun to treat it using home RO units, disposing the brines into the waste water collection systems, whenever available, or into cesspits and finally into the ground. It has been reported that at least 20000 of such units are operated within the Gaza strip. As a result, the concentration of the chloride is increasing steadily since 1980 and reaches now levels up to 1000 mg/l, far beyond the WHO standard of 250 mg/l, and even higher than the PWA temporary standard, set at 500 mg/l.

The quality of the water of the municipal wells had been monitored regularly in the past and the results were reported in all the Master plans, as one of their objectives was to look into the different ways to reduce or at least maintain the present situation. Several temporary measures were proposed:

- replace deep wells with shallow wells
- drill new wells in areas where the quality is better
- close the most problematic wells, with Cl₋ concentrations over 750 - 1000 mg/l
- decrease the pumping rate to 115 m³/h or to 70 m³/h in most of the wells presently pumping up to 180 to 240 m³/h
- use of Mekorot good quality water (if acceptable)
- speed up the construction of the Regional water desalination plant (RWDP)

The infiltration of treated waste water could theoretically contribute to solving the problems induced by overexploitation of the aquifers. Under the present conditions however this is not likely to happen. The required level of treatment is not reached and infiltration would only contribute to the increase of the trend. The only solution is to supply water of better quality, not pumped from the aquifer, and this is only possible when the desalination units will be fully operational, with the brines disposed into the sea or coupling the disposal of the waste waters with some sort of treatment, using reed field's absorption before final infiltration.

Effects on health

In a former report by the author it was pointed out that the presence of high concentrations of chloride, over 1000 mg/l would deter the use of the water as drinking water and would protect the users from the high concentration of nitrate (Nembrini, 2002), particularly the infants, prone to "methemoglobinemia", a disease known to be caused by high concentrations of nitrate leading to "blue babies". This was and still is the case in the Southern governorate, where the chloride content is high and salinity easily tasted, but is not clearly perceived in the northern ones, where the water quality, as far as chloride is concerned, was and still is better. According to Shomar et al (Shomar B, et al, *elevated nitrate level in the groundwater of the Gaza strip*; *ibid*) signs of methemoglobinemia have been observed in 50% of the blood samples of the 640 babies under 6 months of age tested in Gaza, with a high correlation with the nitrate values in the water. However, the results of this study have not been published yet and the importance of the problem may have to be verified.

The fluoride (F₂) concentration in the water from 73 municipal wells has also been analysed by Shomar et al. (Shomar B., et al, *Fluorides in groundwater, soil and infused black tea and the occurrence of dental fluorosis among school children of the Gaza strip*, *Journal of Water and Health*, 02.1, 2004). Relatively high levels of fluoride have been found in the water from the municipal wells of the area of Khan Younis, where levels up to a maximum 4.4 mg/l were observed and in the Middle governorate, where levels were reaching 2-2.5 mg/l. A general increasing trend was observed in the fluoride content of the underground water of the wells from North to South, with a slight decrease in Rafah, where concentrations below the recommended WHO guideline of 1.5 mg/l were observed. Dental fluorosis was observed in 60 % of the permanent dentition of the school children examined (n=353), with the highest occurrence in Khan Younis, where the concentration of F⁻ was significantly exceeding the guideline. Except for this last area, F⁻ does not represent a threat for health. Blending of water with better quality one will reduce the problem.

Measures taken within the health centres

A rapid survey (ICRC, August 2007 assessment, personal communication) carried out within the 9 hospitals of the strip shows that most of them do have a problem with the drinking water. As outlined above, the problem is related to the water quality and with the availability and state of the equipment used to pump or to treat the water, whenever this is possible.

Most have been equipped with their own boreholes, but the quality of the water is lower than what is in general supplied by the Municipality (between 2-3000 mg/l TDS, (total dissolved solids). The European hospital (200 beds) relies on Mekorot water and Al Arabi (100 beds) on water from the Municipality. However, the overall situation is not satisfactory with regard to treatment capacity and with regard to the availability of consumables and spare parts for the Reverse Osmosis systems.

ROs produce water of high quality for the different area of treatment, like the kidney department, the dialysis equipment, for the analytical laboratory and to feed the autoclaves used to sterilise instruments, etc. The use of high quality water in the sterilisation process is of paramount importance to avoid rapid deterioration of the equipment, particularly in such a context, where spare parts are difficult to obtain.

Whenever possible, RO water is also used as drinking water. When the RO units are not producing specifically drinking water, like in the new Maternity hospital in Khan Younis (2006) or in the Shifa hospital, water is provided by the families or its delivery outsourced.

Interestingly, almost all the hospitals have learnt the lessons of the “Summer Rains” incursion and have increased their stocks of fuel, their back-up power capacity and their reserves of water and have generally improved their preparation for the difficult days.

But any preparation will not last for ever and the operational capacity of the hospital will also depend on the number of casualties they will receive and for how long.

Prepare for worst times has always been difficult, as the import of spare parts, like membranes for the RO (reverse osmosis), is still subject to the goodwill of the Israeli authority, which can held them for week, when not months. Coupled with the difficulties of the MOH (Ministry of Health), the equipment is maintained as it is possible, and the membranes are changed beyond their normal operation time. The same can be outlined for the autoclaves and for any medical instrument equipping the hospitals.

The deterioration of the electrical equipment is also due to the quality of power supplied by the grid, which is forcing the management to operate the back-up generators in order to operate the equipment, like the X-ray machines, etc., a dilemma with the problems to get fuel.

According to the hospital administrators and maintenance personnel, the flow of consumables, spare parts and new equipment is extremely slow and the speed of deterioration is largely exceeding the coping mechanisms.

The current situation of closure, the tensions and communication problems between Ramallah and Gaza, and the problems between factions inside the hospitals are not helping to prevent an overall deterioration of the situation.

Desalination of brackish water

The poor quality of the water has induced some donors and a few municipalities to use treatment units capable to desalinate the brackish water drawn from the aquifer, using RO (reverse osmosis) technology. End of 2002, there were 6 operational units within the strip. Table II, compiled from Assaf (Assaf S., *Existing and the future planned desalination facilities in the Gaza strip of Palestine and their socio-economic and environmental impact, Desalination*, 138 (2001), 17-28) gives their location and capacities.

Table II. Operational RO units within the Gaza strip (data from Assaf)

Using brackish water up to
5000 mg/l

Name	Water source	Quality TDS mg/l	Capacity m3/h	Des.water prod. m3/h	Use of water
Deir el Balah, (1991) desalination by Israel	Deir el Balah Municipality	3100	78	45	City network
Khan Younis, 1997 El sharki des. Unit	K.Younis Municipality PWA, Well L 41	2500	60	50	City network
Khan Younis, 1998 Al Saada station	K.Younis Municipality PWA, Well L 87	2000	80	65	City network
AQUA Company,1999 private	Private well	1500	70	50	Water sold NIS 2.5 / 20 l
Al Braji company, 1999 private	Al Braji area	1600	60	40	Water sold NIS 3.0/ 20 l
USAID, 2000 industrial zone	Gaza city PWA	1400	95	75	stopped

1 USD = 4 NIS
(2001)

Under construction using sea water
(35000 mg/l)

Name	Water source		m3/h	m3/day	
French desalination	Beach well		60	up to 5000	operational
Austrian desalination	Beach well		30	up to 5000	
PWA large	Sea water		6250	60000 1st phase	not yet started

				up to 150000 at completion	foreseen to 55 MCM / year
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Some of these desalination plants are using water which is almost close to the WHO standards for drinking water, as far total dissolved solids (TDS) are concerned and their set-up is certainly largely motivated by commercial reasons, as RO water from brackish origin can be produced using less energy than when seawater is used and can therefore be sold at prices competitive with those of bottled water. Even so, they are still higher than the municipal water and only a few Gazan can afford to purchase it.

