A new and scalable approach for rural sanitation in Egypt

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This research was undertaken as a joint activity of Alterra Wageningen UR Wageningen, in association with the Holding Company for Water & Wastewater (HCWW), Egypt. The Alterra Wageningen UR Chief of Party, Dr. Joop Harmsen and HCWW project Coordinator, Dr. Rifaat Abdel Wahaab would like to acknowledge the contributions and support of the management and staff of Minya Company for Water and Wastewater. The contributions of the above individuals, being the project members and authors of this report, are significant and greatly appreciated. This research was funded by the Rijksdienst voor Ondernemend Nederland (project number 5241340) within the Water Mondiaal Programme

Alterra Wageningen UR
Wageningen, November 2014

Alterra report 2584
ISSN 1566-7197

Harmsen, Joop, Kamal Ouda Ghodeif, Mohamed Sherif Saad S. El Tony, Hakiem El Wagieh, Enas Michael, Esam Helmy and Floris van der Veen, 2014. *A new and scalable approach for rural sanitation in Egypt:* The village of Deir Gabal El-Tair as a pilot. Wageningen, Alterra Wageningen UR (University & Research centre), Alterra report 2584. 74 pg.; 26 fig.; 19 tab.; 16 photos; 11 ref.

Abstract: This report presents the result of a feasibility study on treatment of waste water in the rural area of Egypt. For treatment of waste water use can be made of the 80/20 rule, which implies simple and cheap solutions which make use of local conditions. To be successful, extra drivers must be present. Reuse of waste water (nutrients and water) is important, but it is recognized that other drivers can be more important. The village of Deir Gabal El-Tair is selected for a pilot. Water can be treated using natural differences in elevation and a wetland system already present. Presence of a cave where the Holy Family stayed and which is threatened by infiltration of waste water, mobilized other stakeholders. This will make it feasible to start the pilot on the short term. A second pilot with a focus on reuse in agriculture can be started near the new waste water treatment plan of Minya. This report contains the design of the pilot and an economical evaluation. Recommendations for the improvement of waste water treatment in other villages are given. The approach used is applicable in the rural area of Egypt.

Keywords: waste water treatment, stakeholder involvement, reuses waste water, Egypt

Alterra report 2584 | ISSN 1566-7197

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Executive summary

Egypt faces serious problems on the sanitation of water and also on the availability of water for irrigation. No budget for sanitation is available for the large number of villages in the rural area, because cities have priority. On request of the Delta team of Water Mondial Egypt a Feasibility study is performed to find a solution for the waste water in the villages. Key factor in the project is the reuse of waste water after a simple treatment. HCWW has made land available to be used in combination with the reuse of waste water, which can be very interesting for private investors. Also other identified benefits of treatment and reuse may stimulate the sanitation activities in the rural area of Egypt.

The project has started in June 2014 with a mission to Minya, about 300 km south of Cairo. 5 locations were visited to select a village for the first pilot using the following preconditions:

1. It must be possible to start the pilot on the short term (within one year).
2. We make use of the 20/80 rule: with 20% of the investment 80% of the desired result is obtained, which enables the application of simple and cheap solutions.
3. The solution makes use of the value of wastewater (water and nutrients), available land and the benefits of identified stakeholders (investors, local organizations).

In most villages no sewer system was present, which made a pilot on reuse of waste water in a short term pilot not possible. In these villages, use was made of infiltration and septic tanks. Improvements of these systems are possible and advise is given. The village of Deir Gebel El Teir had a sewer system and a large problem with the collected waste water. Moreover the village has a monastery, situated at the edge of a lime stone cliff and guarding a cave where the Holy Family has stayed during their escape to Egypt. Infiltration of waste water will decrease the stability of the lime stone and may lead to a rock slide off, including this Holy Place. This increases the need for a clean, safe and healthy environment in the village. For the water treatment, use can be made of the natural differences in elevation and the presence of a wetland already created by the discharge of waste water. Measurements showed that this wetland is effective in cleaning of waste water. We distinguished between the waste water produced in daily life and the waste water produced during the yearly festival with 2 million visitors (peak discharge). Several stakeholders are willing to be involved in the solution, the inhabitants, the church and also organizations, normally not involved in water sanitation like the Ministry of Tourism and industry within their Corporate Social Responsibility. The solution has the following elements:

- Improving the sewer system in cooperation with the inhabitants;
- Building of septic tanks to separate the aqueous and solid fraction;
- A trickling filter made of local material, in which use is made of the natural differences in elevationt;
- The natural wetland present;
- Reuse of the treated water;
- The solid fraction will be composted together with local available agricultural residues;
- Sanitary facilities and temporary storage during the yearly festival.

The approach used is new for Egypt. It was concluded that this approach, taking into account local conditions and use of simple and cheap treatment methods is applicable in a large number of villages all over Egypt. The site specific approach developed for Deir Gabal El-Tair is expected to be applicable in other villages situated on the lime stone cliff at the eastside of the river Nile. In the rest of Egypt the approach presented in this report and elements of the solution can also be used and will lead to site specific solutions.

Preface

Egypt faces serious problems on the sanitation of water and also on the availability of water for irrigation. The Holding Company of Water and Waste Water (HCWW) in Egypt has prioritized the treatment of waste water in the cities. No budget is available for the large number of villages in the rural area. On request of the Delta team of Water Mondial Egypt a Feasibility study is formulated to find a solution for the waste water in the villages. The Rijksdienst voor Ondernemend Nederland (RVO) has asked Alterra to carry out the project. Monique van der Straatten and Koen Overkamp have acted as contact persons.

