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Water for Mogadishu: water supply in a war torn town

with 6 figures and 1 table

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Abstract

The central water distribution system of Mogadishu (Somalia) came to a complete stop in June 1995. The inhabitants had to rely on boreholes and hand-dug wells, equipped with either hand-pumps, or motorised pumps.
To cope with the demand, the number of wells equipped with motorised pumps as well as the number of boreholes has drastically increased since 1995. Concerns were raised among the Non-Governmental and Humanitarian Organisations on the possible inland movement of the saline wedge due to this increased water abstraction .
At the beginning of 1997 a total of 640 wells had been surveyed by the ICRC and the results of the water salinity, expressed as microSiemens (µS/cm), have been plotted with the use of GIS (Geographical Information System) on a georeferenced map and compared to previous ones. While the 4000 µS/cm boundary has remained fairly constant, the 3000 µS/cm one has moved significantly inland. This has been attributed to the high pumping rates of the motorised wells, supplying most of the donkey cart water vendors, which distribute about 9000 m^3/day to the inhabitants of the town. The situation is not yet alarming but the evolution of the salinity wedge will have to be monitored regularly. The different parameters collected will allow the behaviour of the saline wedge to be modelled, and help to understand and manage the underground aquifer.

Zusammenfassung

Im Juni 1995 kam das zentrale Wasserversorgungsystem von Mogadishu (Somalia) zu einem kompletten Stillstand, sodass die Einwohner auf die Wasserversorgung von Ziehbrunnen (zum Teil ausgerüstet mit Hand- oder Motorpumpen) sowie Tiefbrunnen angewiesen waren.
Um die Nachfrage nach Wasser decken zu können wurde die Anzahl von Motorpumpen für Brunnen sowie die Anzahl von Tiefbrunnen seit 1995 drastisch gesteigert, sodass Befürchtungen von NGO's und humanitären Organisationen geäussert wurden, dass diese zusätzliche Wasserenthnahmen die Grenzzone zwischen Salz und Süsswasser innerhalb des Aquifers landeinwärts tragen könnte.
Insgesamt 640 Brunnen und Tiefbrunnen wurden zu Beginn 1997 untersucht und ihr Resultat bezüglich Salzgehalt des Wassers (ausgedrückt in Micro-Siemens: µS/cm) mit Hilfe von GIS (Geographisches Informations-Systems auf eine georeferierte Karte dargestellt und mit den früheren Daten verglichen. Wenn auch die 4000 µS/cm Grenzzone in etwa stationär blieb, so hat sich doch diejenige von 3000 µS/cm markant landeinwärts verschoben. Dies muss in Zusammenhang gebracht werden mit den hohen Förderleistungen der motorisierten Brunnen, die vor allem die Wasserverkäufer, ausgerüstet mit Eselskarren, versorgen und etwa 9000 m^3/Tag an die Einwohner der Stadt verteilen. Trotz alledem ist die Situation noch nicht alarmierend, doch muss die entwicklung der Grenzzone des Salz-/Süsswassers regelmässig verfolgt werden. Aufgrund der gesammelten Parameter kann nun der Aquifer modelliert werden, um schliesslich das Verhalten der salinen Grenzzone zu erklärt sowie eine Verwaltung der Süsswasserresourcen zu erlauben.

1) International Committee of the Red Cross, CH-1202 Geneva, Switzerland

1. Introduction

At the end of the 80ties the Mogadishu water supply was already on the verge of collapsing. Fuel shortages, lootings and technical breakdowns which went unrepaired for weeks, due to lack of spare parts, made the water distribution through the poorly maintained network very erratic. Complete breakdowns could last for weeks and large areas of the town went without a drop of water for years.

The situation was even more precarious in the 90ties due to the damage inflicted by the civil war, even if some attempts to run the systems were done in the aftermath of the '91 war, when some agencies helped the Water Board with fuel, new generators and spare parts, mainly to keep the system running to cope for their own needs.

During the beginning of the nineties it became clear that the water problem would not be solved by just supplying fuel and spare parts. It also became clear that it would take years until a political settlement would resume the commitment of the donors for the huge investments that are necessary for such a town.

In the meantime the inhabitants have to survive on hand dug wells and boreholes located within the urban areas.

A proposal to improve the dramatic situation of the city population was outlined by E. Sommavilla (1991), in the early months of the international community mobilisation for Somalia, based on his wide experience on the hydrological situation of the town (Sommavilla, 1991). The project proposal was to rehabilitate first the existing hand-dug wells, to sink new ones and to improve the functioning of the existing drilled boreholes within the city, particularly the ones located in the upper zones, at a height of about 70 m a.m.s.l (above mean sea level), which is some km inland from the coast, giving large amounts of water of acceptable quality.

The recommendations outlined in these reports were strictly followed by the ICRC (International Committee of the Red Cross) water and sanitation engineers and by other agencies like ACF (Action Internationale contre la Faim). They are still the cornerstones of the present approach to maintain and to improve the water supply situation of the town.

In this paper we will partially describe what has been done during the emergency phase up to now, more extensively outlined in a former paper (Nembrini, 1996) and present the results of the study carried out at the beginning of 1997 to monitor the effects of saline intrusion near the coast. This will eventually allow the saline wedge, and its movement in response to changing groundwater levels, to be relatively accurately modelled.

2. Mogadishu water supply

Water for Mogadishu was harvested from the well field of Afgoi, about 15 km north-west of the town, and from the well field of Balcad, located about 17 km to the north-east. The locations of these wellfields are shown in figure 1.