Of major concern is the disposal of the very salty brines, which concentrations in dissolved ions, like Cl₋ and NO₃⁻ are high, and therefore contribute to increase the salinity of the soil within the area where the plant is located. Proper disposal to the sea of these brines should be enforced as the possibility to extend the discharge pipe to the sea is no more depending on any authorization by Israel, even if it may be quite costly to implement it.

The same problems can be observed for the 18 other RO plants installed by private owners within the strip (2003). Their capacity is smaller, between 20 to 180 m³/day, and are meant to produce water to be sold to the public.

The necessity to regulate the setup of the private owned RO units has been acknowledged. If the PWA has allowed 18 private companies to build and produce RO water and has also authorised 10 vendors to distribute RO water to the public, issuing appropriate licenses and tariffs, the process has been going on for a while without a proper water quality control and therefore without the possibility to control the business in order to protect the customers health and interests (*El Sheick, Regulatory challenges on Palestinian strategies on distribution of desalinated water, Desalination 165 (2004) 83-88*).

The quality issue at the station may not be the more problematic and the pace of the controls presently carried out is probably sufficient to guarantee a safe water quality. However, as this water is distributed by different means, trucks, bottles and other containers, it is likely that the contamination will occur during this step and proper regular analysis should be carried out in a random basis to ensure that the water is fit for consumption.

Last but not least, an estimated number of 20000 very small units have been purchased by individuals to produce a mean amount of 120/day of water with low TDS values, for their own needs and possibly for the neighbourhood, a trend that has become extremely popular in the recent year. Interestingly, and without any scientific considerations, the very low level of TDS, close to 100 mg/l is used as a marketing argument, when it would be better to have a slightly higher content of minerals.

The next map shows the location of the medium capacity RO units, quoted in the above table. If for some of these units, located close to the sea shore, it would be easy to dispose their brines, it may not be the case for those located too far, the cost of building a pipeline to dispose the highly concentrated brines to the sea would be unbearable.

The cost of the energy is high too. It is estimated that the cost generated by GEDCO ¹(Gaza Electrical Distribution Company) set at 0.125 USD /Kwh, is about the double of that

¹ For the different companies owning, producing and distributing power in the Gaza strip see: B'tselem Act of Vengeance Israel's Bombing of the Gaza Power Plant and its Effects Status Report September 2006, <http://www.btselem.org>, a detailed analysis of the bombing of the power station and about the responsibilities of Israel in regards of International Humanitarian Law and other bodies of law applicable to the strip.

purchased from the Israeli grid (IEC, Israeli Electric Corporation) (Baluusha H., *Desalination status in the Gaza strip and its environmental impact*, Desalination 196, 2006, 1-12).

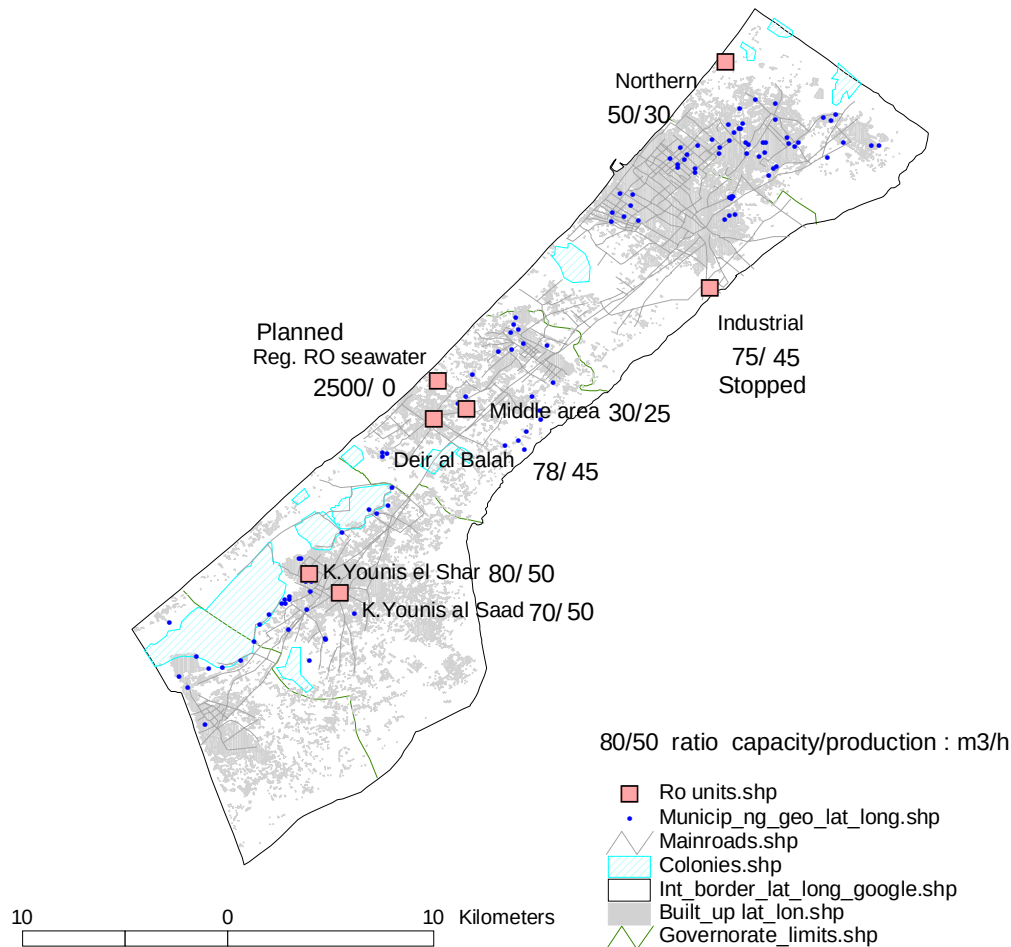


Figure17 Location of the existing RO desalination units within the Gaza strip. The municipal wells are also shown in this figure as well as the built up areas.

This makes the operation of operation of the RO unit relatively expensive and consequently the water too, certainly too expensive if the water produced is used for normal activities, like irrigation or domestic use. In a high capacity Regional RO unit, water can be produced at a lower cost, but the need for energy is anyhow important, and the cost of it will only decrease when the power station can be supplied with gas, recently discovered in large quantities in the sea of Gaza (Assaf, *op.cit.*), provided that Palestinian will be allowed to take advantage of such a resource.

Comparison with other high capacity RO units

Concerns about the land to be used for the installation of the plant can be set aside. For comparison, the newly built RO Seawater treatment plant in Ashkelon (Israel) capable to produce about 223500 m3/day at its second phase, is laid on only 75'000 m2, functioning with a devoted power plant, but also relying from what is produced by the nearby power

station in case of problems (Ashkelon Desalination Plant, Seawater Reverse Osmosis (SWRO) Plant, Israel, Israel, www.water-technology.net, 2008)



Figure 17 Model of the Ashkelon station and Google Earth^R image of the construction site.

Water is produced at a cost of as low as 0.52 USD/m³ (varying with the price of the barrel that regulates the costs for electricity), one of the lowest cost for RO water production in the world, thus making it affordable for low water consumption irrigated crops (greenhouses and drip irrigation technology). When all the phases will be completed it will produce about 330'000 m³/day. Other RO plants are operational (Palmahim about 30'000 m³/d) or under construction in Israel (Hadera (100'000 m³/d), and it is planned to build a few further ones, in principle, to cope with the needs.

The process steps include pumping, pre-filtration, reverse osmosis process, power recovery from the brines, brines disposal, boron removal (important for agricultural production) and re-mineralization of the water prior to distribution. More than 100 MCM/year will be produced representing about 13% of the total consumption of Israel, and more than the present and mid-term needs for drinking water of the whole Gaza strip.