The project team consisted of Joop Harmsen (project leader), Kamal Ouda Ghodeif, Mohamed Sherif Saad S. El Tony, Hakiem El Wagieh, Enas Michael, Esam Helmy and Floris van der Veen, coming from both Egypt and The Netherlands.

This project has been performed in close cooperation with the Holding Company for Water & Wastewater (HCWW). Leading partners were Prof. Dr. Rifaat Abdel Wahaab Professor of Environmental Science and Head Sector, Research & Development (R & D), and Prof. Ibrahem Khaled, Head of Minya Company for Water and Wastewater.

We appreciated the positive responses from:
- Ministry of Agriculture and Land Reclamation
- Ministry of Water Resources and Irrigation
- Ministry of Environmental Affairs.
- Ministry of Housing and New Communities.
- Egyptian Company for Iron and Steel
- Father Thaofelos Priest of the Church of the Virgin Mother of Gabal El-Tair and father Daod Agent Diocese Samalot. This church belongs to Samalout Main Church for Coptic Orthodox (Father - Befnotious).

Besides our main contacts, we acknowledge the help of many others, Koen Roest and Robert Smit (Alterra), several employees of Minya Company for Water and Wastewater and last but not least the governmental employees and residents of the visited villages.

We also like to mention the good and stimulating discussion we had with different stakeholders, Ministry of Irrigation (Dr. Samia El Guindy and Dr. Magdy A. Salah El-Deen), Ministry of Agriculture (Dr. El Gindy).

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Summary

Egypt faces serious problems on the sanitation of water and also on the availability of water for irrigation. The Holding Company of Water and Waste Water (HCWW) in Egypt has prioritized the treatment of waste water in the cities. No budget is available for the large number of villages in the rural area. On request of the Delta team of Water Mondial Egypt a Feasibility study is formulated to find a solution for the waste water in the villages. The Rijksdienst voor Ondernemend Nederland (RVO) has asked Alterra to carry out the project.

Key factor in the project is the reuse of waste water after a simple treatment. HCWW has made land available to be used in combination with the reuse of waste water, which can be very interesting for private investors. Also other identified benefits of treatment and reuse may stimulate the sanitation activities in the rural area of Egypt.

Beginning of June 2014 the project has started with a mission of the Egyptian and Dutch partners to Minya, an area about 300 km south of Cairo. Five locations were visited in order to select a village for the first pilot. We have visited four villages in Minya governorate and one site near new wastewater treatment plant for Minya City. The visited villages in Minya Governorate are; Deir Gabal El-Tair (Deir al-Adhra) – Samalout; the village of Deir Abu Hinnis – Malawe; the village of EL-Shaikh Masoud – El Edwa and the village of Sharona – Maghagha. The following preconditions were used;

1. It must be possible to start the pilot on the short term (within one year).
2. We make use of the 80/20 rule: with 20% of the investment 80% of the desired result is obtained, which enables the application of simple solutions.
3. The solution makes use of the value of wastewater (water and nutrients), available land and the benefits of identified stakeholders. It is very important to have private investors and local organizations interested.

Non-functioning infiltration tank caused by high water table

In most villages no sewer system was present, which made a pilot on reuse of waste water in a short term pilot not possible. In these villages, use was made of infiltration and septic tanks. Improvements of these systems are possible and advice is given. In the village of Sharuna the high water table has made the infiltration tanks less effective. The high water table is probably caused by infiltration through an irrigation channel in the village. Prevention of this infiltration should be the first step followed by improving the construction of the septic tanks.

The village of Deir Gabal El-Tair had a sewer system and a large problem with the collected waste water. Moreover the village has a monastery, situated at the edge of a lime stone cliff and guarding a

cave where the Holy Family has stayed during their escape to Egypt. Infiltration of waste water will decrease the stability of the lime stone and may lead to a rock slide off, including this Holy Place. This increases the need for a clean, safe and healthy environment in the village. For the water treatment, use can be made of the natural differences in elevation and the presence of a wetland already created by the discharge of waste water. Measurements showed that this wetland is effective in cleaning of waste water.

We distinguished between the waste water produced in daily life and the waste water produced during the yearly festival at the end of May with 2 million visitors (peak discharge). The waste water produced during this festival asks for its own approach. There are possibilities by controlling it by a system of mobile toilets as used at festivals in Europe and by creating buffer capacity.

The monastery including the cave were the Holy Family stayed

Natural wetland and height differences to be used for waste water treatment

Several stakeholders are willing to be involved in the solution, the inhabitants, the church and also organizations that are not normally involved in water sanitation, like the Ministry of Tourism and Industry within their Corporate Social Responsibility. Although not all input data were available, the first economic evaluation, including sensitivity analysis, showed that revenues of the sanitation will be higher than costs.

The solution has the following elements
- Improving the sewer system in cooperation with the inhabitants;
- Building of septic tanks to separate the aqueous and solid fraction;
- A trickling filter made of local material, in which use is made of the natural differences in elevation;
- The natural wetland present;
- Reuse of the treated water;
- The solid fraction will be composted together with local available agricultural residues;
- Sanitary facilities and temporary storage during the yearly festival.

For reuse of waste water the visited area near the new Minya WWWTP was most suitable for a pilot project. Private investors are interested and a pilot project at this location can be realized on the short term.

