

International Committee of the Red Cross Regional delegation of Nairobi

Study of the traditional wells of Lamu and of Shela (Kenya)

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Executive summary

According to an undocumented study² the number of traditional wells of Lamu town was estimated to be close to 300, mainly located in private houses with a few wells in public spaces or within the Mosques. In Shela the number of wells was close to 30.

This study has been carried out to document the importance of these wells for the inhabitants of the town of Lamu and of the village of Shela.

Many households were and are still depending on traditional wells to source their daily water, even if the majority of the users were reserving this water for domestic purposes and using water distributed through the network for their drinking needs.

A high resolution satellite image (QUICKBIRD^R) has been used to locate the wells and a number of physical parameters like total depth, depth of the water, type of protection, number and characteristics of the pump equipping some of the wells, number of people using the water were collected during the survey, carried out with the assistance of the Lamu branch of the Kenya Red Cross and the Lamu Water Department.

A total of 277 wells have been surveyed in Lamu and in Shela, including 20 wells located in the dunes wellfield.

Some physico-chemical parameters were also measured. As little was known about the quantities withdrawn from these wells a study has been conducted in order to appreciate the importance of the salt water intrusion along the shores of the town, using conductivity data, recorded between August and October 2005.

In Lamu 155 of these wells are equipped with electrical pumps and the quantities of water retrieved from these wells are considered important as they are providing domestic water to about 6500 people. 33 of these wells over the 212 are managed by communities within the town.

Arcview GIS software has been used to analyse the spatial behaviour of the underground water and to produce thematic maps. It appears that the salt intrusion is negligible and that the salinity of most of the wells is within the WHO recommendations.

However, preliminary data obtained with field instruments on the possible nitrate contamination of the water in these wells, linked to the ways of disposal of human and domestic wastes, show slightly higher values than the recommended ones and a further study should be carried out to confirm these results.

The proposals outlined in this report are of the sole responsibility of the author and do not necessarily reflect the position of the ICRC.

² Department of water , 1992

Study of the traditional wells of Lamu and of Shela (Kenya)

Introduction

This study was carried out in 2005 when the ICRC began to be involved in the coastal region, in the islands North of Lamu. While carrying out our baseline survey in order to understand how people were getting water within the islands, our attention was focused on the ways that people living within the town were getting access to water.

Following a request from the District Water Officer the ICRC assisted the Lamu Water Service with 5 submersible pumps to be installed in the wells located immediately behind the main dunes of the islands. The aim was to assist the Water Department in its daily task to supply water to the town's inhabitants, in order to match the demand, on constant increase, due to, among other factors, to the higher number of tourists visiting the town.

Several hydro-geological studies and geophysical investigations have been undertaken in order to assess the capacity of the aquifer and to locate the area where water could be tapped³. According to these studies the following conclusions were drawn⁴:

- the potential fresh water resources available for exploitation were estimated at more than 3'400 m³/day over an area of 21 km²
- the recommended harvesting for the existing well field, including the new wells, for a total of 30 wells, was 750 m³/day (22 % of the potential amount for the island)
- Mokowe , the mainland harbour of Lamu, a well field could be supplied from the depression of Bele Bele, with a potential of 250 m³/day over an area of 4 km²
- the groundwater development would have to be done in a way to avoid sea water intrusion in order to protect the fragile fresh water lenses, laying beneath the dune
- that additional investigations would have to be carried in order to assess the potential for any further development

With the 5 pumps put at the disposal of the Water department the number of wells equipped and used has reached 20 and has increased to 25 by the end of 2005.

The mean production of the well-fields has then gradually increased from 800 m³/day in 2001 to 1500 m³/day in 2005 and is expected to reach 2000 m³/day with the equipment of an additional 25 wells by the end of 2005.

A detailed description of the system is outlined in the UNESCO report, under technical proposals⁵.

In this report we will describe the results of the study carried out on the traditional wells, still used by the people, even if water is used mainly as domestic water, particularly in stone town. In other areas, not yet covered by the network, and where the poorest people live, water from these wells is still used as drinking water as it was before the 1956, when the Lamu water supply system was built.

As water is harvested from the same underground aquifer, sea water intrusion could have been important, depending on the amounts retrieved.

This study has been conducted also in order to appreciate the importance of the salt water intrusion along the shores of the town, using conductivity data, recorded between August and October 2005.

³ References quoted in the UNESCO report

⁴ summary of the findings from the a/m report

⁵ UNESCO report. Technical proposals, previously quoted

Methodology

All the data were collected during the month of August 2005, when the aquifer has been fully recharged. The main rainy season is lasting from March to July, when almost half of the total of mean monthly rainfall is observed (700 mm over a total of 1300 mm/year)⁶.

The topographic map available for the island is at 1:50'000 and therefore of poor interest for such a study. To locate the wells with a precision of about 5 m a high resolution image has been purchased with a resolution of 0.6 m/pixel at ground.

The image has been obtained from Digital globe, Quickbird imagery, Enhanced Standard Imagery collected on 29 July 2003, 60 cm natural colours, processed by MAPS geosystems.⁷

All the wells have been located with the use of a GPS GARMIN E-trek. In case of doubts and when the satellites coverage were poor, owing to the particularly dense architecture of the town, the wells were positioned on the map visually.

ARCVIEW software with Spatial analyst extension was used to analyse the data, compiled in Excel^R.

The depths of the wells and the level of the water were measured from the ground using a water level. Conductivity and pH were measured using a Combo pH and EC from Hanna, with automatic compensation of temperature, calibrated with standard solution from HANNA instruments at pH 7.01 and at 1413 $\mu\text{S}/\text{cm}$ at 25 °C.

Nitrate concentrations were measured using a HACH test kit nitrate pocket colorimeter calibrated using a standard solution.

Samples from different areas were collected and analysed in the laboratory of the Ministry of water.

Results

The town of Lamu is located in the Eastern shores of the island, facing Manda island. The village of Shela is located at the extreme South-East edge of the island where Indian Ocean enters the channel. On the southern part of the islands the dunes can reach a height of 50 m asl and the town of Lamu is also located on dunes or outcrops of limestone. Apart from these dunes the island is generally flat. Rainfall is accumulating in between and recharges the aquifer.

The following figures shows the area of interest plotted on a topographic map used to purchase the high resolution satellite image, covering a surface of 30 km². The town of Lamu is approximately located over the topographic map to give an idea of its location.

The high resolution satellite image, shown in the following figure, covers the town of Lamu, the village of Shela and partially the well field, located beneath the dunes. From the high resolution satellite image, several features can be easily recognised and vectorized using the software.

Buildings, roads, shores limits, cultivated fields have been digitised in order to obtain a baseline on which other features have been located, like the position of the wells within the well field, the pumping station, the transmission lines to the main storage reservoir and the distribution lines of the primary and secondary network. The position of the traditional wells have then been collected and located on the map as described above. Other features have also been located, like the main power network and the location of the transformers.