With an estimated population of 1.5 million in the strip, the amounts produced at Ashkelon represent a mean 180 l/c/day for every Palestinian, which is much higher than what is foreseen to cope with the future demand of the strip.

It is not known if the future SWRO plant in Gaza will also have a devoted power plant, with possible connection with the nearby GEDCO power plant.

Anyhow, the project is on halt, like many others, and no one will dare to give an estimate on its realization.

Waste water treatment plant in the Gaza strip

At present there are only 2 WWTP operational. Beit Lahia and Gaza city. Khan Younis has the 4 ponds built by ICRC. This guarantees perfect anaerobic treatment. Aerators are due to be installed. Prior to the 4 ponds Khan Younis only had the storm water collection pond (lake) that can be seen on Google earth^R.

The characteristics of these WWTP are listed in table III. Some data may vary from those published by other authors, as it is sometimes difficult to sort out which amounts are reaching the facilities and which are bypassing them, without being treated.

The Beit Lahia WWTP is collecting the wastewater from municipalities of the northern governorate, Gaza town wastewater are partially treated at the Gaza WWTP. The wastewaters of the municipalities of the Middle Governorate are not treated at all and are partially infiltrated but mainly discharged directly into the Wadi Gaza and directly to the sea. The waste waters of the Khan Younis town and of some municipalities are collected to a WWTP of limited treatment capacity and were disposed to an infiltration lagoon. Those of Rafah were collected at a collection pond, South of the town, close to the border with Egypt, and pumped to the sea to avoid the expansion of the lake of waste (see figures) Rafah never had a plant that merits the name. It had a dedicated lagoon for partial anaerobic treatment. As mentioned previously a treatment plant is under construction (ICRC).

As outlined, until mid-end of 2008, only part of the sewage collected was undergoing treatment. The situation was due to improve in Khan Younis and in Rafah, where new treatment capacities were under construction.

Table III. Wastewater production and treatment in the Gaza strip (see next page)

Out of about 110'000 m3 of waster water / day produced in the whole strip, only roughly 70 % are collected. With a treatment capacity of 45- 49'000 m3/day only 60 % of the sewage is somehow treated as not all the WWTP are functioning at their maximum design capacity. The infiltration capacity reported in the table is including the new basins built at the WWTP of Khan Younis and Rafah, even it is not known yet what will be their exact performance. End of 2008 45'000 m3/day were discharged untreated. With the work carried out at last two WWTP the treatment and the infiltration capacity will increase to about 35'000 m3, thus coping with the mid-term projected outputs of the southern governorates.

The amount of water distributed through the network by the coastal municipal water utilities (CMWU) is exceeding by far the amount reaching the existing wastewater treatment plants. This is due to the fact that not all the buildings are connected to the existing sewage network, and that the network is not completed for some parts. Large amounts of wastewater are disposed through cesspits or via septic tanks using their independent infiltration systems. However, an increased number of users are getting connected to the newly built sewers, and, in some situations, like in Khan Younis, the users have started to connect the outflow of their septic tanks to the storm water network, which creates additional problems to the already poor treatment capacities, when they are functioning.

Even if not all the water pumped into the network reaches the existing WWTP the amounts were on increase until 2006, when the unilateral withdrawal of the Israeli settlement took place. A period of difficulties has then followed, with many projects at standstill, frequent closures and all the related problems to get fuel, pipes, spare parts. Despite former agreements and approval from the Israelis, imports were blocked and projects had to be put on halt. A detailed analysis of the frequency of the closure at the different entry points is reported elsewhere.

Not only the project were on standstill but the different incursions by the IDF resulted in important damage to both the networks, the drinking water one and to the waste water collection system (*Coastal Municipalities Water Utility, Latest update on the effects of the Israeli incursions, July 2006, August 2006, November 2006*). The magnitude of the recent "cast lead" offensive is likely to create un-precedent damage and bring back the infrastructure to a situation worst than what Gaza has experienced during the 2006 "summer rains" one, where many pipelines and networks systems were extensively damaged.

WWTP to be built (at different planning stages in 2009).

The current war will create important damage, no doubts. Emergency repairs will be carried out with the assistance of the acting INGO and UN bodies, with considerable loss of time and funds. All the agreed and funded projects (see main projects on hold), aimed to ease the situation, already on hold, will have to wait again and again.



This was and still is the case of the planned NGEST (North Gaza East), where only the infiltration ponds could be built. The latest Google image available, shows the infiltration ponds, almost completed. However, mid 2008, the new pumping station, located close to the Beit Lahia WWTP was not yet completed, nor was the pipeline connecting the pumping station to the infiltration ponds. However, the layout of the pipeline had reached 90% completion and was expected to be fully completed by the end of the year.

(ICRC, personal communication, September 2008).

Figure 17 NGEST infiltration basins (Google Earth)

In the meantime several interventions have been carried out. The attention of the media and of the authorities was focused on the Beit Lahia lake, where the treated and untreated waste water was disposed, creating a huge volume of poorly treated sewage, prone to burst at any time. An initial warning came when a temporary storm water infiltration basin, filled with wastewater, burst its western banks on the 26 of March 2007. The village of Um al Nasser was completely flooded by the partially treated wastewater (Beit Lahia Wastewater Treatment Plant, Floods, 27 March 2007 OCHA) with fortunately only a few losses of lives. A major emergency operation, mobilizing the ICRC, UNICEF, the World Bank and other INGO under the supervision of the CMWU technical management, was triggered to improve the



disposal of the partially treated sewage and to decrease the level of the Beit Lahia lake (Gaza Emergency Water Project, Emergency response and mitigations at the northern wastewater infiltration basins, Inframan, April 16, 2007).

With two new infiltration basins dug in the security area and regular pumping, the level of the lake decreased of more than 2 m, thus limiting the risk of a "new tsunami".

Figure 18 Beit Lahia WWTP, showing the present set-up, the "Beit Lahia lake" and the area affected by the 26 th March 2007 tsunami. (Google Earth image ^R)

With these temporary measures and with the likely commissioning of the new infiltrations basins the situation of the northern governorate has been considered under control. However, the last war has certainly brought additional problems, even if the power outages may have decreased the flow of any wastewater to the station.



Figure 19 Excavation of the 2 ponds, installation of the pumps and first filling-up of the lagoons at Khan Younis WWTP (Courtesy of the ICRC and Qatar Red Crescent society).

However the infiltration capacity at all the sites had to be improved, at least in a temporary way, until the planned WWTP would be made operational. End of 2008 the WWTP of Khan Younis and Rafah have also been improved when new infiltration ponds have been built.

At the Khan Younis WWTP two new lagoons have been added and a third one has been completed by the end of 2008, with the aim to mitigate the nuisances of the existing collection pond during the next 5 -10 years, until the planned South WWTP, located at the eastern side of the strip will be built.

At Rafah, the volume of the retention lagoon became insufficient to cope with the increased volume of sewage. The existing forced main, discharging to the sea, was not able to cope with the increased amount of sewage and storm water and the site became overloaded (Marwan Bardawil, *Rafah Emergency Waste water treatment plant, April 2008*). Overflow in a nearby depression has resulted in environmental nuisances and concerns about the problem were raised both by the Israeli Civil Administration and by the Egyptian Authorities.

In the same pond were and are still discharged the wastewater collected by the vacuum tankers from the septic tanks and cesspools of the houses not yet connected. In 2006 some improvements were done with the installation of more powerful surface aerators. However, it is estimated that the number of served population has increased from 25% to 75% from 1997 to 2007, increasing the amount of sewage to about 8-8500 m³/d, obliging the authorities to increase and improve the design in order to cope with the current volumes of sewage.

As outlined above the condition of the Rafah WWTP will be upgraded to reach a treatment capacity close to 20000 m³/d, thus coping with the projected increase of the population, until the South WWTP will finally be built. Partial treatment followed by infiltration may reduce the amount to be pumped, through a forced pipeline to a sea outflow (M. Bardawil, Rafah emergency Waste Water Treatment Plant, April 2008).