The Afgoi and Balcad well fields could produce about 45'000 m^3/day with all the wells operational. Afgoi production decreased from 35'000 m^3/day before the war to about 20'000 m^3/day end of 1994. Between 1970 and 1978 the Balcad wellfields were supplying about 6.5 million m^3/year (17800 m^3/day), with water flowing to the town by gravity. The Balcad well fields were closed down at the end of 1992 due to the poor condition of the boreholes, generators and equipment: only 2 out of 21

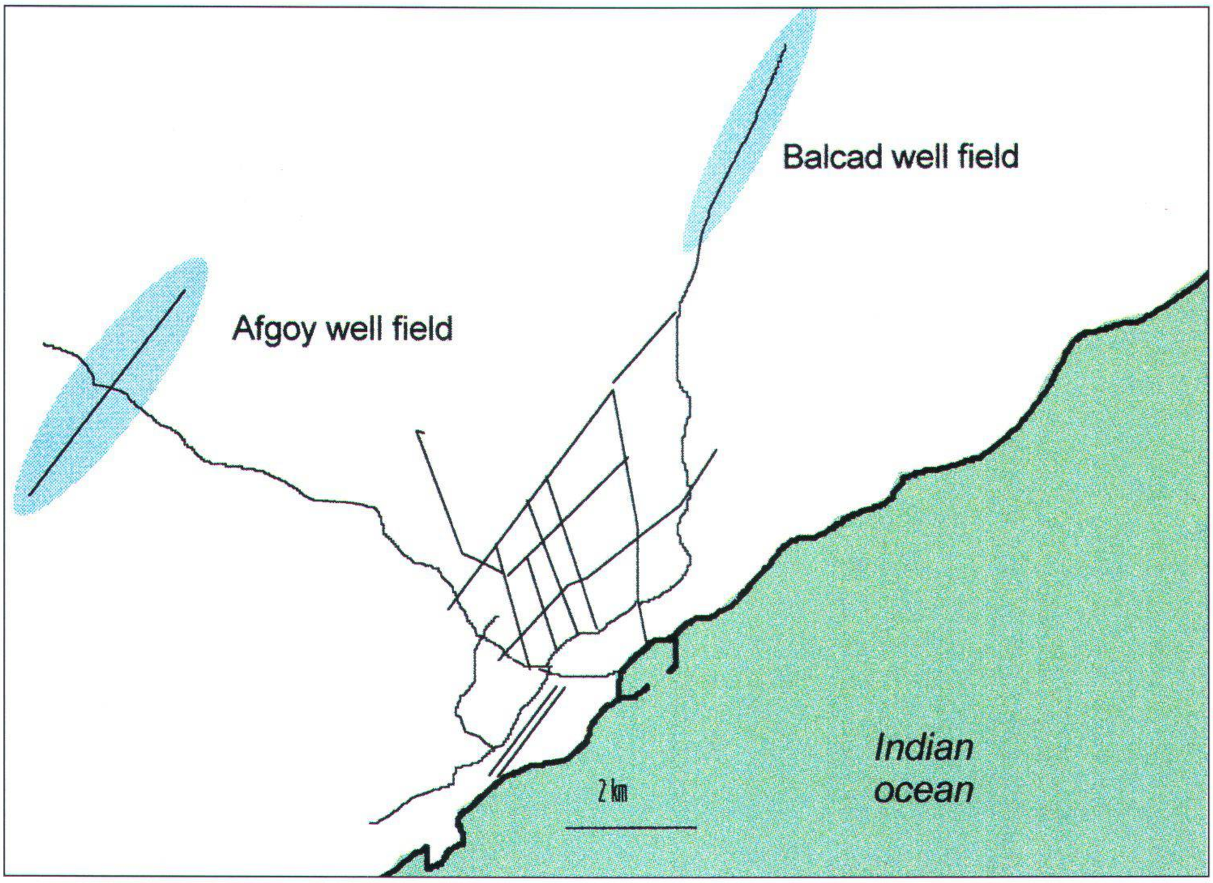

Fig. 1: Mogadishu: location of the Afgoy and Balcad wellfields

boreholes were still operational. Later the plant was looted. The Afgoi well fields were operational until mid 1995. Of the 32 boreholes only two have collapsed. Presently 14 are, in principle, fully operational, the others need pumps and other equipment. Power is provided by 4 x 325 KVA Cummins diesel generators and by 4 x 600 KVA Caterpillar ones. These generators are old and even though 2 of the 600 KVA's have been replaced by 2 new Detroit generators given by UNOSOM (United Nations Operation for Somalia), the problem of the supply of diesel, consumables and spare parts of course remains.
During the foreign military presence fuel was provided initially by the US Army and then by UNOSOM, the fields being operated under the supervision of UNDP (United Nations Development Programme). This was mainly because a large part of the water produced was in fact needed to cover the troops needs (25% of the consumption of the water produced). The last delivery of fuel by UNOSOM took place in February 1995. Two private companies, Somalifruit and Sombana then delivered quantities sufficient to run the water supply for about two months. In June 1995 the production came to a complete stop and despite several attempts to fund the project by ECHO (European Community Humanitarian Organisation) and again UNDP, the water supply has not yet been resumed (Ulens, 1995). Now the part of the town supplied by these wells also lives on hand-dug wells, on a few boreholes and on water carriers (donkey carts).
Since 1980 a large number of boreholes were drilled within the city in response to industrial and economic expansion and many hand dug wells were equipped with motorised pumps.