The approach used is new for Egypt. It was concluded that this approach, taking into account local conditions and use of simple and cheap treatment methods is applicable in a large number of villages all over Egypt. The site specific approach developed for Deir Gabal El-Tair is expected to be applicable in other villages situated on the lime stone cliff at the eastside of the river Nile. In the rest of Egypt the approach presented in this report and elements of the solution can also be used and will lead to a site specific solution.

1 Introduction

In general, there is a severe lack of proper sanitation in rural Egypt. Although most households possess latrines or flush toilets, storage, collection, treatment, and disposal of sewage is highly inadequate. Open drains receive large quantities of highly polluted flows which often results in severe threats to public health through water-borne diseases. Not only farmers directly reusing water from these drains are exposed to such diseases, but also households using water for dish washing and house cleaning purposes from irrigation canals that are part of the reuse of drainage water schemes of the MWRI. This situation with respect to surface water quality is further compounded by illegal dump practices of sludge from septic tanks and latrines into drains and irrigation canals.

Rolling out sanitation programs in Egypt falls under the responsibilities of the Holding Company for Water and Waste Water (HCWW) and its affiliates. The HCWW is part of the Ministry of Water and Waste water Utilities and has many programs in the field to improve sanitation. For the rural implementation of these programs they also cooperate with other involved ministries, notably 'Local Development', 'Health and Population, and 'Water Resources and Irrigation'.

Given the fact that the HCWW, and thus also its major government supported sanitation programs, is not going to serve villages below 25,000 inhabitants on short notice, decentral sanitation solutions need the support of the local communities, also for keeping them in operation This brings us to the 'willingness to pay' for the treatment of local waste water, which is illustrated in Figure 1 showing the 'willingness to pay' against costs per m^3.

Industries, and specifically those in food processing and high technology, could bear relatively high treatment costs. In the more affluent countries households are also willing to pay higher costs. In the Netherlands, households pay on average €1.35/m3 leading to an end-product suitable for drinking water. In countries where treated household water is not suitable for drinking water, people are willing to pay about €1 for a liter of water. In Egypt bottled drinking water is sold at prices ranging from €0.20 to €0.80 per liter. However, in rural areas and urban areas alike, most citizens are unwilling and often unable to pay such prices. This sheds sufficient light on the cost recovery aspects of current sanitation practices in Egypt.

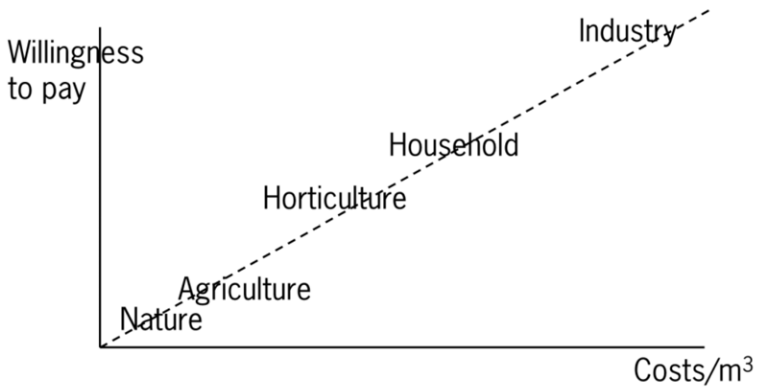

Figure 1 *Willingness to pay' against treatment costs of water.*

Due to its huge tasks and budgetary limitations HCWW concentrates its activities on the larger cities. The challenge remains however how to cover the smaller communities in order to tackle the 'diffuse' pollution loads on the surface water system and improve public health. This raises the question which technology, or combinations thereof, is the most appropriate to be affordable.

One of these solutions may be a Public-Private Partnership using (treated) waste water in areas with serious water scarcity and with opportunities to use (desert) land for cultivation. Part of such solutions also comprises the (re-)use of the nutrients present in the reclaimed water. This puts a direct focus on the value of reclaimed water, the value of the nutrients therein, but also on the value of the solid fractions containing organic matter and nutrients. While these uses are most likely solutions in the Egyptian environment (bearing in mind appropriate solutions), the use of energy that can be gained from wastewater streams may also be considered. The best locations for such a project may be found in Upper Egypt, where in general neither sewer networks, nor wastewater treatment plants exist for the small villages (up to 50,000 inhabitants). In Upper Egypt desert lands are also available at a short distance and at relatively low prices to re-use the reclaimed water and solid fractions. These lands are sparsely populated and in addition offer cheap opportunities for a biological treatment of reclaimed water through natural filtration feeding back into the river Nile. Therefore, new sanitation systems can/should be designed based in anticipation of (specific) re-use in agriculture, now and in the future.

Figure 2 illustrates the effort required to design a water quality for a certain use. With an intensive treatment clean water, to be used in households and industry, can be produced. With a less intensive treatment water of lower standards can be obtained (e.g. A, B, C and D as described in the Egyptian Code for reuse of waste water).
Direct use of the reclaimed water, in order to utilize all nutrients, is also possible and can be handled in a similar way as manure applications. Water is freely available to farmers in the Nile Valley and Delta. In the desert where mostly groundwater is used, farmers only pay for the pumping cost. Since farmers are not used to paying for water, activities on reuse of waste water in agriculture, should concentrate on methods not involving payments for water. This puts emphasis on the less intensive and low costs treatment methods.