Figure 20 General location of the Rafah WWTP (Google Earth[®]) and existing collection pond and lakes (courtesy of M. Bardawil and ICRC, 2008) .



Figure 21: Gaza WWTP under maintenance and with aerators in operation

Some improvements of the disposal of wastewater were also made to the Gaza WWTP, with a new infiltration pond, allowing to decrease, if not to suppress, the amounts disposed directly into the into the sea.

Wastewater and sludge disposal

The amounts of wastewater presently produced within the Gaza strip and conveyed to the existing WWTP (Gaza Central, Beit Lahia, Khan Younis and Rafah) can just be treated and disposed relatively safely with the latest implementations carried out in order to improve the infiltration capacity of the sites.

However, there is a need to increase the treatment capacity to cope with further needs linked with the increase of the demand for water triggered by the increase of the population, foreseen to reach the 1.7 M by 2010. The planned capacity will have also to cope with the increase amount conveyed to the plants due to the increase in sewer connectivity in all the built up areas.

Three new regional waste water treatment plant are to be built with one, the NGEST in an advanced phase of completion and with 2 the still in the planning process (Buriej and South).

The existing ones and the new WWTP are generating or will generate important amounts of treated sewage, which should be reused for agricultural production or at least infiltrated into the ground to avoid the rate of depletion currently observed.

According to Ghbn et al. (*Concept for integrated water and sludge management for the Gaza strip*, N. Ghbn, J.E.Hall, K.Brook and R.Bufler, EM Water Project Reg. conference 2006, *Efficient management of Wastewater, its treatment and reuse in Mediterranean countries*, Amman, Jordan) the volume of wastewater to be treated by the planned Buriej WWTP will be close to 115'700 m³/day. The wastewater can be discharged directly to Wadi Gaza, provided that they reach a effluent quality of 20 mg/l/BOD (biological oxygen demand), TSS 10-15mg/l (total suspended solids), total Nitrogen 10-15 mg/l and a faecal coliforms MPN (Most probable number) below 1000/100ml. It is foreseen however to find a compromise between discharge, which would improve the situation of the Wadi, and wastewater reuse, to irrigate unrestricted crops, for which appropriate standards will have to be re-interpreted in order to make sure that the crop produced will be within environmentally safe and that the human health will be protected, or to infiltrate it in order to recharge the aquifer.

If any of the treated water is going to be used the limit of 1500 mg/l as TDS (total dissolved solids) will have to match the levels of the water pumped from the aquifer, which are close to 1800 mg/l. Despite the higher salinity the water can be used for irrigation, provided that the correct crops are selected by the farmers. Orchards may have to be dropped in favour of more adaptable crops less susceptible to salinity. If drip irrigation is chosen enough time must be given to the plants to adapt their roots to use the available water and this will take time and training.

The outlined proposals will have to be tested even if it seems that from surveys carried out within the farmer's community, the willingness to use treated wastewater for irrigation is apparently high. The surfaces concerned by the treated volumes are important, up to 3000 ha, that is about 30 km², even if they fall within the areas defined as agricultural areas in the recent development plans of the authorities.

If infiltration is carried out, based on infiltration rates of 0.5 to 5 m³/m², an area of 3 Km² is sufficient to cope with the volumes at the design capacity. Precise surveys will have to be done to confirm the absorption potential in the designated areas, particularly in the southern areas

where it may be possible to find different patterns of absorption than those observed at the NGEST WWTP site, where environmental impact studies have been carried out

(Environmental assessment, North Gaza emergency Sewage Treatment Plant project, PWA, EMCC, February 2006) .

Conveyance system will have to be designed in a way to minimize the cost the distribution of the irrigation water and proper billing will have to be established.

Sludge disposal

Treated wastewater is not the sole product of the waste water treatment plants. They also produce sludge within the treatment process but also within the infiltrations basins, which bottoms have to be scraped regularly to maintain the infiltration rate and cope with the outflows of the WWTP.

This should be done at a regular interval, every two weeks, in order to maintain the infiltration rate. Presently the scrapped sludge has been disposed on top of the embankments but a permanent solution will have to be found to dispose this particular sludge and also the normal sludge created during the treatment process.

According to Gbhn and all. (*Gbhn N, J.E.Hall, K. Brooke, R. Butler, Concept for integrated wastewater and sludge management in the Gaza strip, ibid.*), the quantities to be disposed are important. The quantities of sludge foreseen to be produced annually are estimated to be close to 30'000 MT/dry solid and may be more, depending on the population increase.

The question of their re-use is depending on the presence of toxic metals or other contaminants, on the willingness of the farmers to cooperate in this field and of the land available for this reuse.

Toxic metals and other contaminants in the wastewater and in sludge.

Owing to the relative small importance of the Gaza industrial production, toxic metals should not be an important problem yet. The relatively small number of industries are concentrated within the city of Gaza GIE (Gaza Industrial Estate) and in the Beit Hanoun Industrial Estate (BHIE). The outflow of these industries is poorly treated if ever, and is disposed within the ground through septic tanks and infiltration pits or mixed with the domestic waters to be treated at the WWTPs, in this case of Gaza city and of Beit Lahia.

Between 2001 and 2003 a study has been carried out by the University of Heidelberg (*Wastewater of Gaza, chemistry and management approach, B.H. Shomar, G. Mueller and A. Yahya,*) in order to determine the importance of the contamination of wastewater and sludge by the industrial outflow. The concentrations of the major toxic metals have been determined in about 31 composite samples collected from the wastewater outflows of 10 different industries in 2001 and 2002 and 11 other industries sampled in 2003. During the same period, 20 samples of influent water and 20 samples of outflow water have been collected at the two WWTP and analyzed for the major toxic metals and treatment parameters. 35 samples have also been analysed in samples collected from the sludge of the drying lagoons and from the accumulated piles in the surrounding areas.

If the data show that the domestic wastewater influent to the WWTPs contains considerable amounts of heavy metals, the data obtained from the outflow show that both plants are capable to remove between 40 to 70 % of most metals during the treatment process, without any significant impact on treatment bioprocesses. According to the study, the wastewater

effluent had good characteristics, close to the guidelines and standards of many developed countries, and could be used for agricultural purposes.

In the sludge, only Zn and AOX (organic halogens) were found to exceed the standards. The origin of the former is from metal electroplating and galvanizing industries and the second one from paper industries, using a lot of chlorine and organo-chlorine in old technological processes. Owing to their phosphorus and nitrogen content, and to their relative low concentrations of toxic metals, the data were clearly showing that the sludge recovered from the WWTP of Gaza could be used for land application, with a proper information given to the users.

Energy in the Gaza strip

Gaza is supplied with electricity mainly by Israel and by Egypt. Out of about 1000 MWh/year consumed within the Gaza strip roughly 700 MWh/y are purchased from the Israeli grid and reach Gaza through 11 feeders located all around the strip. Two lines are also connected to the Egyptian grid, supplying mainly the governorate of Rafah.

In 2004 the GECHO power plant was put into operation with a potential production capacity of 140 MW. The power plant is located south of the Wadi Gaza, about 10 km south of the city of Gaza, occupying roughly 150'000 m².



Figure 22 Cropped images from Google Earth, showing the general location south of the Wadi Gaza and a detailed view of the site.

4 Gas turbines (ABB GT1B2 (GTG) have been installed. Combined with 2 steam turbines, (STG) the installation forms 2 generating groups, each consisting of 2 gaseous turbines and 1 steam turbine, the latter recuperating the heat produced by the exhaust of the gas turbine.

The total energy which can be produced by the Gaza generating plant cannot be higher than the available step-up/step down transformers. Each GTG and each STG block deliver the power to a step-up transformer from, goes through a step-down one and feed the grid, at a voltage of 22 kV.