3. Water supply programme carried out by the ICRC and other NGO's[1)]

3.1 The famine-civil war period (1991-94)

A total of about 250 hand-dug wells have been rehabilitated or constructed by the ICRC throughout the country during this period. The main objective of the ICRC programme was to provide water to the displaced people, there where public kitchens were established to feed them. These people were leaving a drought affected countryside, made worse by fighting between the factions. In Mogadishu a total of 70 new hand-dug wells were sunk with the help of local contractors, at a cost of about 100 US $ /m. Most of these wells (43) are now equipped with handpumps. In the meantime the ICRC has also supported the main boreholes with diesel, in order to maintain their delivery to the water sellers and to the «poor people» who could not afford to pay for water. People collecting water with a container not exceeding 10-20 litres were given water for free. 18 boreholes or motorised wells were supported during the crisis period and other organisations like SCF[2)] were having the same approach throughout the country. This support was then stopped after long negotiations, according to a common policy among the few agencies working in the field. The borehole owners were asked to charge the water sellers enough to cover the running expenses of the pump.

3.2 The recent approach (1995-96)

The strategy has been substantially the same. The total collapse of the distribution network from the Afgoi well fields has however triggered a more ambitious programme. Besides the usual maintenance of hand-pumps, the ICRC watsan engineers have embarked on a drilling programme, wherever it was possible and needed, with the aim to increase the water supply of larger parts of the city. This was carried out at the sites of former productive boreholes. Other agencies, like ACF[3)] were concentrating their efforts on the rehabilitation of hand dug wells supplying water to internally displaced people.
In fact, most of the work was carried out at the locations of old boreholes, which were dug sufficiently far from the sea to avoid the salinisation problems, and were either not operational or in poor condition. The usual balance between the different factions had to be maintained to avoid unnecessary problems.

The ICRC paid for the drilling and for the equipment of the new boreholes and the «owner» of the borehole was then responsible for the ongoing running of the water distribution. Since the beginning of 1995 up until now, a total of 6 new boreholes have been drilled, tested and equipped with a submersible pump. The diesel generators to power the pumps are installed in protected premises: (University Residence camp, Gupta, Muuri, Yakshid, Daynile, Medina). 4 have been cleaned and equipped (Black sea, Livestock, Big Pipe, Gulwadayasha) and 12 further hand-dug wells have been equipped with submersible pumps powered by diesel generators (2 in Medina, 2 in Bermuda, 4 in Mogadishu North and 4 in Mogadishu South). Some boreholes located in critical locations, like the one supplying water to Digfer hospi-

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1) Non-Governmental Organisation

2) Save the children fund

3) Action contre la faim

tal, have been completely rehabilitated. Others, like the one in Sheikh Adan camp are still operating without any problems since 1992. In figure 2 the locations of these different boreholes are shown, together with the already existing ones.

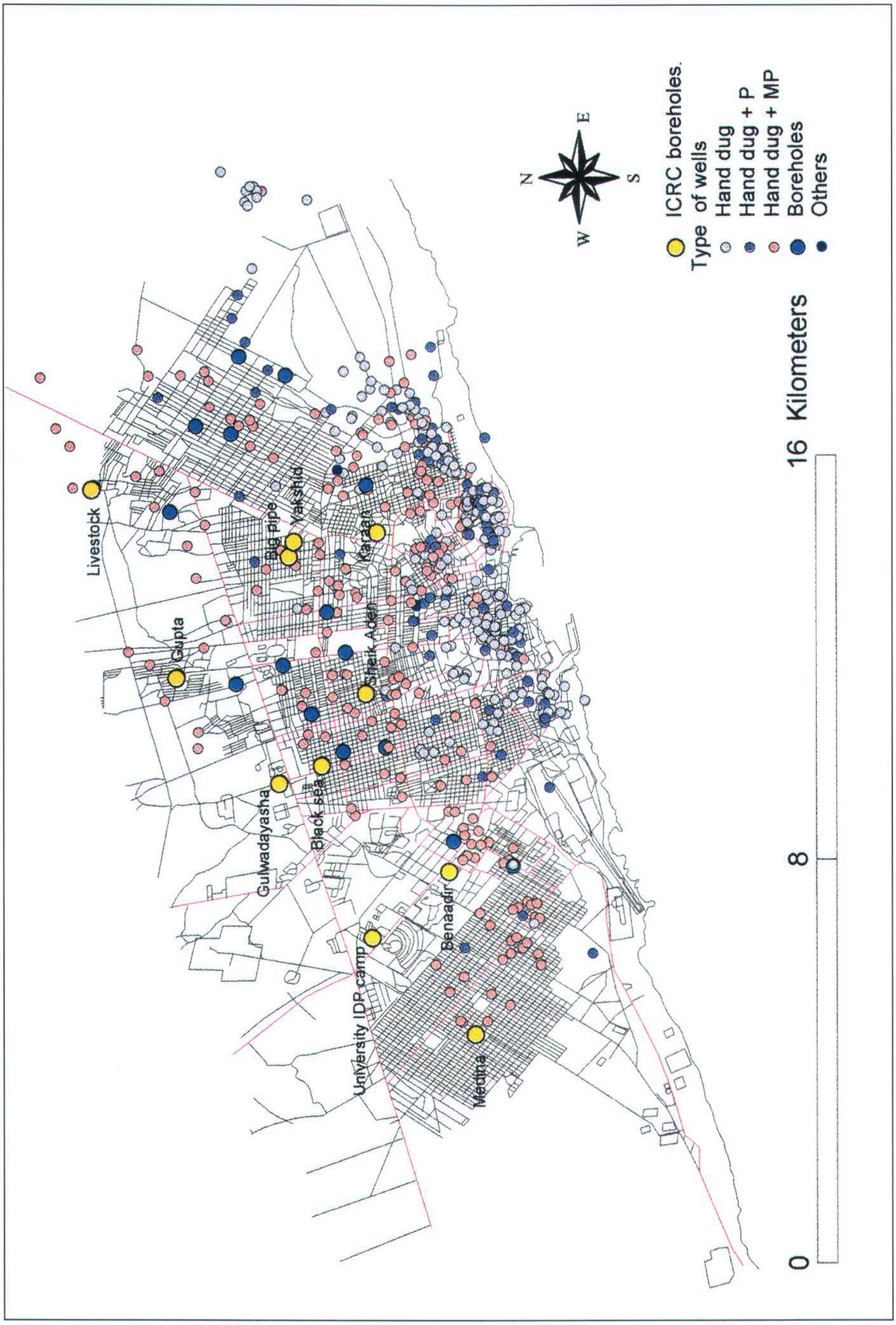

Fig. 2: Mogadishu: Location and type of wells. Boreholes drilled or rehabilitated by the ICRC