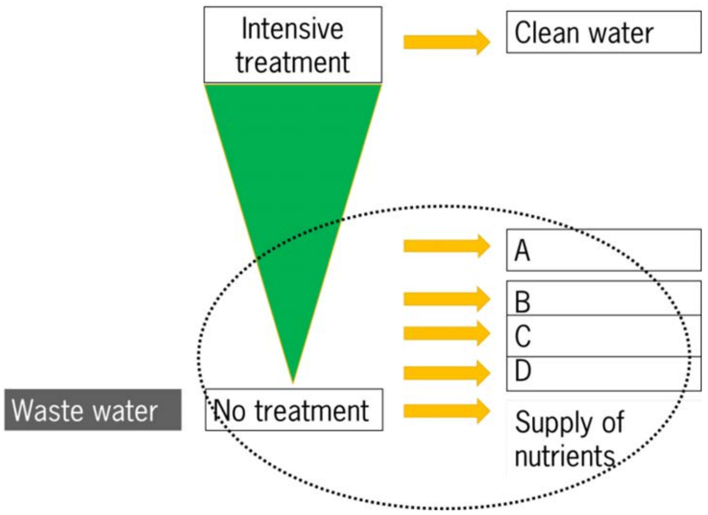

Figure 2 *Investments required for different effluent qualities.*

Given these difficult financial conditions for rural sanitation, appropriate land lease options may very well play a pivotal role in finding solutions. Lands consigned to Holding Company for Water and Wastewater (HCWW) are at 63 locations in 15 governorates. Individual plots vary in size from 100 to almost 10,000 feddans, averaging about 1500. HCWW intends to issue Requests for Proposals (RFPs) inviting private sector for designated land parcels cultivation with code-compliant crops and, post-harvest processing and marketing of output.
The HCWW is therefore looking forward to exchanging experience and knowledge with Dutch colleagues at Organizations / Institutes in the following areas:
- Low-cost wastewater treatment technologies for rural area and small communities;

• Upgrading of the overloaded existing wastewater treatment plants (different technologies);
• Private sector participation in wastewater reuse-integrated projects;
• Sludge management/application;
• Capacity Building Programme.

Water management in Egypt is facing numerous challenges with two important challenges running at the forefront:

1. Imminent water scarcity and seen from that perspective every drop of water should be used and reused whenever and where ever possible and not discharged to the sea;
4. Fertilizers are expensive, especially in the Egyptian context with smallholder famers. Recycling of valuable nutrients such as nitrogen, phosphorus and potassium from animal excrements as well as from reclaimed wastewater should therefore be pursued.

On the other hand, there are a number of impediments obstructing the large scale reclamation and reuse of wastewater. The most important problems are:

1. Reclaimed water use in agriculture is strictly regulated and it is difficult to identify high value crops that are allowed to be grown using such water and / or reclaimed compost;
5. Farmers are not accustomed to pay for the water they use and water users in general are not accustomed to pay for the pollution of the water they use.

To exploit these challenges and deal with the impediments at the same time, smart combinations of technologies and stakeholders have to be found. Reclamation and reuse of waste water has therefore two main components:

1. Reuse of the solid fraction in the water and the probability for composting and application as soil amendment;
2. Reuse of the residual water containing the nutrients.

Any proposed reuse scheme, however, needs to include the spatial and temporal variability in quantity and quality of the water envisaged for reclamation, while on the receiving end crop choice should match these parameters. It can even be foreseen that for tangible solutions also fresh water needs to be made available temporarily. All such alignments require an integrated approach.
Figure 4 presents a flow chart indicating the major pathways between various urban pollutions and the use of these products onto agricultural fields. The ultimate goal is to recycle all reclaimed waters and most of the nutrients contained in the liquid and solid flows for agricultural production.

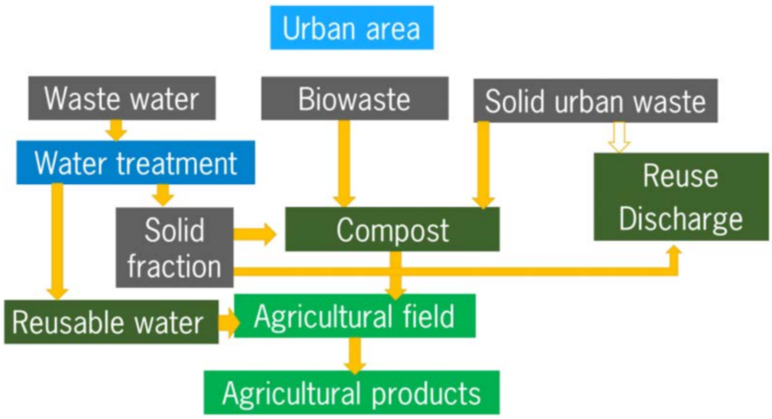

Figure 3 *Pathways for the recycling of liquids and solids from urban areas for agricultural production.*

Based on Figure 3 we can analyse the routes of nutrients, salts, pathogens and contaminants. Doing this, it becomes clear that the reclaimed water is not the largest source of nutrients. Nutrients are mainly contained in the reclaimed compost. Composting will consequently be an important activity if we want to reuse the nutrients. Other compostable residuals like bio-waste (especially residuals from agricultural production), should be included in composting activities. In our approach we will connect the different water and nutrient streams to come to an optimum solution. We also think that our attention to the solid part of the waste water and other compostable residues will increase the interest of the private sector and the possibilities for PPP-constructions.