At present, the gaseous turbines are working on liquid fuel (filtered diesel oil No. 2) but they also can work on natural gas, being equipped with a dual ignition system, would a proper supply been able to cope with the consumption. Fuel is presently supplied from Israel, but it is possible that in the near future, gas will be made available from the sea of Gaza, where important stocks have been found.

Basic Components and equipments of the plant:

- Four gaseous turbines (Electric generators) type GT10B2 and all related accessories
- Four steam boilers dual-pressure to recover heat, with gases converter and chimneys
- Two medium-pressure steam turbines
- Two condensers , cooled down by sea water
- Electrical equipments and transformers to raise Voltage
- Controlling system and direction systems

The system was first operated in June 2002, with the ignition of the first gas turbine. The others were then successively operated, reaching full productive capacity on the 15th of March 2004, when commercial distribution could start.

A scheme of the different units and of the set up of the step-up/step down transformers is shown in the following figure, where also the grid connections are given.

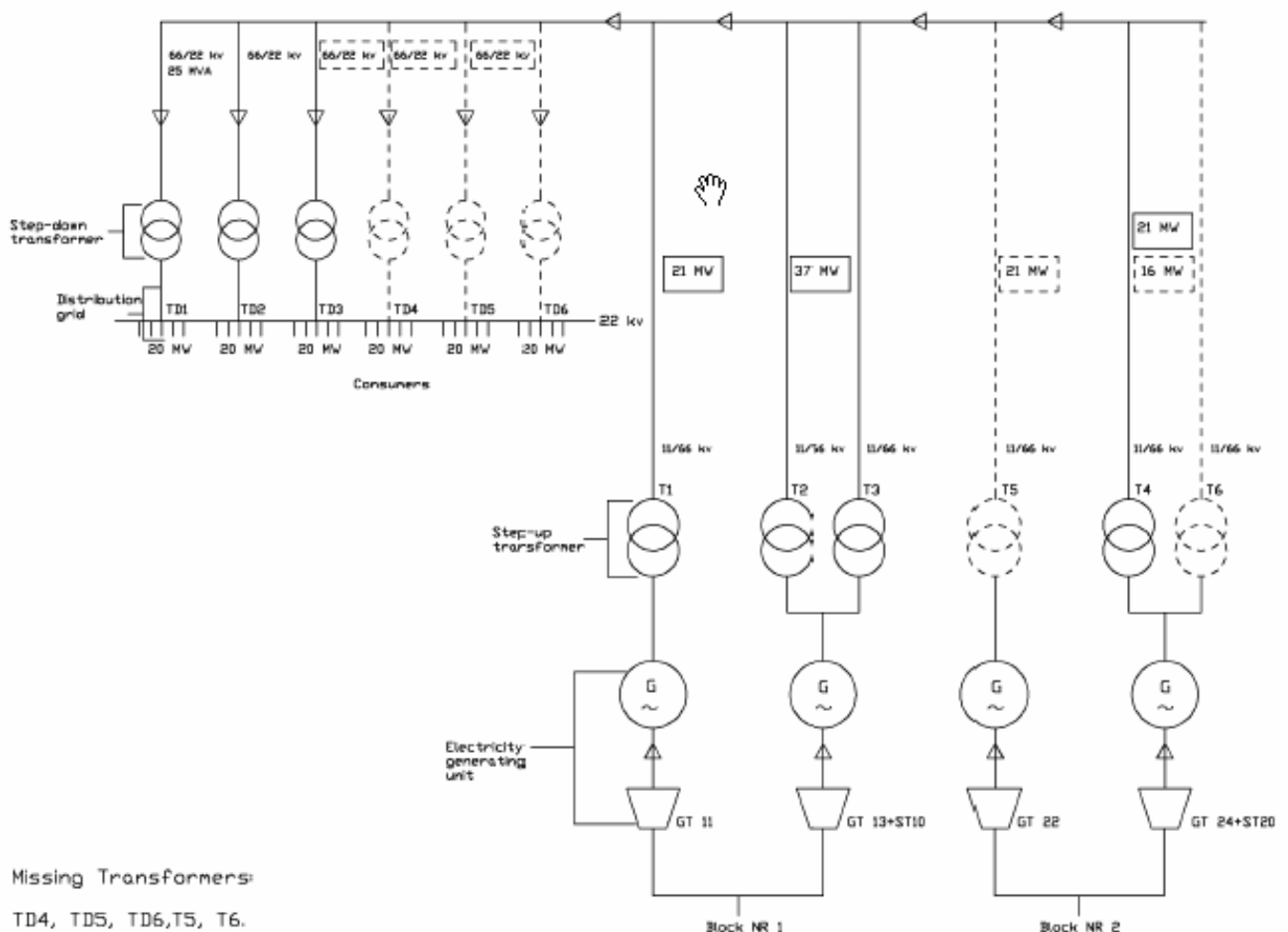


Figure 23 Schematic layout of the essential unit of the GECO Power Station) courtesy from ICRC. Step-up transformers T 5 and T6 are lacking as well as step-down TD4, TD5 and TD6.

The lack of the step-up and down transformers limits the plant capacity to about 79 MW, about 60 % of the rated capacity.

The plant was damaged during the summer rains military operation when the two out of 4 step-up transformers were damaged, hit by rockets (*B'tselem Act of Vengeance Israel's Bombing of the Gaza Power Plant and its Effects Status Report* September 2006, <http://www.btsalem.org>).

Repairs were carried out since. End of November 2007 the plant reached a production of 116 MW. However, with two step-up transformers lacking (21 and 16 MW) only 79 can be given into the grid. Moreover, with 3 step-down transformers (66/22 kV) lacking about only 60 MW could be fed to the grid. A 20 MW step-down transformer was due reach Gaza, thus matching the step-up capacity, with about 79 MW to be connected to the grid

In principle, the Gaza generating plant has the capacity to supply close to 90% of the electricity used within the Strip. However the high cost of fuel, the un-complete network to carry and to distribute electricity, limit the present use to about 40 %.

The next figure shows the importance of the supply from the Gaza electric company and the Israeli electric company in the total energy consumed in the Gaza Strip during the period from March 2004 until December 2004.

During the last nine months of 2004, the part of the consumption supplied from the Gaza Electrical CO has been close to 36 %, with the remaining supplied by Israel and a small part by Egypt. This part was due to increase but for the reason mentioned above the dependence from Israel has remained almost the same.