Figure 3 shows the logs of two different boreholes (University town IDP camp, drilled in 1996 and Benaadir Hospital, drilled in 1990). The Benaadir borehole was carried out under the supervision of professional hydrogeologists (Sommavilla, 1990). In this log the monitoring of the electroconductivity showed the existence of two slightly different aquifers, corresponding to the loose medium quartz sand layer, and to the loose fine quartz sandy one.

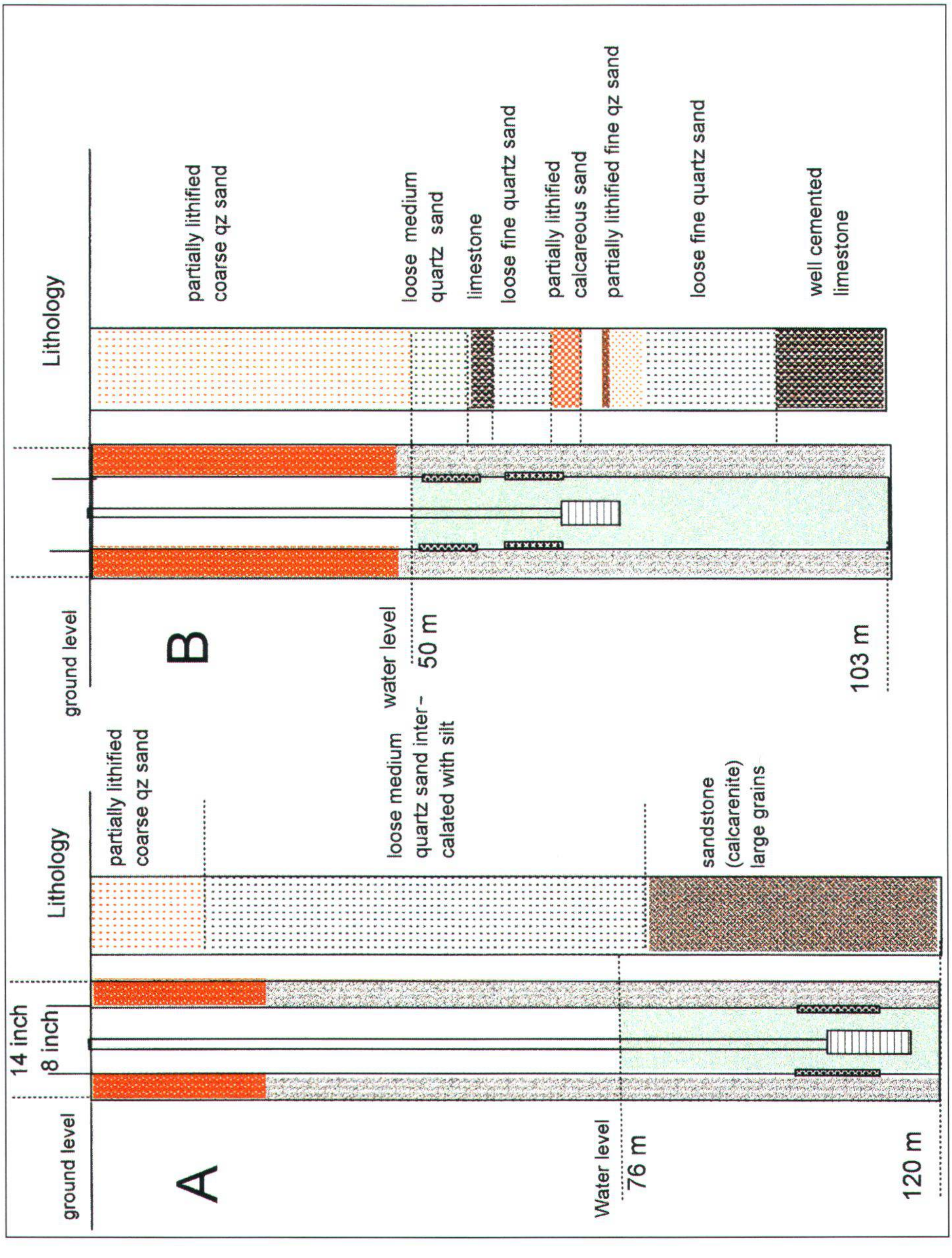

Fig. 3: Logs of two boreholes: University town IDP camp (A) and Benaadir hospital (B) (see location in fig.

Screens have been placed at these positions and the pumping tests carried out (pump level at 75 m, flowrate 15.5 m^3/h) showed that the well could be operated without any danger of mining and supplying water of good chemical quality (EC = 1500 µS/cm +/- 1000). Such detailed investigations have not been carried out for the other boreholes, these having being drilled at known locations, where old boreholes had to be abandoned, mainly because of poor maintenance (corroded rising mains, blockages, etc.). While boreholes have to be tested carefully in such a context, they are nevertheless located well away from the coast (about 3 km) and they tap into a fairly deep fresh layer, estimated at a depth of between 40 to 60 m below sea level. Another layer of water of «just acceptable quality» of about 20 to 30 m thickness is found below the fresh aquifer. This layer is easily perturbed by the abstractions of the different wells and mixing of brackish water can occur. This phenomenon is even more pronounced in the hand-dug wells closer to the coast and particularly in those located in the Abdul Aziz, Shingani, Hamar Weyne, Hamar Jajab and Wadajir districts, but also in Karaan, in Bondhere and in Shibis. Here the depth dug below the level of the water table is of paramount importance and where the abstraction has to be carefully controlled, if one wants to avoid salt water intrusion.