⁶ Mean monthly rainfall from 1981 to 1991

⁷ www.digitalglobe.com and quickbird@mapsuae.com

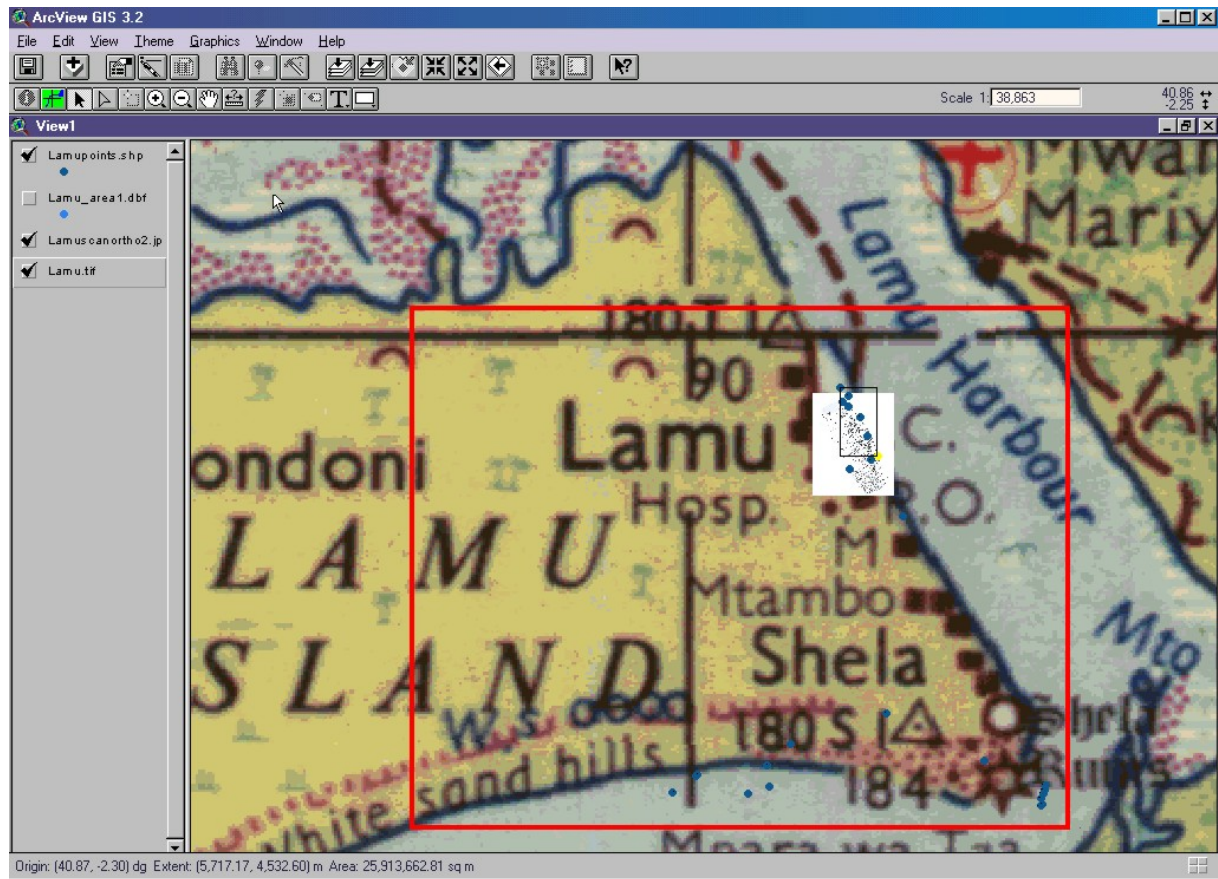


Figure 1 Topographic map and area of interest



Figure 2 High resolution satellite image (Quickbird imagery Digital globe, 29 July 2003)

The urbanised area (July 2003) is easily observable on the previous figure, where the building have been plotted in orange. Pathways have also been reported on this image.

Buildings can be vectorised to clarify other features and to avoid too many information in any Arcview view. However, the precision of the results is depending on the possibility to make precise distinctions between roofs, courtyards and other features. In the case of Stone town it is somehow difficult to vectorize more than buildings and it would be useless to do more.

The following images show the results for different areas of the town, namely Stone town, the southern part of the town where the King Fahd hospital can be easily recognised and finally for the village of Shela.



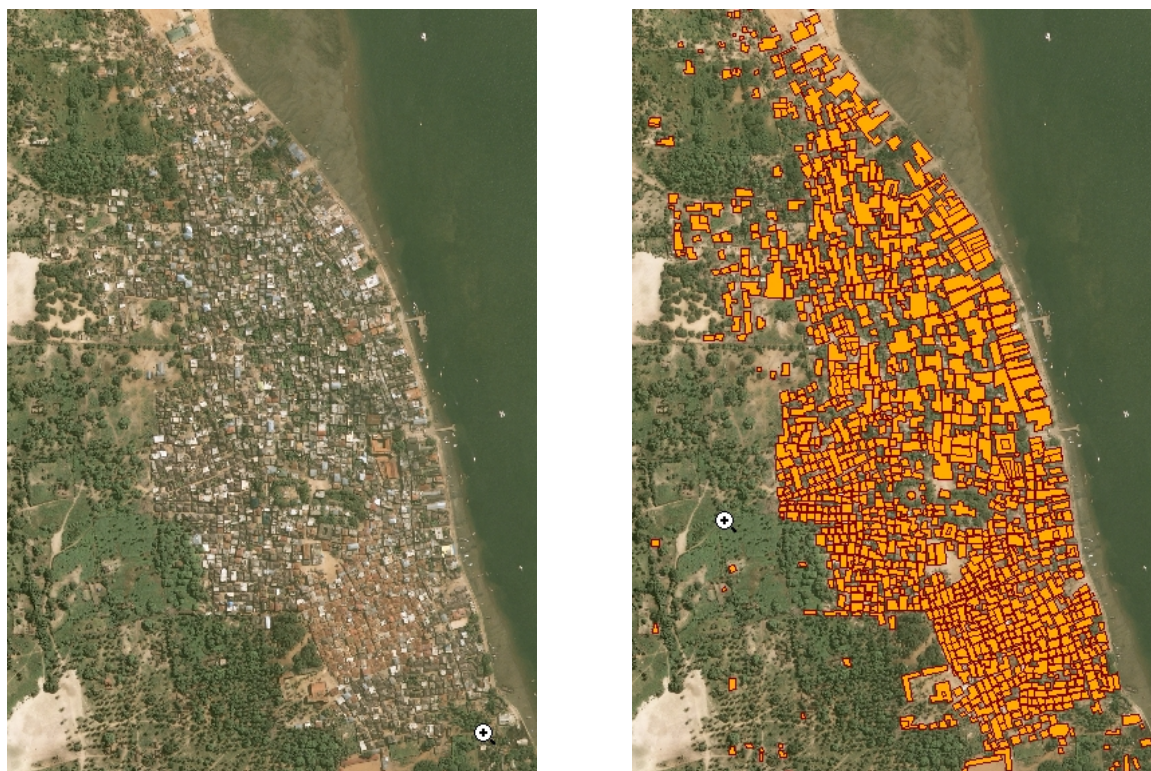


Figure 3 HR cropped image of Stone town and vectorized buildings.