Reuse of the solid fraction (sludge) is common practice in the European Union. Approx. 40% of the sludge coming from Waste Water Treatment Plant is reused in Agriculture (Milieu Ltd, 2008). The same report mentions that the current European Sewage Sludge Directive addresses both pathogen reduction and the potential for accumulation of persistent pollutants in soils but sets no limits for organic contaminants. The Directive sets limit values for seven heavy metals (cadmium, copper, nickel, lead, zinc, mercury and chromium), both in soil and in sludge itself. It specifies general land use, harvesting and grazing restrictions to provide protection against health risks from residual pathogens. The Directive requires all sludge to be treated before being applied to agricultural land, but allows the injection of untreated sludge into the soil under specific conditions. While it calls for the use of treated sludge, the Directive does not specify treatment processes.

In The Netherlands, sludge is not used anymore because the content of heavy metals became too high in the second part of last century due to discharge of heavy metal by industry. This discharge has reduced drastically and ideas are coming up to use it again to close nutrients circles. It is expected that in most villages in the rural area the contents of heavy metals and other contaminant in sludge will be low, which makes it reusable.

Egypt can make use of the experiences in Europe. This was not foreseen in this project. In a follow- up of this project, the sludge directive and experiences with sludge have to be included.

2 Preconditions for the pilot

It is necessary to develop a common view of the team and stakeholders on the preconditions for the pilot to be developed. It is the intension of all involved in the project to come with a solution. It is therefore necessary to break the assessment circle (Harmsen and Naidu, 2013). Figure 4 gives a variation of this circle specified to this project.

Figure 4 *Breaking the assessment circle.*

In assessments the problem is recognized and a simple assessment already shows that in this case there is a waste water problem for which solutions are available. It is however too expensive to solve the problems and moreover, towns in Egypt have priority for treatment of waste water. The sanitation problem is not solved and the circle can start again. In this project we want to break the circle by using local possibilities and using the 80/20 rule (see further).

First steps were made during a meeting with Dr. Rifaat and a meeting with Dr. Samia and Dr. Magdy A. Salah El-Deen. In a workshop in Minya with the team and several stakeholders the preconditions were formulated and finally they were slightly modified and established at the debriefing in Cairo with Dr. Rifaat. Preconditions were:

1. Use of cheap technology.
2. It must be possible to start the pilot directly after this project (autumn 2014).
3. The pilot has to cover the whole village.

2.1 Use of cheap technology

Because the amount of financial resources is limited, we used a variation of Pareto's rule. The Pareto principle (also known as the 80/20 rule) states that, for many events, roughly 80% of the effects come from 20% of the causes (Wikipedia). Management consultant Joseph M. Juran suggested the principle and named it after Italian economist Vilfredo Pareto, who observed in 1906 that 80% of the land in Italy was owned by 20% of the population; Pareto developed the principle by observing that 20% of the pea pods in his garden contained 80% of the peas. It is a common rule of thumb in business; e.g., "80% of your sales come from 20% of your clients. Many natural phenomena have been shown empirically to exhibit such a distribution.

As a variation of Pareto's rule we used the principle that with 20% of the necessary investment, you can have 80% of the desired result. Translated to waste water treatment this means that with low investments (20%) it is possible to remove 80% of the contamination in the water. 20% of the contaminants are left and it will take the other 80% of the investment to remove these. Regarding the limited available funds, we choose for using these funds for removal of 80% of the contaminants. The effect on the desired result, less discharge of contamination to the environment is shown in figure 5.

It is assumed that the amount of wastewater will grow with 3%/year (reference year is 2014). This year is set at 100.
There is money available to build treatment plants for 5% of the wastewater. Investments will lead to 100% cleaning of the treated wastewater.
The graph shows the following;
- A = no treatment, Linear growth (3 units/year) of discharge wastewater;
- B = investment in installations for full treatment. This gives a decrease of the discharged waste water (2 units /year);
- C = use all investments for 80-20 rule for 4 years followed by using the investments to clean the increase (3/year) and the rest of the money to clean the residual waste water from the 80/20 rule;
- D is a mixture of B and C.

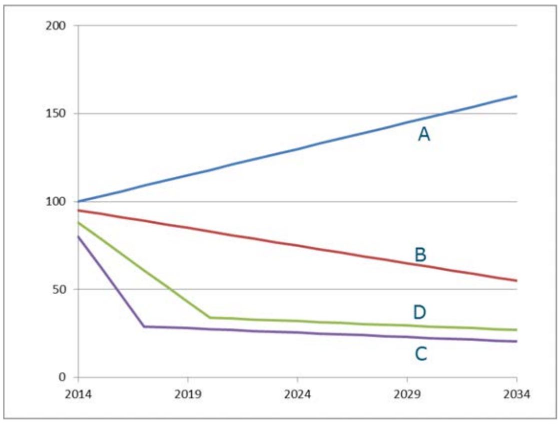

Figure 5 *Efficiency of the 80/20 rule.*

The graph shows clearly that using the 80/20 rule is most efficient to decrease the amount of discharged contaminants. The profit is the surface between the two lines.

2.2 Quick start of pilot

It was agreed that it is necessary to have a quick start of the pilot, because this has to be followed by implementation of the ideas in other villages. The planning of the pilot is given in table 1.
The start of the pilot is foreseen starting in autumn 2014. In 2015 first results can be shown to stakeholders which will mean start in following villages in 2017 (front runners) and implementation in slower villages in following years.