3.3 Assessements on the quantity and quality of the water

Previous studies

Before the war several studies had been carried out to monitor the saline intrusion in the underground waters of the city, mainly to try to evaluate the impact of the abstractions at the Balcad wellfields and of the planned ones at Afgoy (Gibbs, 1980, Parsons 1970). These abstractions would have significantly decreased the aquifer recharge, which was considered to occur by underground seepage from the Shabelle river and was expected to vary greatly from one year to another, according to the annual flows of the river.

In recent times, the first attempt to survey the water supply of Mogadishu was initiated by Sommavilla's group (Sommavilla 1991) but only part of the results were available. At the beginning of 1994 the ICRC carried out an extensive survey to monitor the characteristics of the existing wells with the aim to identify the areas at risk and to react accordingly. 180 wells were surveyed and located on a map in the districts of Yakshid, Bondhere, Wardigley, Hamar Jabab, Shibis, Shingani, Hamar Weyne and Karaan. Access to Medina was precarious at that period, and it still is today. Most of these wells were located in areas where the water could be potentially saline, which, in such a context, means more than 3500 µS/cm. The value is slightly higher than the one recommended by the WHO (World Health Organization), but one has to take into account the high content of Ca, Mg and SO_4^{--}, their contribution to the measured E.C. being substantial, due to the particular geochemical properties of most of the underground waters of Somalia (Faillace 1986).

The high salinity is not surprising. Most of these wells are located within 2 km of the sea, where the fresh water layer can easily be perturbed by too-deep wells or by overharvesting habits. Moreover, the water layer is fluctuating according to the tide amplitudes and any attempt to deepen the water layer during low tide may result in salinisation during the high tide (Dal Pra 1986).

Following the complete stop of the water distribution from Afgoy a survey was carried out by UNICEF in October 1995 (Unicef 1995) with the objective to «identify the size of the population with access to an adequate amount of safe drinking water within a convenient distance from the user's dwelling». A total of 598 wells were surveyed, comprising almost 95% of all the wells of the city available to the public. Of these, 22 were deep boreholes (max. 120 m) and a further 8 were identified as having a reasonable potential for rehabilitation. The remaining 576 were hand-dug wells of which 75 were equipped with a motorised pump.

The main conclusions were that there was enough water, approximately 25'000 m^3/day, for the city's population, coming from the above mentioned water sources, and this within a reasonable distance. Only a few districts had poor chemical quality water but bacteriological quality remained problematic. Hovever, about 26'000 internally displaced people needed immediate attention.

Since 1995, besides what was carried out by the ICRC, other wells have been rehabilitated and equipped by their owners to supply clean water, which is of course abstracted from the same aquifer. If we analyse the ICRC programme and if we neglect the borehole located at the Digfer hospital, 9 new boreholes (4 of them rehabilitated ones) and 12 hand-dug wells equipped with a motorised pump are now operational. If we make the same assumptions as UNICEF, that is: 15 m^3/h per borehole and 6 m^3/h (4 - 8 m^3/h) per motorised hand-dug well and a mean pumping time of 10 hours per day, then there are a total of about 2070 m^3/day that are made available for the city's inhabitants, and this at particularly critical locations. This means that a total of 100'000 people are, in theory, entitled to 20 liters/person/day at the end of 1996. The ICRC programme for the town has now stopped.

These figures are based on assumptions and future programmes will have to be based on precise data.

3.4 Results of the 1997 ICRC quality survey

Material and methods

A total of 640 wells have been surveyed. The same parameters as the ones collected during the previous surveys were collected. In addition, GPS lat/long co-ordinates were recorded using a GARMIN 45 GPS in an attempt to ease the location work and to analyse the results with GIS software. ARCVIEW GIS 3.0 (ESRI) was used to plot the data on a digitised map prepared with the assistance of GRID Nairobi (UNEP), georeferenced using ARCINFO. The Mogadishu map was drawn with the assistance of a local cartographer working on behalf of the Somali Red Crescent Society (SRCS). The collection of the data was carried out with the assistance of a local NGO, Community Concern Somalia, supervising 16 teams from the SRCS, trained to use a GPS and to collect the information. Conductivity values were recorded with the use of a WTW conductivity meter, calibrated with a standard solution. Depths were measured with an electrical dipper or with acoustic dippers. All the positions of the wells were also located on the map, to allow comparison with previous recent data, but also to compare them with the results plotted on the georeferenced map.

District	HDP	HDHP	HD	BHP	Total	Nr.of donkey carts loads (1 load=200 l)
Karaan	44	23	77	2	146	7,828
AlAziz	37	27	74		138	0
Shingani		2	12		14	0
Shibis	14	2	3		19	1,635
Bondhere	4	3	9		16	771
H/Weyne	4	6	25		35	0
H/Jajab	6	22	36		64	235
Wabari	4	3	14		21	226
Yakshid	31	2	3	5	41	6,747
Huriwaa	15	8		3	24	2,904
Wardhigley	17		3	4	24	7,290
H/Wadag	16	I	3	3	23	7,110
Hodan	13		5	2	20	4,094
Daynile	9			1	9	980
Wadajiir	31	3	2	1	37	4,283
Darkenley	20				20	980
Total	**264**	**102**	**264**	**21**	**653**	**44,535**

Tab. 1: Number and type of wells in Mogadishu. Distribution per districts. No. of donkey carts loads per day and per district. HD (hand dug wells), HDHP (hand dug wells equipped with hand-pump), HDP (hand dug wells equipped with motorized pump), BHP (borehole with pump).