Figure 4 HR cropped image of the southern area of Stone town, the Kashmiri settlement, the school complex and the King Fahd hospital

Shela village

Traditional wells

Traditional wells have been the only water supply before 1956, when the town system was built. Despite the improvement of the water distribution and the increase of the number of connection, close to 900 in 2005, many inhabitants are still using the wells sunk within their courtyards. Many have been equipped with electrical pumps, with power varying from 0.5 kW to 1 kW, capable to pump water from the wells into the elevated tanks. As stated before this water is now mainly used for domestic purposes as the water distributed by the network is of good quality. The accessibility of larger quantities of water through the wells has also resulted in larger use of water, to flush toilet, to wash clothes, for showers, etc., increasing the volumes of grey water to be evacuated through the open

drains⁸. The increased availability of water has however lead to the conversion of many of the dry pit latrine, using a relatively small amount of water for anal cleansing, to flushed toilets and “the amount of water discharged into the pit has drastically increased”. It is therefore of paramount importance to know where wells have been equipped with electrical pumps as it is in these dwellings that flush latrines and showers, using larger volumes of water, may contribute to the groundwater contamination, adding to seepage from the open channels into the underground aquifer.

Types of wells

Traditional wells are dug into the limestone formation and lined with coral stones or blocks. Some of them are lined with concrete rings from the bottom up to the surface. The majority are lined only in the upper part. A wall is built to prevent gross contamination and for security and in some cases an apron is built. The general quality of the protection is poor, particularly in many public wells. Wells built within the mosque have been better protected.

In public wells water is fetched with buckets. Contamination is visible, with empty plastic bottles, plastic bags and “makuti” thatches floating on the surface of the water. The following figure give an idea of the type of well that can be found in Lamu.

Figure 5 Semi-protected well with small apron



Covered well without apron



Figure 6 Protected well no apron,



Well and distribution reservoir



Data collection and protected well

⁸ UNESCO, report quoted



Figure 6 Well with wall and no apron



Protected well at a mosque



Figure 6 Lining with coral stone



Upper lining with mortar and centrifugal pump

Results of the survey

Location of the traditional wells

In the following image the global location of all the wells surveyed is shown. The well field is located beneath the dune and the wells and 20 wells have been reported within the image. These wells have been located visually from the satellite image, where than be easily spotted. The two reservoirs at the pumping station have also been considered as wells for practical reasons. The transmission lines have been reported on the image using GPS coordinates collected all along the pipeline. The distribution lines have been located on the image according to the indications of the Lamu Water department and with the positions collected in the field. As described previously the position of the traditional wells have been located using GPS coordinated and/or using colour printouts of enlarged tiles of the satellite image at a scale of 1:1250 to locate visually the wells, when the GPS collection was difficult.

The 1:1250 scale is the largest possible reasonable enlargement. An example of the resolution at this scale is given in the next figure.



Figure 7 Enlarged tile at 1:1250 scale of the northern part of Stone town with wells (pale blue dots) roads or pathways (red lines) and primary network (blue line). The sizes of the “Jahazis” is a good indication of the resolution.

Private wells have been approximately located on the image according to their position within the premises. Lat/long coordinates were then computed using the software and reported automatically into the Excel datasheet.

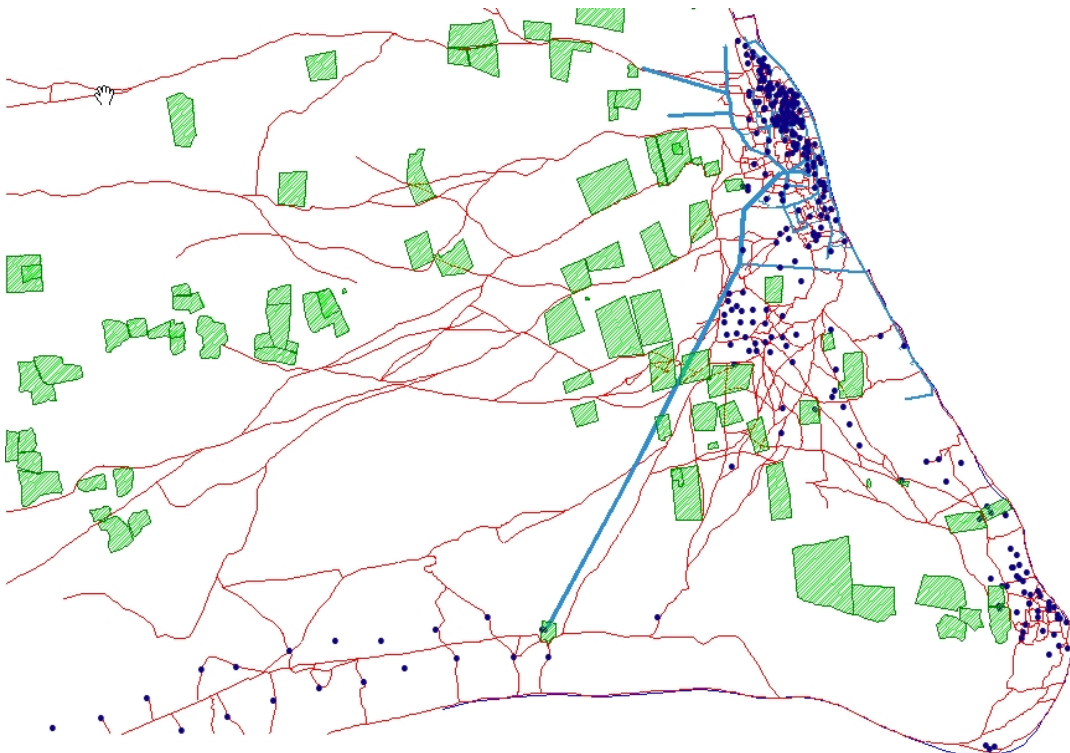


Figure 8 Location of the wells surveyed of Lamu and Shela, transmission lines and primary distribution network.