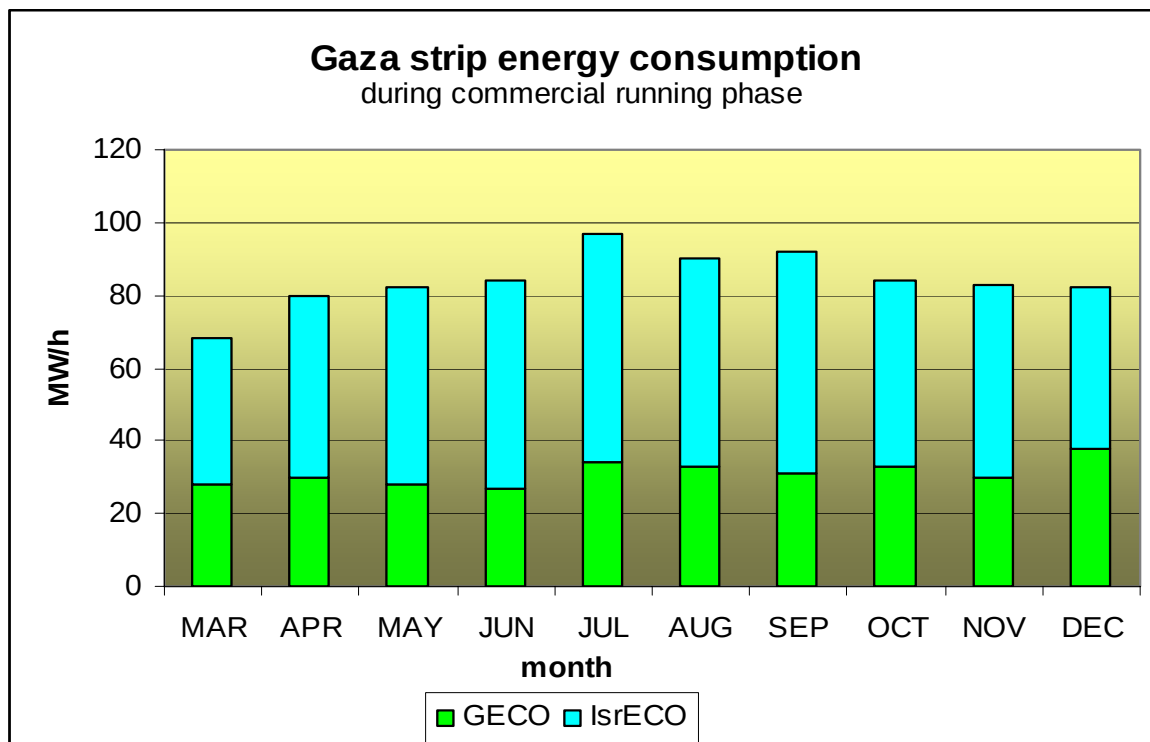


Figure 24 Total monthly consumption of electricity in the Gaza strip by origin (Egypt not shown, about 10-11 %)

Closure of the Gaza strip and incursions

Before and after the 2006 unilateral disengagement by the Israeli IDF, the response to any attack by militants using makeshift rockets fired to Israel from the Gaza strip, or by any activity considered to threaten the security of Israel, has been to close the different crossing between Israel and the strip or to launch military incursions deep into the strip, either by aerial raids or by ground offensives. It is also true that the recent use of more sophisticated rockets (Type GRAD) has worsened the situation.

These incursions are allegedly conducted to attack specific targets but collateral damage is in general important. If direct casualties are creating dire suffering among the population, collateral damage to the infrastructure is part of the strategy used by the IDF to create difficult life conditions within the strip, with the aim to induce voluntary departure. Direct targeting of the power station on 28 of June 2006 during the "Summer Rains" incursion in June 2006 is part of this strategy, conceived initially during the Itzak Rabin rule and maintained by the different governments, under Sharon and E. Olmert PM, outlined by A.Gray (the water crisis in Gaza, IV Online magazine IV386 February 2007, International viewpoint).

After these incursions a list of damage is generally dressed and forwarded to the different International Aid Organisations for funding and purchase (*Coastal Municipalities Water Utility, situation reports of water and wastewater services due to the prevailing security situation, 23 July and 6/22 August 2006*). Sadly, the very same donors are sometimes ending up to pay for what they have already funded, when major projects are undergoing damage during the military incursions (Gaza Emergency Water Project, funded by the WB, *Updated Damages to the Water and Sanitation Network in Beit Hanoun, the World Bank, 1 December 2008, letter to the COGAT, Infrastructure Liason*).

The repairs carried out on the power station after the June 2006 bombing, expected to last between 9 to 18 months, were completed beginning of 2007, have suffered from the same constraints and fall under this surrealistic situation. As a rule complaints handed over to the Israeli authorities are neglected and donors have no other issue than put the projects on hold, when they are not giving up.

Ironically, purchasing electricity from the Israeli grid costs less than producing it from fuel which is purchased from Israel anyway. But the burden put on the civilian is high as all the grid connections will have to be modified, with disruption of the distribution of drinking water, of the wastewater evacuation and, last but not least, with large areas of the strip on outage.

The international aid organisations do react swiftly to resume or to improve the distribution of drinking water, by delivering fuel or by equipping the pumping stations lacking back-up power, with emergency electrical generators. As an example, after the "summer rains" incursion, a deal between the ICRC and CMWU has been signed for the purchase and installation of 14 back-up electrical generators, with power varying between 80 and 250 KVA, to equip the municipal wells or the waste water lifting stations, providing as well the necessary fuel and spare parts to operate and maintain them.

In June 2006, when the 50% of power supply was cut the immediate reaction of the INGO (International non governmental organisations) was to deliver fuel to operate the different pumping stations. Roughly 120 wells were to be operated for 12 hours/day and 37 wastewater lifting stations for about 4 hours/day, with fuel consumption close to 15'000 litres/day. 115'000 litres of fuel were supplied, plus 15000 litres purchased in Gaza at a higher cost, allowing to operate the system for about 10 days, until the EC via the TIM

(Temporary International Mechanism) started a programme of fuel supply to cover all the needs for the water supply and for the sewage evacuation during 6 months.

Days of closure

During the closures, little or nothing is allowed to enter into the Gaza strip. As outlined previously fuel is of paramount importance to maintain operational the installations essential for the survival of the civilian population, as power is necessary to operate the water systems, but also to maintain operational the cold chains, the food refrigerators, and all the equipment used within the health facilities. Wealthy Gazan have set up their own stocks and purchased their own private generators to cope with these closures, if these do not last too long. But the large majority of the population relies on the utilities and these are badly affected.

There are three main crossings to import goods from Israel into Gaza: Karni, Sufa and Karem Shalom. Until June 2007 the vast majority of food and goods were entering the strip via the main terminal, Karni, with about 300 trucks a day. However, during the closures, only a few trucks are allowed to cross to the strip, after lengthy negotiations. Statistics compiled by WFP during the last three years are appalling (*WFP VAM Vulnerability analysis and mapping, Food security and market monitoring, Report no. 9, June 2007*). In 2005 the strip remained closed during 42 days, in 2006 during 90 days and in 2007(June) during 27 days. The number of days of closure per month is shown in the next graph (quoted report).

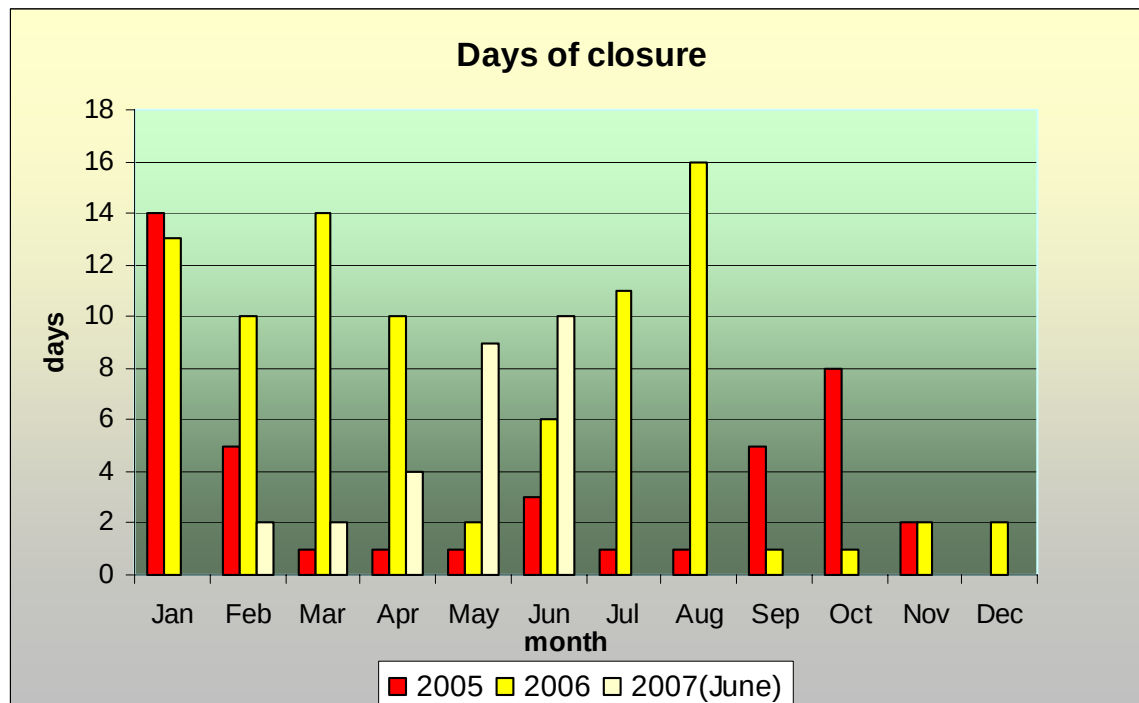


Figure 25 Days of closure per month at Karni crossing (from ref. WFP_VAM, June 2007)

As pointed out in the a/m report the crossing are sometimes open for 2 to 3 hours only. The number of trucks crossing the entry point is also misleading, as for unknown reasons, only half the cargo or even less is allowed to cross.