Results

The total number and type of wells surveyed per district is presented in table 1.

The number of wells is slightly higher than the one recorded by UNICEF during the 1995 survey, but is certainly not exhaustive for several reasons: some owners did not allow the teams to collect any information within their premises, and important areas of the city could not be surveyed for security reasons. The collected data do however allow comparison with older results, previously quoted in Gibbs (1980) and Parsons (1970).

Type of wells:

The location of the different types of wells, classified as hand-dug (HD) (wells using animals to lift the water are included in the hand-dug category), hand-dug with hand-pump (HDHP), hand-dug equipped with motorised pumps (HDP), boreholes (BHP) is also shown in figure 2. It is easy to observe that most of the wells equipped with motorised pumps (HDP, BHP) are located relatively far from the sea, extracting water from depths between 25 to 50 m, and only a few of these motorised wells are located in suburbs near the sea. The proportion of some types of wells has changed since the 1995 UNICEF survey; the number of hand-dug wells equipped with motorised pumps having increased from 75 to 264. This reflects the need to respond to a new demand triggered by the lack of distribution from the Afgoy wellfields. Many owners had to equip their wells to cope with the demand, but also to improve their income, the water being sold to the donkey carts at a fairly standard price, varying from 500 to 750 Somali Shillings per drum (1 USD = 7000 S.Sh.), (i.e. roughly 11 US cents per 200 litres) with a maximum of up to 1000 S.Sh./drum (200 litres). The water is then sold to the consumers according to the carting distance, with prices of up to 2500 S.Sh./drum, (36 US cents per 200 litres) with a maximum of 3000 S.Sh./drum.

Electroconductivity of the water:

The electrical conductivity measured at each well, expressed as microSiemens/cm (micromhos/cm), is shown in figure 4.

Fig.4: Mogadishu: conductivity of groundwater in wells expressed in microS/cm.

In figure 5 we have also plotted the 3000 and 4000 µS/cm boundaries, adapted from the literature (Parsons 1970, Gibbs 1980). Most of these wells are extracting water whose quality is between 3000 and 4000 µS/cm, therefore selling water of an acceptable quality, as far as salinity is concerned, and if criteria established for Somalia are used.

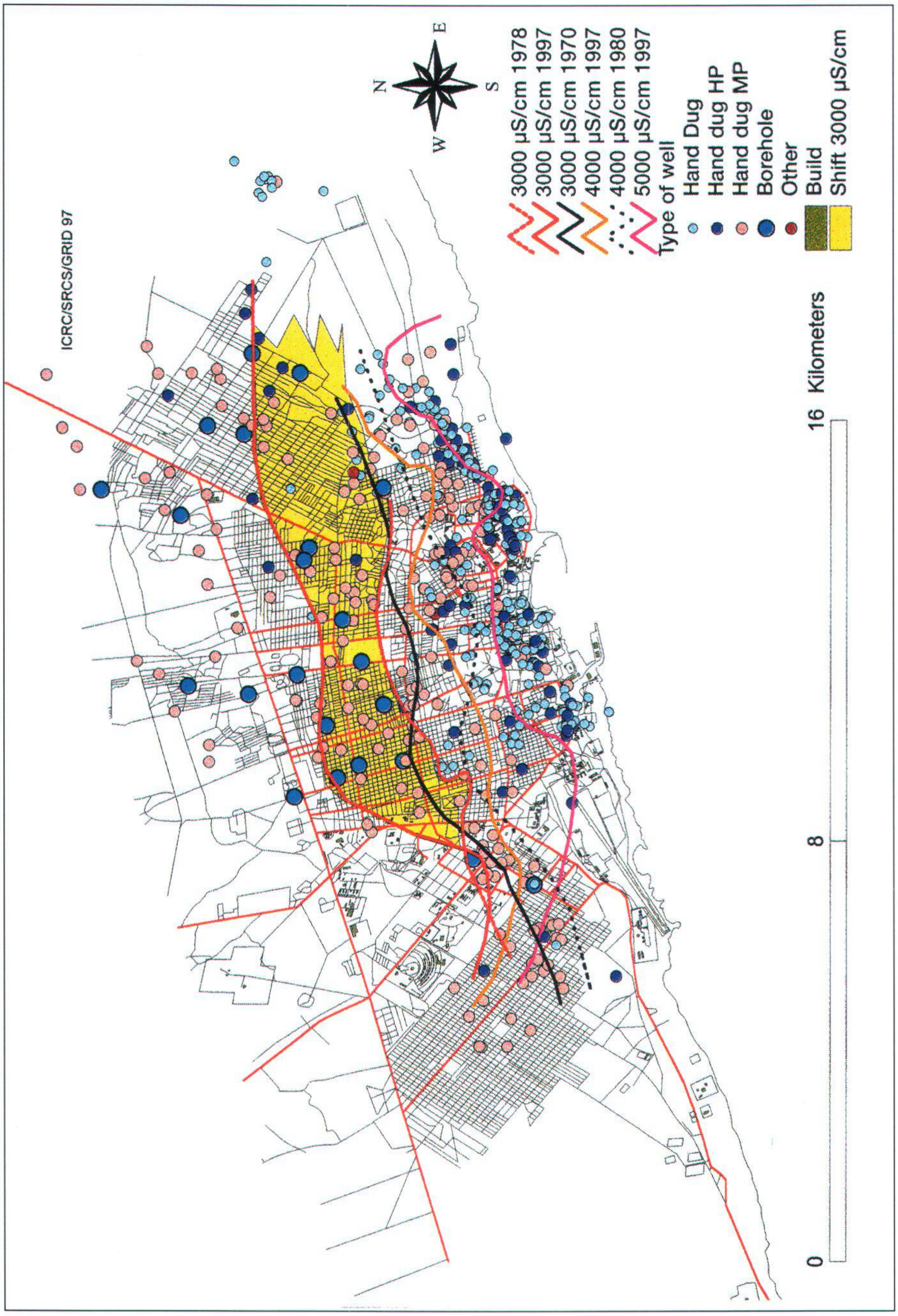

Fig. 5: Mogadishu: shift in the conductiviy of the groundwater and type of wells The yellow area represents the approximate inland shift of the 3000 µS/cm boundaries between 1978 and 1977.