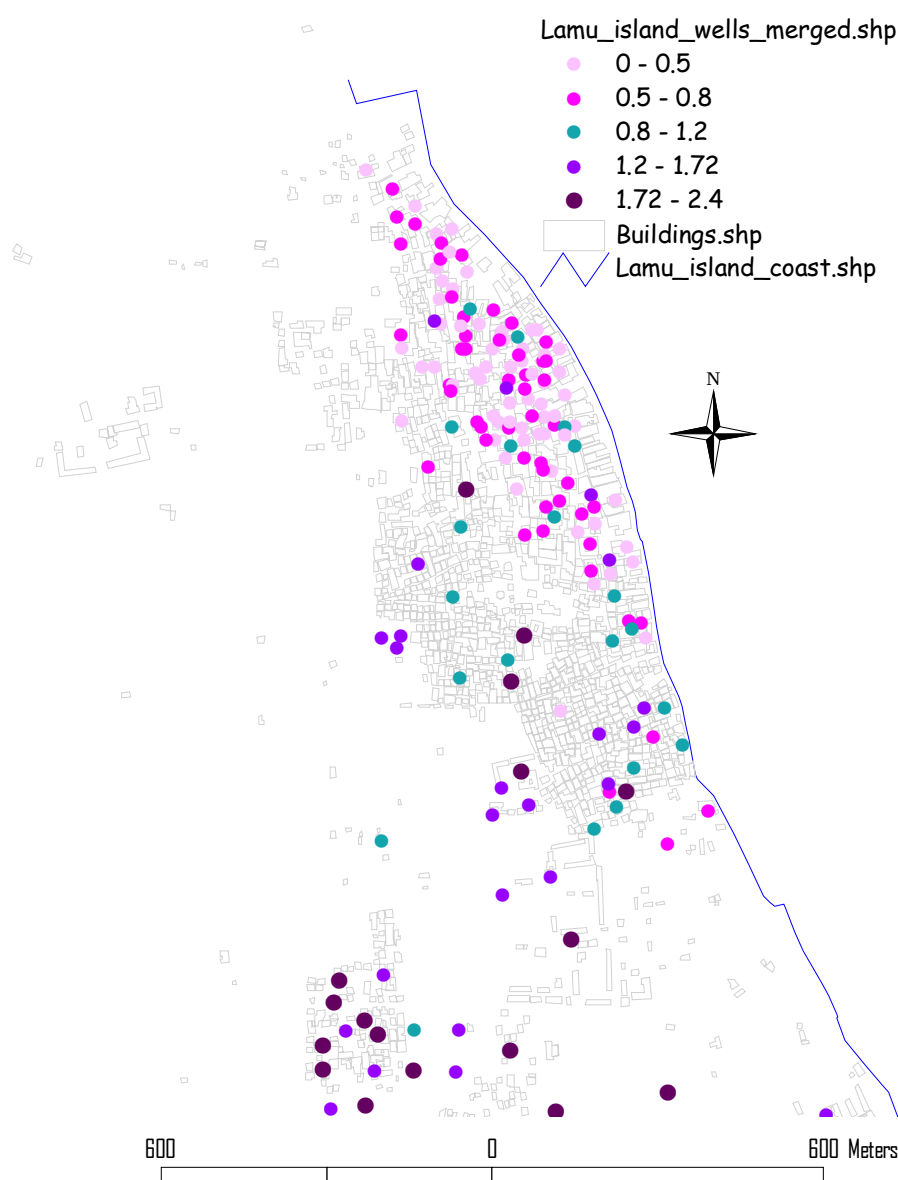


Figure 9 Mean depth of the water column

the more salty layers. The experience of the well diggers has been transmitted from one generation to the other and in general, when the water is reached, only another meter or even less are dug, depending on the distance from the sea shore.

Detailed measurement have been carried out on 247 wells. As the level of the water may be affected by the tide fluctuations, particularly if located close to the shore, all these measurement have been carried out within two hours from the highest tide. Tests have been done to assess the influence of the tide on two different wells, one located away from the sea and another close to the shore. In the following figure the depths of the measured wells for Lamu stone town and for the southern areas have been reported and classified according to the depth of the water. The water column of the wells dug on in the Kashmiri settlement located at the South-West of the town is deeper than 1.2 m and similar ones can only be found in a limited number of wells located in the area of Stone town, where the thickness of the water is in general less than 1.0 m. It appears that as soon as the water is reached the well diggers do not dig too deep for the reason outlined above but most probably also because there the depth of the wells are quite deep and any extra work is difficult. More than 2/3 of the wells have been dug to reach a water column of less than 1 meter and most of them are located in the northern part of Stone town. This could be related to a particular geological formation harder to dig or

The previous image shows the geographical distribution of the 275 wells on a image at a 1:25'000 scale, where only a few features have been maintained for clarity. To give an idea about the distances, the distance between the wells of the well field is of 250 m and the total length of the transmission line from the pumping station to the main reservoir is of 3.0 Km.

For clarity, we will from now on describe separately the wells of Stone town, those of the less developed southern part of Stone town (Kashmiri) and the wells of Shela.

Data recorded

The total depth of the wells is related to their geographical distribution. Unfortunately we did not have a DEM (digital elevation model) and we did not had access to a map with the necessary elevation contours to try to model the water table, using the total depth and the level of the water. However, wells in such an environment are generally dug to reach the water and of course dwelling at higher locations will have to dig deeper in order to reach the water table. But when the water table is reached it is essential to avoid to dig too deep in order to avoid to reach

which would either favour a possible salt intrusion. Only further analysis could help to confirm what well diggers know since generations. Conductivity measurements for the water may help to clarify the issue and the results will be discussed under the chapter dealing with conductivity and salt intrusion.

Table I Number of wells of different depth of the water column

Depth of the water column	number of wells
< 0.5 m	93
0.5 m < d < 1.0 m	80
1.0 m < d < 1.5	34
1.5 m < d < 2.0	37
> 2.0 m	3
Total	247

Equipment of the wells

More than half of the wells surveyed are equipped with pumps. In Stone town most of these pumps are centrifugal pumps located above the water level and are powered with electricity, with a consumption between 0.5 to 1 KW, capable to pump water into the elevated tanks, from where water will then be used by gravity. The equipment is also somehow related to wealth and to an electrical connection. For instance, in Kashmiri, only a few wells are equipped with a pump. On the contrary, the majority of the wells of Shela are equipped as wells as those of Stone town. The next table shows the proportion for the different areas and the next figures the spatial distribution of the wells equipped with pumps and those not equipped.