The effects of the closure are dramatic. Stock supplies are reduced to their minimum level, humanitarian convoys are obliged to use the Karem Shalom crossing with transport costs three times higher than through the Karni crossing, and only a few trucks are allowed to entry the strip, down from a mean number of 240/day to 10-20/day. Prices of staple have increased in the last period of 2007 of about 60 to 70 %, with wheat flour up to 160 NIS /60 kg bags from a mean price of 100 -110 NIS in the previous months, reflecting global trend but exacerbated by the closure and, at the same time, the prices of goods exported from the strip into Israel have also dropped, due to the freeze in the export by Israel. The price of the tomatoes and of the potatoes has dropped of about 70% as compared to the previous period of 2006.

The truce signed on 19 June 2008 between Hamas and Israel lasted until the 11th of December, when the border was close, for an unlimited time, plunging the Gaza into darkness for hours, with intermittent power supply, the GPGC (Gaza Power and Gas corporation) trying to use at best the power produced by the Power plant and what is available from the Israeli and Egyptian grid.

Gazan are fearing for their daily life, with cooking gas, food, and almost everything in shortages (*Hass H., Dark days in Gaza, resident worried about winter, Haaretz, 17 Nov. 2008*)

The positive conditions are back again, for the worst.

TIM (Temporary International Mechanisms)

As a result of the financial, socio and humanitarian crisis induced by the political changes that occurred within the West Bank and within the Gaza strip with the arrival on power of the HAMAS, the Middle East Quartet welcomed a proposal from the European Union to develop a mechanism in order to provide a direct assistance to the Palestinian people.

Through three windows of interventions the TIM set up systems to provide essential supplies and services in the health, education and social sectors.

In 2006, during a period of 6 months, following the June incursion, more than Euros 188 M have been channelled through the TIM, ensuring access to water, health care and sanitation for 1.3 millions of people in the Gaza strip and direct financial assistance to about 150'000 Palestinian households with a direct impact on 1'000'000 Palestinians. End of 2006 the TIM was further extended to 2007.

Windows I and II are meant to support the essential services within the WB and the Gaza strip, mainly with the provision of fuel and Window III was addressing the increased social problems due to the loss of income as a result of the deterioration of the situation.

An external independent evaluation of the objectives pursued by the TIM, carried out on July 2007, concluded that the TIM was an "innovative instrument to quickly mobilize resources from different donors and to target them efficiently to the most needy", achieving, after 12 months of interventions, almost all the expected results, with about 300 millions Euro disbursed within the WBOT and the Gaza strip. (*Interim evaluation of the Temporary International Mechanism (TIM) final report, July 2007, SOGES*).

The Gaza strip has received a substantial part of the funds. Among other, TIM has "provided 100% of the fuel needed to produce electricity in the only Palestinian based power station,

with an amount of more than 60 millions litres of fuel from Mid November 2006 to June 2007”.

The system can be resumed quickly and its efficiency can even be improved. It has been essential in maintaining alive a large part of the Palestinians, and certainly those living in Gaza, whose resilience has been put to their limits. By supporting the utilities, in their strive to provide essential services, the Tim has achieved to maintain them afloat, despite the fact that HAMAS did not comply with some of the conditions required by the donors, like the recognition of the existence of Israel.

The fundamental problems leading to the crisis are still not solved and one wonders how many TIM windows will have to be used and how much money will have to be put in such mechanisms before that anything viable can be initiated.

The spiralling trend of violence, used by both parties and within the Palestinian themselves is not going to be change in the near future.

If any aid is a must in such contexts, something putting more constraints on the different actors must be found to avoid the total collapse of any institution, leading to the creation of a rough state, similar to what has been observed with Somalia.

Infrastructure projects on halt

The closures and the tight controls exerted by Israel on the Gaza strip have resulted in the complete halt of almost all the very much needed infrastructure projects, necessary to cope with the increased needs of the Gaza's inhabitants. End of 2008 a tentative list can be outlined:

- Completion of the Gaza Power plant with the installation of one step-up transformer and 2 step down ones and improvement of the distribution grid
- Implementation of the modifications of the water networks and construction of the storage tanks
- Drilling of new wells recommended by the 5 Master Plans for the governorates
- The Gaza regional desalination plant, aimed to supply 60000 m³/day of drinking water with low saline content. On halt with the freezing of funds by USAID due to the arrival at power of the HAMAS in 2006
- The Gaza regional water carrier, aimed to distribute parts of the water produced by the plant to the different agglomerations. In the planning process
- The Gaza North waste water treatment plant to deal with the excess sewage reaching the Bait Labia waste water treatment plant. Pipeline: 90% completed, infiltration lagoons: operational, pumping station at Bait Labia: to be completed. Waste water treatment plant at North Gaza: in advanced planning stage.
- the Buriej waste water treatment plant, aimed to treat part of the Gaza city wastewater and part of the Middle governorate ones: In advanced planning stage
- the South waste water treatment plant aimed to collect water from Khan Younis and Rafah: In the planning process.

- Construction and operation of an autonomous port
- Rehabilitation of the damaged airport

To implement these projects funds were made available by different donors. Some have been frozen since, other have been suspended since 2006. However the restrictions of the import of the necessary construction materials and equipments have made every simple operation impossible. Steel pipes are retained at the crossings for various reasons, cement and building materials do not enter the strip since 2006 and without materials nothing can be built, obliging humanitarian agencies to revert to what can still be found within the strip, or to go through endless negotiations to import common items. Even pumps are considered strategic material, obliging the agencies to install home made ones, built with ingenuity by local manufacturers, until they will run out of parts. The same ingenuity is probably used to build the makeshift rockets that are launched to the neighbours areas, triggering retaliation from the Israeli Defence Force, to an extent that is always difficult to foresee.

In the meantime the needs are increasing, the electricity outages are more common than ever, the disposal of wastes is still a huge problem and the daily life for the inhabitants of the strip is becoming a nightmare.

On top of that the recent war has disrupted all the services, preventing the utilities to carry out basic repairs, as security of the personnel cannot be granted when even civilians cannot get any protection. The damage to the grid, to the buildings, to the pipelines and to the pumping stations has reached unprecedented levels and the very first effort will have to be devoted to the reconstruction of what was somehow working at the end of 2008.

Beside the unacceptable high level of casualties, more than 1000 deaths and 5000 wounded (15 January 2009), a considerable number of buildings have been destroyed, either by direct shelling within the urban agglomerations or destroyed to increase the "shaved" areas in order to limit the operations of the Hamas military branches. It is reported that more than 2500 buildings have been flattened, sometimes without taking the minimum precautions to avoid unnecessary casualties, as the number of civilians killed or wounded is likely to show.