There is relatively little shift in the 4000 µS/cm boundary since 1978, but an important shift can be observed in the 3000 µS/cm boundary, which is now close to the main road parallel to the coast (Spaghetti factory), with a move inland of about 2 km. It has to be pointed out that we have placed the 3000 boundary at the edge of the 3000 to 4000 µS/cm values, at the wells symbolised with a star, which is a crude approximation, until computerised boundaries will become available.
These are trends, which have been analysed with the use of GPS lat/long records, whose precision can be evaluated to +/-100 meters, if one takes into account all the possible errors, namely from the original map. When all the well locations have been plotted manually or the georeferenced map, we will be able to perform a more precise analysis, allowing comparison with the results of 1994, for which we could not obtain lat/long coordinates.

3.5 Discussion

The main objectives of the survey were to find an answer to two main questions:

- How the saline wedge and the related groundwater quality have been affected by the interruption of the abstractions at the different wellfields, and particularly since the complete stop of the Afgoye well fields in 1995; the Balcad ones already being out of use since 1992.
- How the present abstractions due to the ICRC programme, and due to the wells newly equipped with motorised pumps by private owners, would affect the movement of the softwater/salinewater interface.

Parameters other than the electroconductivity have been recorded, and will be of importance when an attempt to model the behaviour of the aquifer will be initiated; namely the well depth and the static water level.

The reasons why we need to know these answers are quite obvious when we think that the life of more than 1 million people is concerned. It is also of paramount importance to be able to follow what is happening in the perspective of the resumption of the abstractions at the Afgoy wellfields, a new project (Diakonie, 1997) being under implementation to restart a centralised water supply for the town.

In fact, the two questions are related. Already between 1970 and 1978 a large number of boreholes were drilled within the city in response to industrial and economic expansion (Gibbs 1980), and groundwater abstractions within the town doubled from about 1400 m^3/day in 1970, to about 2700 m3/day in 1977. In 1976 the total wellfield abstractions were close to 6500 m^3/day and was expected to increase up to 40’000 m3/day in 1995, according to Gibbs and partners (Gibbs 1980). It was estimated that the aquifer could safely support an abstraction of about 70’000 m^3/day (25 million m^3/year). The aquifer is recharged from the Shabelle River.

This safe abstraction was modelled taking into account the need to protect the groundwater supply from contamination, and therefore the optimum solution was to locate the wellfields away from the sea but also not too close to the Shabelle river, where groundwater drawdowns were, and are, a limiting factor.

The situation has drastically changed, and the effects of the abstraction at the wellfields have not been an issue since 1995, due to the complete stop of both wellfields, but the problem of the movement of the saline interface has become important due to the increased pumping close to the salt water wedge.

According to a survey carried out by UNICEF, the amounts abstracted were estimated to be close to 25’000 m^3/day in 1995, assuming a fixed volume of water per type of well per day.