Table 1
Desired Time scheme for implementation of the pilot

	2014	2015	2016	2017	2018	2019
This project						
Pilot						
Private investors convinced						
Rolling out						

2.3 Covering the whole village

With a pilot, part of a problem is solved and this pilot is used as an example to solve the whole problem. In this project it was decided to have a pilot for a complete village. The consequences of this decision is that it is not possible to choose for a part of the village with ‘optimal’ conditions while not taking into consideration the more difficult areas. The plan for the pilot to be made should therefore include a proper phasing of the pilot, still in line with the desired quick start of the pilot.

3 Background Information on the Minya district

The background information will cover in general terms the location, administration, geology, topography, climate, water resources, drinking water supply and sanitation, survey of crops and present role of the private sector. Information has been gathered through archival data and field survey in addition to laboratory and office work. Archival data is available mainly at Minya Governorate Information Centre and Local authority of villages, Water Company and Holding Company for Water and Wastewater (HCWW), Ministry of Water Resources and Irrigation and Minya University. Moreover, direct contact with local communities and personall interviews are other sources of information.

3.1 Minya Governorate

Minya governorate is located along the Nile Valley and its desert fringe in Upper Egypt. It is surrounded from the North with Beni Sweif governorate, at the South is Assuit governorate, at the West is El-Wadi El Gadeed governorate and Red Sea governorate at the East (Fig. 6). Minya is about 247 km away from Cairo. It covers an area of about 32,279 km^2. The governorate is one of the most highly populated in Upper Egypt. It consists of nine administrative localities (Markaz and major cities) from north to south; El-Idwa, Maghagha, Beni Mazar, Mattay, Samalout, Minya, Abu Korkas, Mallawi, Deir Mowas. It also includes about 3,375 villages and 10,875 sub-village and hamlets. The administrative division of Minya governorate is shown in figure 6.

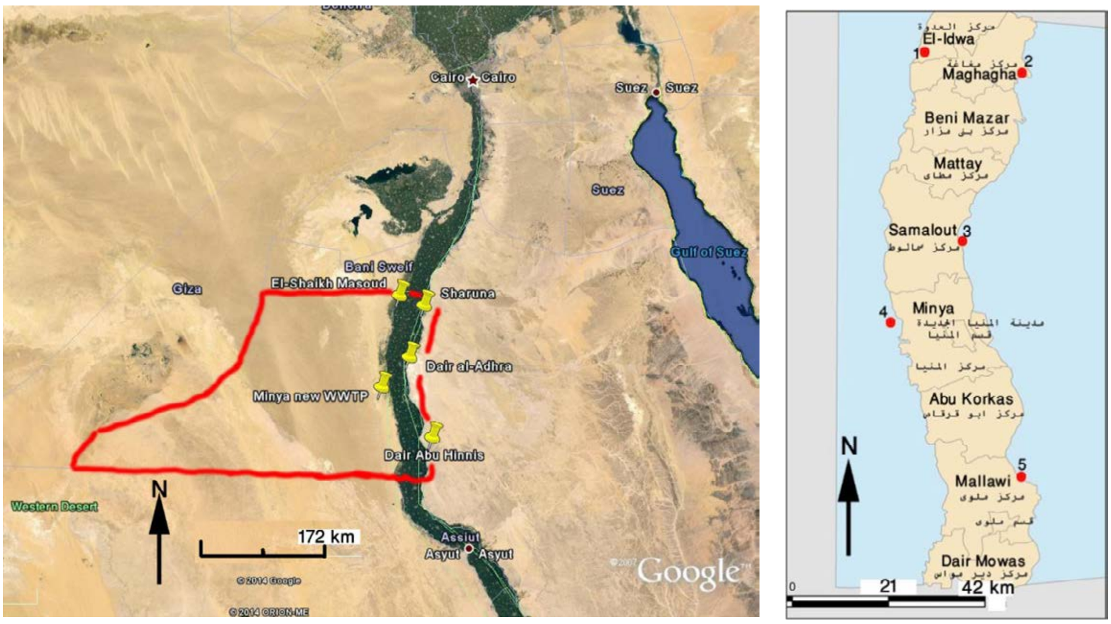

Figure 6 *Left: Location map of the nominated sites at Minya governorate (from Google earth website).*
Right: The administrative division of Minya Governorate and the distribution of the visited sites (1 is EL-Shaikh Masoud; 2 is Sharuna; 3 is Deir al-Adhra; 4 is New Minya Wastewater Treatment Plant; 5 is Deir Abu Hinnis)

3.2 Climate

Al-Minya governorate has a desert climate, throughout the year. There is virtually no rainfall in Al-Minya. It has a long hot, rainless summer and a mild winter. The average annual temperature in Al-Minya is 21.3 °C and the warmest month of the year is July with an average temperature of 28.2 °C (table 2). In January, the lowest average temperature of the whole year is 12.2 °C. Annual and monthly quantities of rain appear to be very small. Most precipitation falls in February, with an average of 1.5 mm. The difference in precipitation between the driest month and the wettest month is 1.5 mm. The maximum amount of rainfall in one day is 11.4 mm during February (figure 7). Such high values in one day can cause flash floods in the desert wadis that drain towards the flood plain of the Nile valley. Minya receives ample sun shine all over the year. The sun shine reaches 393 hours in July, which means 13 hr/day. It has a very high evaporation rate, the average daily evaporation varies between 4.8 mm/day in winter and 12.4 mm/day in summer. Relative humidity reaches its maximum during November and December recording 60% and 62%; it decreases during spring to reach its minimum rate of 35% in May. Wind speed reaches its maximum value in June (9.2 knot/hr), while its minimum speed is recorded during December at 4.9 knot/hr with an annual average of about 7 knot/hr.