Table II Proportion of wells equipped with a pump according to the area

Area	Equipped	total	%
Stone town	100	161	62.2
Kashmiri and central	3	47	6.3
Shela	41	47	87.2
Total surveyed	144	255	56.5

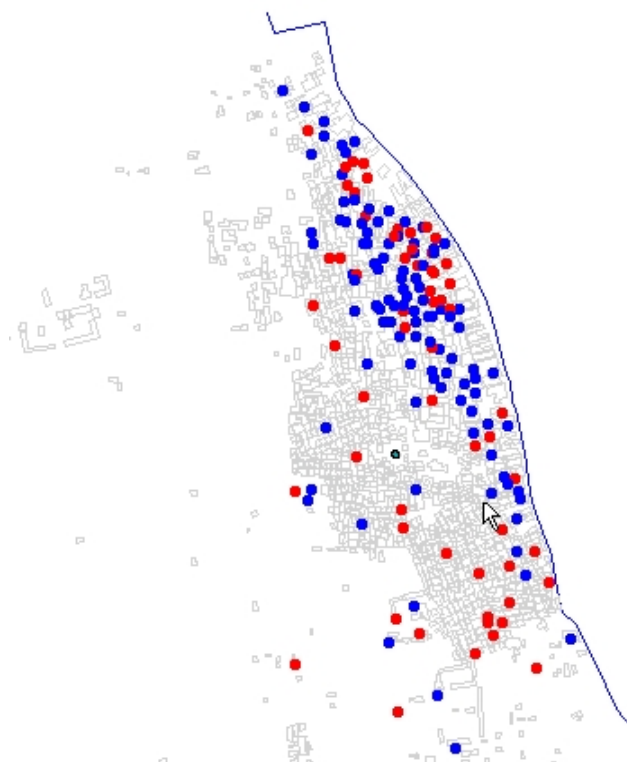
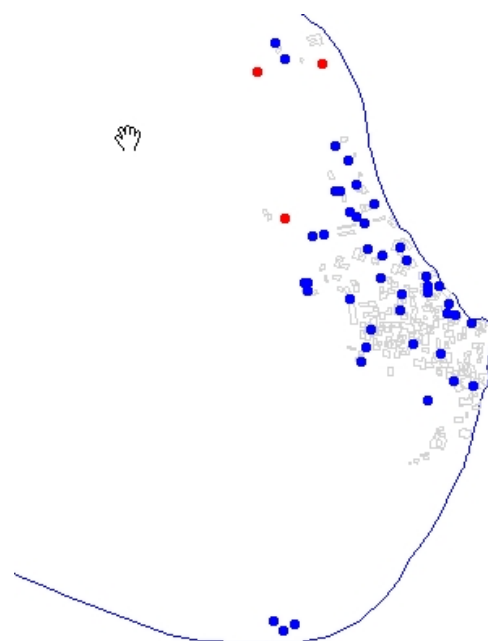
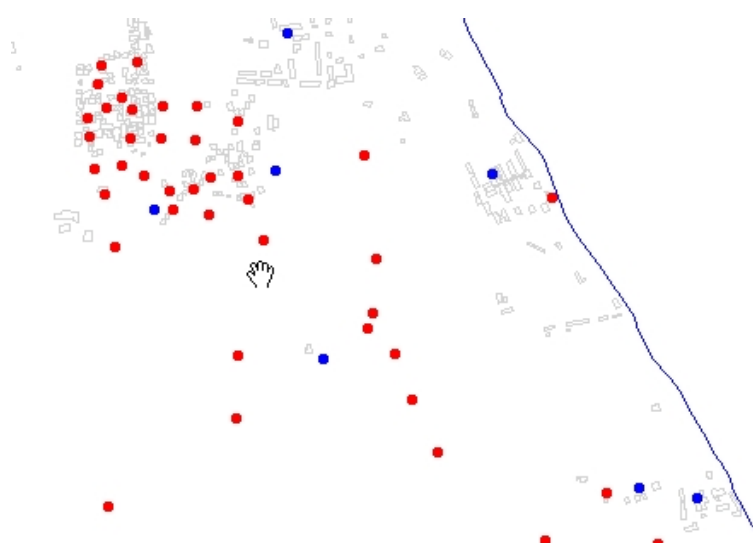


Figure 10 Proportion of wells equipped with pumps in Stone town (blue dots) and not equipped (red dots)



Figures 11 a, b Proportion of wells equipped with pumps (blue dots) and not equipped (red dots) in Kashmiri area and in Shela area.

The proportion of wells equipped with pumps may have an importance in town, due to the particular way used to dispose grey water (water used for domestic purposes) and to flush latrines. As outlined in reference 2 the increased use of water, due to increased wealth and influx of tourists is increasing the volume of water reaching the open channels and disposed in the sea front. Piped water distributed from the network is also responsible for the increase but the amounts from the wells cannot be neglected, if a solution has to be found to dispose the grey water away from the sea front. Assuming a mean volume of 2 m³/day pumped by every pump (100) from the traditional wells into the elevated tanks, a quick calculation shows that more than 200 m³ have to be added to those distributed through the network, estimated to be close to 1200 m³/d. The value is a conservative one and is likely to be higher, probably close to 300-400 m³/d, thus close to 1/3 of the total water pumped from the aquifer. These amounts cannot be neglected and a more precise study may help to assist the designers of the future water collection system of the town.

Number of people using the traditional wells

The database allows to compute the number of people using water from the traditional wells. The results are reported in the next table, where a distinction between the three areas considered, Stone town, Kashmiri and Shela has been done. For Kashmiri two areas have been considered, the Kashmiri settlement and the area east of the village which includes the King Fahd hospitals and the wells located in the surroundings.

The total number of people using water from these wells is quite important. If we consider the great Lamu there are about **6517** people depending on these source of water. Most probably the inhabitants of Stone town are using the water mainly for domestic purposes and rely on water distributed from the network for their drinking needs. This is probably not the case for the inhabitants of the settlement of Kashmiri, not connected to the network and depending entirely from the water of the traditional wells. The situation is again different in Shela where villagers are also not connected to the network but where wealthy residents may have the means to use mineral bottled water for their drinking purposes or may have purifiers installed within their premises. But some of the less well off inhabitants may also use this water as drinking water, as in Kashmiri or in other parts of the Stone town. As a matter of fact the distinction between domestic and drinking may be quite difficult to establish and is most probably related to the wealth/education of the people using the water of a given well and only a in-depth household's survey may allow to clarify who is doing what in term of water use.

Area	No. of people
Stone town	4376
Kashmiri	1006
East of Kashmiri	1135
Shela	1434
total	7951

Table III Number of people using water from the traditional wells in different areas of Lamu island

What is evident is that **an important number of people is depending on the underground water** collected from traditional wells particularly in area where the network has not yet been laid. Even where piped water is available, people still use water from the traditional wells for economic purposes.

Effect of the tides on the level of the water

The following graph shows the fluctuations of the water level, collected at different days, from the 5th to the 10th of August 2005, at two different hours of the day, for wells not equipped with electrical pumps. The total depth of the wells is also shown. Two different area are concerned: Kashmiri and the wells close to this settlements and some at the southern urbanised part of the town. The data were collected from North to South, that means from the southern part of the urbanised area toward the Kashmiri settlement, starting from the 5th until the 10th of August. Our objective was to observe if there was any significant variation of the levels related to the tidal heights and with the distance from the shore, varying from 100-250 m in the southern part of the urbanised area to about 750 m in Kashmiri. The higher levels (thicker water column) have been collected at high tide, in general between 8 to 11 pm and the lower levels in the afternoon, when the tide is generally low at this period of the year. In fact one would have to plot the difference between the collection time and report it on the known tidal variation at that specific day in order to understand the effect of the tide. Unfortunately such studies must be better planned as people do need water, and the collection of water has of course an influence on the level of the water.