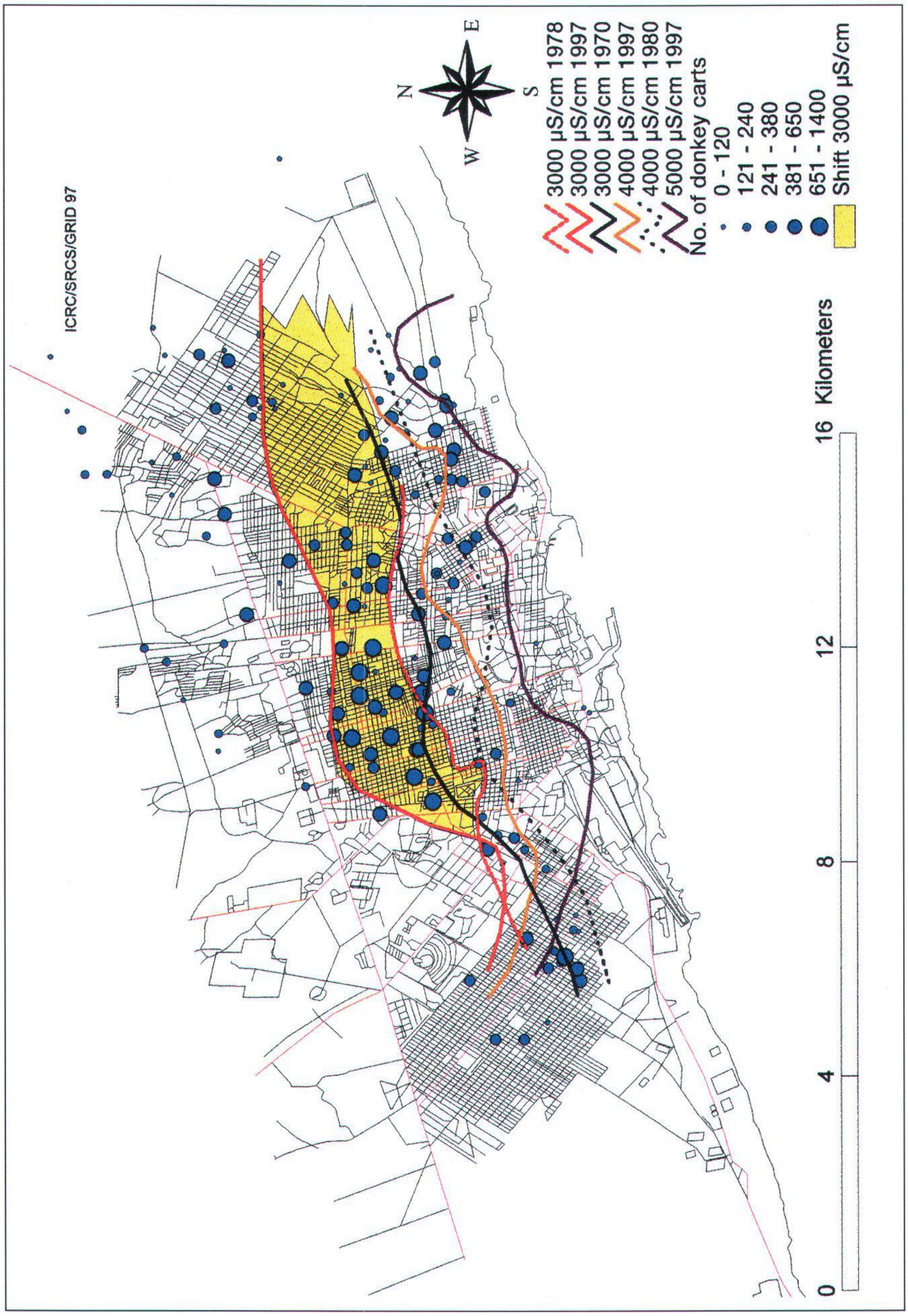

Fig.6: Mogadishu: number of donkey carts supplied by each well.

If we make the same assumptions as UNICEF, then the estimated abstraction is presently close to 24'000 m^3/day, which is surprising if we bear in mind that the number of motorised pumps has drastically increased. According to our results, the number, of donkey cart loads distributed per day is close to 45'000, which represent about 9000 m^3/day. If we add the amounts not sold and used directly from these wells, and from the ones which do not supply any donkey carts, we may reach these values, but the UNICEF estimation is probably too high. These are, of course, crude calculations and only a more detailed analysis of the results will help to clarify the issue. What is striking are the respective movements of the 3000 μS/cm and 4000 μS/cm boundaries. Although the 4000 boundary has not moved and is approximately the same as in 1978, the 3000 μS/cm has moved significantly inland. This may reflect the increase of the total abstraction from the motorised wells, whose number has increased by a factor of 4 since 1995, as well as from the new boreholes, even if their number is relatively less important. Not only the number of wells has increased but also the quantity delivered to the water vendors, as it can be seen from figure 6, which represents the wells supplying donkey carts every day.

The increase of the electroconductivity values is certainly related to the amounts pumped, but the intrusion of the sea water into the coastal aquifer is difficult to study due to several factors. The wells are dug at different depths into the aquifer, they are sometimes deepened to permit a higher abstraction, and the different pumping rates may result in mixing at certain locations, particularly where large amounts of water are sold.

The fresh groundwater is flowing towards the sea and it has not been perturbed by any abstraction between the recharge area and the coast since 1995 . This helped to maintain the wedge close to the sea, at least the more saline one, but the shift in the 3000 μS/cm boundary is worrying, particularly if the abstraction at the wellfields resumes. May be the quantity sold by the well owners to the water vendors will drop, if the centralised distribution is able to supply the vendors at a significantly cheaper price than the present rate. If this happens we should observe a shift in both the a/m boundaries toward the coast, the phenomenon being in principle reversible, even if the timescale is very long.

In the coming years it will be of paramount importance to maintain the monitoring of the evolution of the quality of the ground-water. This to avoid a further inland movement of the fresh/saline water interface, until the abstraction and distribution to the town through a centralised network eases the situation. The issue can only be taken up globally once the political situation allows.

4. Conclusion

The movement of the saline/fresh water wedge of the underground aquifer of the town of Mogadishu has progressed inland between 1970 and 1978. The results of this study, carried out in 1997, show a further shift inland, related to the significant number of new privately owned wells, sunk or equiped with motorised pumps since 1995. The inhabitants had to rely on the underground aquifer since 1995 when the main distribution to the town from the Afgoy well fields came to a complete stop. The number of these motorised wells, located relatively far from the sea has recently increased from 75 to about 260, and the combined effects of these individual abstractions, added to those of the newly drilled boreholes, are reflected in the quality of the water, expressed in microSiemens/cm. It is surprising to observe that only the 3000 µS/cm boundary has moved significantly inland, the 4000 µS/cm boundary being located at more or less the same place as in 1978, when a similar study was carried out.

Despite the fact that there were not any water authorities to control the construction and the abstractions of these new wells, the situation is not yet considered dramatic, at least as far as salinity is concerned. This was also possible because most of the NGOs and the ICRC, who drilled several boreholes and equipped existing wells at appropriate locations, strictly followed the recommendations outlined by several hydrogeologists, based on years of field and research experience.

Despite the difficult working conditions, the collection of data on the water resources could be maintained, thanks also to other organisations, and will allow for future comparisons of the underground water table evolution, of paramount importance for Mogadishu and in general for all cities located on a coastal aquifer. Understanding the movement of the saline wedge, particularly at the 3000 - 4000 µS/cm boundaries is essential for the proper management of the whole aquifer, as more than 1 million people are using it. However, only a 3-D modelling of the salt concentrations will help to define the exact shape of the saline wedge, which will one day allow a proposition for a master plan for the town's future water supply.

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