The 2008-2009 war on Gaza

Damage to the infrastructure essential for the survival of the civilian population

The 22 days of war have been conducted with an unprecedented use of force by the Israeli Defence Forces. It has been reported that more than 2400 buildings have been completely destroyed and about 20'000 have been severely damaged by the bombardments.

The damage is not only affecting the immediate livelihood of the inhabitants but it will have medium to long term consequences as well on their life.

Before this war there was a need for many development projects, aimed to cope with the future needs of a growing population, trapped into a ghetto with shrinking resources.

After this war the emergency is acute and the humanitarian actors have to deal with the immediate needs created by the bombardments. The task is huge and the cost to bring back the infrastructure to the situation prevailing before the war is enormous.

As usual a detailed assessment of the consequences of the war will be carried out by the local utilities assisted by the different specialized agencies of the UN and by other

organisations. Some of the problems which are likely to be identified will need to be addressed immediately. A tentative list can be outlined:

1. Damage to the electrical network

- Many kilometres of cables will have to be re-installed or repaired at the medium voltage lines (22 KV) and at the reconnection from the step-down transformers to the buildings. Some problems will be faced within the electrical wiring of the buildings, when damage has hit them.
- A number of step-down transformers, which are prone to be hit by “shrapnels” or by any projections if they are not hit directly. The number affected will be high, most probably over a few hundred, owing to their density in such an urban environment. All will have to be checked for leaks and for any damage to the insulating items
- Leaks will result in transformer oil spillage into the ground. The type of fluids used are extremely toxic (PCB, polychlorinated by-phenyls insulating fluids). Owing to the type of soil, they will be leached into the ground during any rainfall and will reach the underground water table, from which most of the inhabitants rely for their drinking needs.

2. Damage to the water production and distribution systems

- Some pumping stations may have been damaged as being located close to “military targets”. The number of wells used to pump domestic water into the network is close to 120. It is possible that only moderate damage is observed and the pumping can be resumed relatively quickly, if it has been stopped. Most if not all the pumping stations have been equipped with stand-by generators and fuel stocks. It is not known what is the current situation, but it is likely that one of the first tasks of the humanitarian efforts will be to make sure that water can be pumped. An initial re-supply of diesel will allow pumping to distribution gantries located within the well stations, in order to fill up distribution tankers. Emergency storage tanks will have to be installed at strategic locations. The distribution by tanker may last for months, and will be downscaled when part of the network may be used again.
- When water will be pumped one will start to understand the extent of the damage to the conveying pipelines and to the primary, secondary and tertiary network. It is likely that important leaks will be observed in all of the three networks, particularly close to targeted houses or buildings, where huge craters have been observed. These leaks are quite easy to identify as the amounts of water spilled are easy to see. Their repair requires specialized equipment, like mechanical digger, mobile welding machines, powerful dewatering pumps and repair equipment and materials (pipes of the type used and special collars). Small leaks on the secondary and particularly on the tertiary network (connection to the houses) are more difficult to spot, particularly in this type of sandy soil, prone to easy absorption of any fluid. The proportion of asbestos cement pipes in Gaza governorate (450 Km of pipes) is low, close to 4%, but their diameter is relatively important, between 4 to 6 inches. There are prone to be more affected and losses may be quite important.
- Due to the high number of huge explosions (4-60/days) shaking the ground and therefore the pipe network, the number of leaks due direct damage at the craters will be high, as well as along the pipelines, due to breaks. Many of them will go unnoticed as small leaks are difficult to spot in sand. The direct consequence is that the amounts of water lost will increase dramatically, with UFW (unaccounted for water) increasing from an estimated 30 % to 50% or more. All the efforts done to reduce the proportion of the losses will have

to be resumed. The number of leaks will be high, more than a few thousands. The repair of those easily identified will require an important number of collars and pipes and a time consuming digging, using mechanical shovels, if available.

- Damage to the elevated storage tanks. Almost all the buildings in Gaza were equipped with elevated storage tanks. Water was pumped up to the roofs and then distributed by gravity within the buildings. A large number of them have been damaged, sometimes on purpose, as it has been observed during the previous incursions, and are leaking. Their number may be slightly less than the number of buildings damaged, but they will have to be replaced, at least in the long term. In the meantime the inhabitants will have to queue at the distribution tanks, until the distribution of water from the network will be resumed. Not all the areas have been affected similarly.

3. Damage to the sewage network and lifting stations.

- Among the 37 lifting stations some have certainly been hit and damaged. Emergency systems may have to be installed to keep the flow of sewage going. It is likely that in the early weeks, the flow of sewage will be reduced, as the pumping of domestic water has decreased too. Any damage to the sewage network is even more problematic than that to the domestic water, as interventions are more difficult. Seepage to the water table is inevitable and cross-contamination to domestic lines may be important, creating the conditions for the transmission of water related diseases, which may reach epidemic proportions.
- Treatment of sewage is less critical in the short time. The problem will be to make sure that the sewage will reach the existing treatment stations, which can be bypassed, if necessary.
- The quality of water should be monitored as soon as possible and compared with former results. Wells in heavily affected areas are likely to pump water of poorer quality, with higher levels of nitrate, even if their increase may occur in a later stage, owing to the time needed for sewage seeping out of the broken pipes, to reach the water table. Any rainfall may contribute to speed up the contamination process, by leaching spilled contaminants into the soil and finally to the water. A particular attention must be given to toxic chemicals spilled from damaged step-down transformers.
- It is not known what kind of chemicals are released from the exploding ordnance used by the Israeli army.

4. Loss of professional people during the hostilities.

The number of deaths and injured has been important. More than 1200 people have lost their life and more than 5000 have been injured. It is possible that key professionals may have been killed or injured during the bombardments and the utilities may be confronted with a loss of personnel and knowledge. This is likely to create an additional problem, in a situation where the needs of competent people is of paramount importance. A particular effort must be done by any international agency involved in any emergency reconstruction to support the utilities, by allowing them to hire additional people.

Conclusions

A dramatic increase of the population of the Gaza strip, the limited land available within the strip for any further development, the overuse of the available resources and the organised dependence by the occupying power have led and will inevitably lead to a predicted environmental catastrophe in the coming years. The organised blockade of the strip by the Israeli, their tight control of any import and of any movement of people through the few crossings, the blatant non respect by the power exerting its control over the strip of any provisions agreed during the fragile truce negotiations, have made the situation unbearable for the inhabitants of Gaza.

None of the very much needed projects to be built within the strip in order to improve the access to water, to protect the fragile aquifer from where the essential resource is obtained, to improve the treatment and the disposal of the wastewater, have been completed. When it was the case, like for the power station, its normal operation has been anyway depending from the goodwill of the Israeli, who did not hesitate to damage it when they considered that the collective punishment of the Palestinian society had to be increased.

On top of this, the recent war on Gaza, carried out with an unprecedented and disproportionate use of force by the Israeli Defence Forces, has brought deaths, wounded, destructions and damage to an already deprived society and poorly protected urban environment.

A huge humanitarian effort will have to be launched to reconstruct what has been destroyed and damaged, requiring hundreds of millions of USD, with most of the necessary items to be purchased ironically within Israel, paid and repaid by the International Community, who has remained too long silent, leaving the occupant to carry out its war against the civilians in a total impunity.

The responsibility of Israel and of Hamas before and during this war must be thoroughly established by a fact finding commission and those involved in the key decisions brought in front of the International Criminal Court and being made accountable for their crimes against humanity and for their war crimes.

In the meantime the people of the Gaza strip have been left with their deaths, their rubbles and in a state of deprivation never experienced before.

This paper may help to appreciate how far, by describing how services and resources essential for the survival of any organised society were available to the Gazans just before the war. Since the last war the situation has worsened as well as the environmental health problems related to it.

It is likely that the reconstruction efforts will focus on the emergency created by the recent war. The fundamental problems of this strip will remain and have to be addressed if the International Community has any intention to avoid the predicted environmental catastrophe.