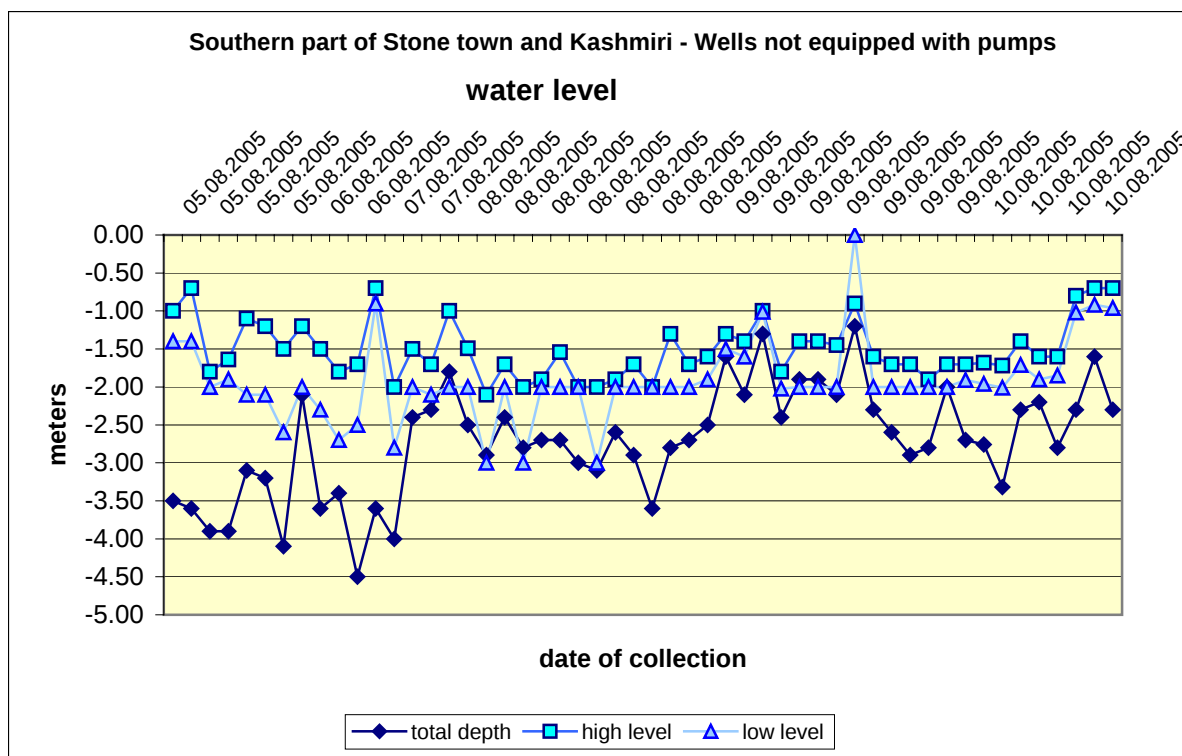


Figure 12 Total depth of the wells and variation of the water levels according to the day of collection.

All the wells of Kashmiri have been collected between the 8 to the 9th of August and show a relatively less variation in the level of the water, close to 0.5 m compared to the variation of the level of the wells collected on the 5th of August, located at the southern fringe of stone town, closer to the sea shore and where the effect of the tide is likely to be more important.

However, from these results, only trends can be considered as other factors have to be taken into account. The afternoon levels most probably reflect some sort of a “mixed dynamic level”, a combination of abstractions, recharge and tidal effect.

To gain some information of the effect of the tide a specific collection of data had to be designed, measuring the level's fluctuation in two wells, where no abstractions were done, one close to the shore and another located at a higher distance.

Contamination of the aquifer and use of motorized pumps

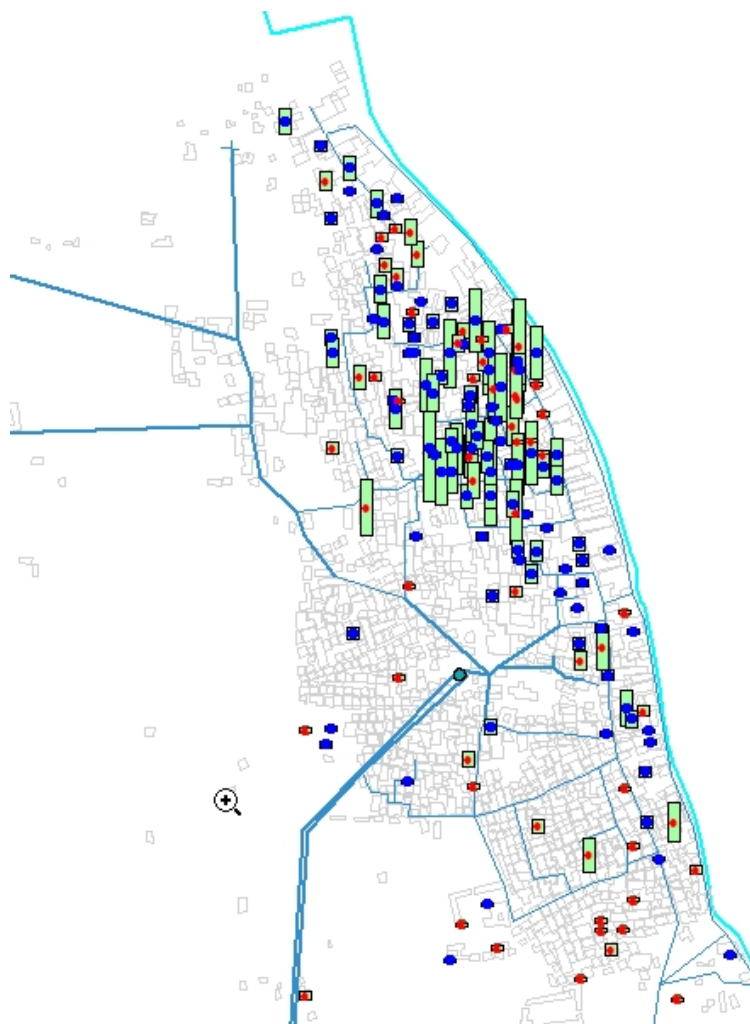
If the water extracted from the well field is relatively clean⁹, the water drawn from the traditional wells may be of less quality. If the provision of piped water has induced many owners to convert dry latrines to flush toilets, increasing the amounts of water discharged into the pits, and altering the efficiency of the pits and leading to a contamination of the underground water through seepage, the number of wells equipped with pumps may also play a role in the contamination of the aquifer. More water used to flush toilets means more contaminated water seeping into the ground, reaching the aquifer.

A tentative appraisal of the potential contamination problem is reflected by the relatively high level of the concentration of nitrates within the area of Stone town, where the habitat density is the highest and where the majority of the wells are equipped with motorized pumps.