Table 2

Climatic data; temperature, rainfall, Relative humidity and Wind speed (Minya Weather station)

Month	Temp (mean/min/max) °C	Average rainfall mm	Max. amount in one day mm	Relative humidity%	Wind speed knot/hr
January	12.2/3.8/20.7	0.5	6.8	58	8
February	13.6/4.9/22.4	1.5	11.4	53	5.9
March	16.7/7.7/25.8	0.3	3.2	48	7.9
April	21.1/11.7/30.6	0.3	10.2	40	8
May	25.5/16.3/34.7	0.4	8.4	35	8.7
June	27.5/18.9/36.2	0	0	39	9.2
July	28.2/20/36.5	0	0	45	7.8
August	28.1/20.1/36.2	0	0.1	51	6.6
September	25.8/18.3/33.3	0	1.2	54	7.4
October	23.2/15.3/31.2	0.4	6.5	54	6.6
November	19/11.2/26.8	0.1	2.7	60	6
December	14.3/6.6/22	0.5	4.4	62	4.9
Total/mean		4/	/4.6	/49	/7

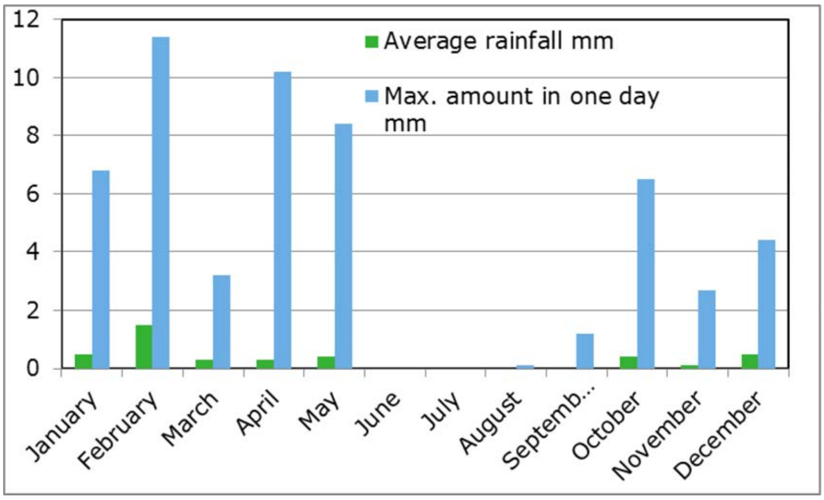

Figure 7 *Average rainfall and maximum amount fall in one day.*

3.3 Geologic setting and geomorphology

Minya governorate occupies the middle part of Upper Egypt. It covers the Nile River flood plain (Nile valley) and parts of both western and Eastern desert fringe (Figs. 8 &9). The Nile valley has a gentle topographic profile. It is dominated by low land flat areas with presence of relatively raised terraces. Most of the urban area had been constructed on terraces and raised islands. The flood plain contains the major part of the cultivated land and also the urban areas of the governorate. Most of the population is concentrated along the flood plain that spreads along the western bank of the current course of the River Nile. The sediments covering it are mainly fluvial sediments (clay, silt and fine sand with few abandoned sand and gravel islands). River terraces, sand dunes, wadi deposits and fluvial sediments spread mainly to the west. Marine limestone with caves wide spread mainly along the eastern plateau and western high lands. Limestone rocks are distributed at Minya Formation (Early Eocene) at the base and Samalut Formation (Middle Eocene) at the top. Both Formations are characterized by presence of subsurface hidden sinkholes and caves. The eastern bank has a steep slope towards the Nile valley.

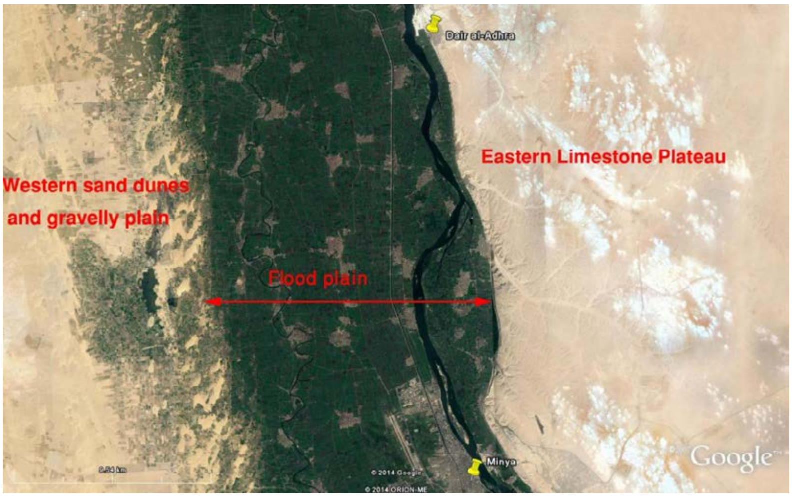

Figure 8 *Geomorphologic satellite image of Minya Governorate (source is Google earth website).*