Initial screening measures have been carried out in order to appreciate the level of this parameter, which can be used as an indicator for faecal contamination.

⁹ UNESCO Water and Sanitation Assessment mission to Lamu, Paris, 15th of March, 2005

The next figure shows the results obtained. The concentration of nitrate measured (vertical green bars), is varying from 5 mg/l to a maximum of 106 mg/l. On 145 wells tested in Stone town, only 19 show levels of nitrate (NO_3^-) above 50 mg/l, which is the recommended guideline value for WHO for drinking water¹⁰. The highest concentrations measured is just above 100 mg/l. The spatial distribution of the data shows that the high concentrations of nitrate have been found in wells equipped with motorized pumps, suggesting increased seepage from the pits in areas where pumps are used.



Unfortunately these results were obtained on samples collected before, during and after the rainy season and any attempt to link the levels of the nitrate ion with the use of water may be subject to caveats.

However, several samples collected in different areas of the town and in Shela, analysed by the Central Water testing laboratory in Nairobi show levels of NO_3^- of similar magnitude, ranging from 45 mg/l in Kashmiri to a maximum of 110 mg/l, for a well located in Langoni, suggesting that the contamination is there. Documenting a link between contamination and use of water may be more difficult and further studies will have to be done to better understand the behaviour of the nitrate concentrations in the groundwater of Lamu. Data on Shela and on other areas of the town had to be discarded due to a technical problem with the instrument.

Figure 13 Levels of nitrate and equipment of the wells with motorized pumps

Evolution of the electrical conductivity

Data were collected at two occasions: first within Stone town during the month of April 2005 as an initial campaign to understand how the conductivity was varying. This campaign was then followed by a second one, carried out between July and August. The data have then been merged and completed for other parameters, like the total depth, the level of the water, the type of equipment etc.

¹⁰ Guidelines for drinking water quality, WHO, Geneva, 1998

Evolution of EC (microS/cm)
Data collected April 2005

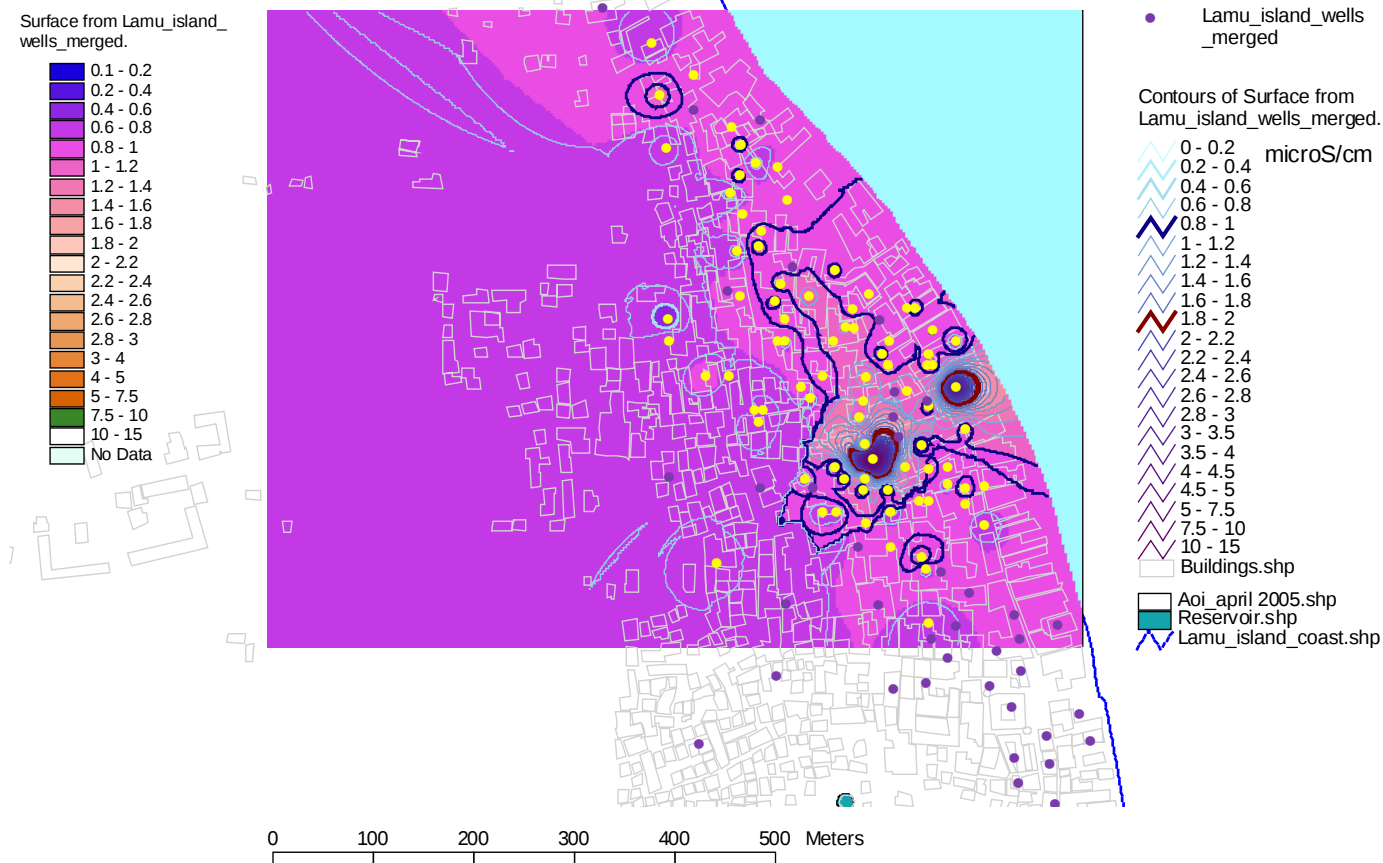


Figure 14 Interpolated run for conductivity for an AOI located in Stone town

The above figure shows the results of an interpolated run using ARCVIEW spatial analyst and electro-conductivity data for the AOI selected, for wells measured during this first period.

The boundary limit for the interpolation was the coastline. Technically speaking one would have introduced “virtual” wells on the shore line with an electro-conductivity close to that of the sea, which is higher than 20’000 microS/cm in order to understand the behaviour close to the coast and appreciate the possible salt intrusion.

We have decided not to do so as wells located close to the shoreline do not show high conductivities, close to 2-3 microS/cm, indicating a poor penetration of salty water into the underground water. This is acceptable, as the data have been collected before the rainy season, when the “pressure” of the water table is at the lowest.

From the figure it is easy to observe that only at two specific spots, located at the well of the Lamu Museum (40 m from the sea shore) and in another further behind (150 m from the seashore), the conductivity is higher than 1.8 microS/cm. The high levels are also influencing the 0.8 microS/cm contour, as it is observable from the figure. It is not clear if the two wells have been dug too deep once reaching the more salty water below, allowing it to mix with the less dense one of the rainwater aquifer.

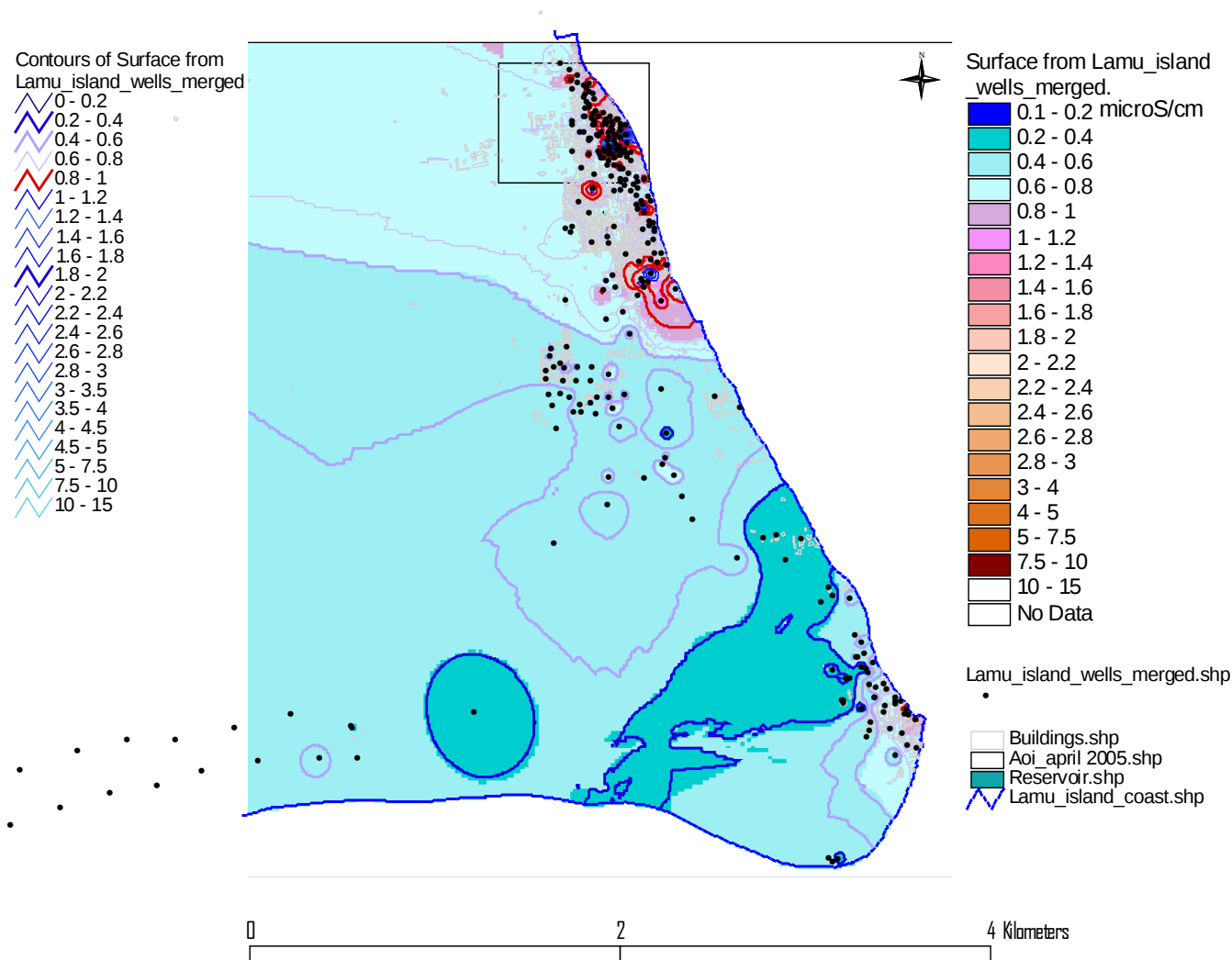


Figure 15 Spatial interpolation of the conductivity values for the Lamu aquifer including Stone town, Shela and the hinterland. Note the different colours of the legend.

A part from a few specific locations where the high conductivities may be explained by possible salt intrusion, the small increase of the levels of the electro-conductivity may also be due to anthropogenic effects.

In figure 15 (above), the evolution of the electro-conductivity of the aquifer has been mapped using a larger AOI (area of interest), integrating part of the wells of the dune's well-field.

In this figure we also show the AOI used previously for Stone town. In this interpolation run we have included the values measured before the rainy season, to gain a global figure.

The levels of the electro-conductivity are close to those measured at the well field, between 0.4 and 0.6 microS/cm on the entire aquifer, with a slight increase where the areas are urbanised.

As outlined before, anthropogenic activities are likely to be responsible for the increase of conductivity with the exception for wells close to the shores, where abstraction may have been important.

Preliminary conclusions

From the results it appears that the initial quality of the underground water, as far as salinity is concerned, is good. Water is abstracted from a protected aquifer, located relatively far from the town, and pumped to an elevated tank from where it is then distributed to the network.

In this preliminary study we have not considered the water distributed to the population by the network, which reaches an average value of 1233 m³/day¹¹. We have put our emphasis on the water abstracted from the traditional wells, which may represent a third or even more of this average value, allowing many inhabitants of the town to cope with their daily needs of water, not always covered by the piped distribution. This is however a gross estimation, based on the number of electrical pumps equipping about 2/3 of these traditional wells.

Despite this pitfall in our study, the volumes of water used are important and must be added to those distributed through the network. As water is more and more used by many owners for domestic purposes and to flush the latrines, it is likely that the possible seepage of contaminated water into the underground aquifer may lead to the observed slight degradation of the quality of the water, which is also affected by the poor disposal of the grey waters, discharged in open channels leading to the seafront.

A slight increase of the conductivity is observed on the wells located in the highly urbanised area, likely to be due to the same reasons. Salt intrusion from more saline water under laying the quite "soft" water flowing from the "dunes" aquifer toward the sea, is not too important, at least according to these preliminary results.

However, the data collected on more than 250 wells do not totally reflect the possible yearly evolution, even if some samples have been measured before and after the onset of the rainy season. The difference between these two extreme values are not high and variations are more likely to be attributed to anthropogenic uses and more specifically to the increased seepage outlined above, due to new hygienic habits within the urbanised areas (particularly in Stone town), where the use of water has increased.

This study must be considered as a preliminary one and all the results should be confirmed by a collection campaign followed by "official" analysis, to be carried out on selected wells at least at two occasions, before and after the rainy season, in order to appreciate the importance of the abstractions and the possible related evolution of the salinity, if any.

A detailed study should also be carried out within the aquifer in order to appreciate the possibility to increase the abstractions from the well-field in order to cope, if necessary to the increased demand of the town.

Aknowledgements

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¹¹ Source : District Water Office records 2004