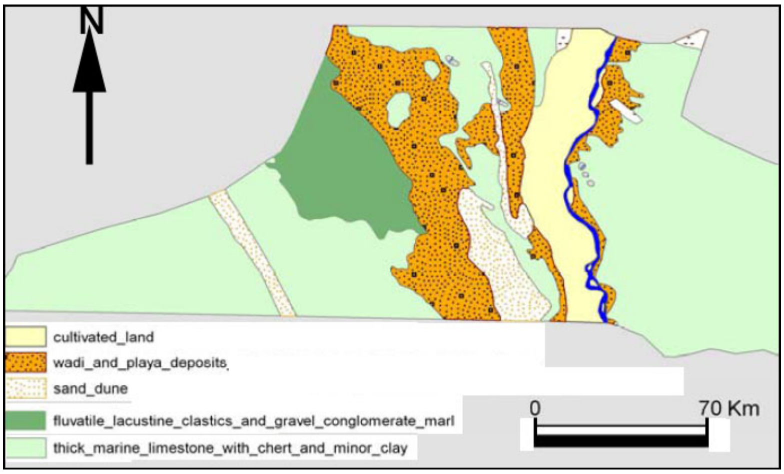

Figure 9 *Geologic map of Minya Governorate (source geologic map of Egypt).*

3.4 Population

According to the Data Information and Supporting Decision Centre (Cabinet of Ministers) the population census of Minya governorate in the year 1986 was 2,645,000. It was 3,310,129 in 1996 with a density of 102.5 inhabitants/km². Population census in 2006 was **4,166,299** inhabitants with density 129.1 inhabitants/km². The growth rate between years 1996 to 2006 is **+2.33% /year**. The population growth rates illustrate the general trend of population size during previous periods in addition to the possibility of using it in population estimation studies. Growth rate in the rural part of the Minya governorate exceeds the urban ones, as it recorded 2.64% in the country side. Most families in Minya live with each other in big extended families. The average family number in the rural area **is five**, while the average family number in the urban area is four. The rate of population condensation or the number of persons in one room is related to the social and economic conditions as well as the living standards. The average **extended family number** in the rural area is much more than five (many small families live together in one big extended family).

3.5 Agricultural production and Crop types

Minya governorate is one of the leading governorates, regarding agricultural production that represents about 11%, of the total agricultural production all over the country. Field crops represent about 7.6%, vegetables and fruits represent 3.6% of the country's production. The governorate is producing corn crops (maize, wheat, rice), sugar crops (sugar cane & sugar beet), cotton and oil crops (table 3). The governorate produces more than ½ million ton of wheat, 1.7 million tons of sugar cane that is used in making sugar, molasses and juice and about 154 thousands ton of sugar beet that is used in producing sugar. The governorate also produces large amounts of vegetables and fruits that need more care especially in the field of producing these products and the possibility of exporting it. The governorate as well produces 27.1% of the medical and perfume plants all over the country. The most famous crop in the governorate that takes the first place over most of the other governorates is maize.

Table 3
Crops cultivated in Minya

Crop	*Area / feddan*	*%*	*Production in ton*
Cotton	33612	2.7	2184680
Wheat	182959	14.9	3842139
Maize	260931	21.3	6087690
Rice	11	-	34
Oily crops	34767	2.8	382063
Sugary crops	36533	2.9	1762595
Fodders	123671	10	865697
Vegetables	41830	3.4	322292
Fruits except citrus	24888	0.2	147323
Orange and citrus	3994	0.3	22502
Medical and aromatic plants	19838	1.6	42250
Total	**1223631**	**1000%**	**25704677**

Source : Agricultural management – Information Center in Menya.

3.6 Water Resources and Drains

The River Nile and the main canals (Ibrahemia canal – El-Bahr El-Youssefy canal) are considered the main source of fresh water. Ibrahemia canal crosses the governorate from the South to the North in the middle of the flood plain in the middle of Minya. It is a 350 km long canal diverting water from the River Nile, running through most west bank towns and cities between Assyut and Giza. Out of this canal branches the sub canals that are spread over Minya. El-Bahr El-Youssefy canal gets its water from Ibrahimiya canal and ends at Fayoum Oasis and it also runs from the South to the North. It lies on the western edge of the flood plain. Fresh water supplies all sectors (drinking, irrigation and industry) with their needs. The distribution of fresh water courses and drains at Minya governorate are shown in figure 10.

The main drain in Minya is Etsa (El-Mohit) that is extending to the west of Ibrahemia Canal. It is mainly agriculture drainage water that is mixed with sewage effluent. According to the National Water Resources plan for Egypt (NWRP, 2001), the Nile River from Aswan to Delta Barrage receives wastewater discharging from 124 point sources, of which 67 are agricultural drains and the remainder are industrial sources. The worst water quality is that of Khor El-Sail Aswan, Kom Ombo, Beba and Etsa drain. They do not comply with Law 48/1982 (article 65) regulating the quality of drainage water which can be mixed with fresh water. Etsa drain contributes about 11% of the total COD load discharged into the River Nile (Table 4).

Table 4

Water quality of Etsa drain at the tail ends, before discharge into the River Nile (Shaded values are non-compliant with Law 48)

Code	Drain Name	Dis. From AHD (km)	Discharge Mm^3/day	COD mg O_2/l	BOD mg O_2/l	DO mg O_2/l	TDS mg/l	FC MPN/100ml	Heavy Metals
	Consent. Standard			15 mg/l	10 mg/l	5 mgO_2/l	500 mg/l	5.00 E+03	3
DU35	Etsa	701.2	0.57	100	38.00	1.58	575	3.50E+04	0.19

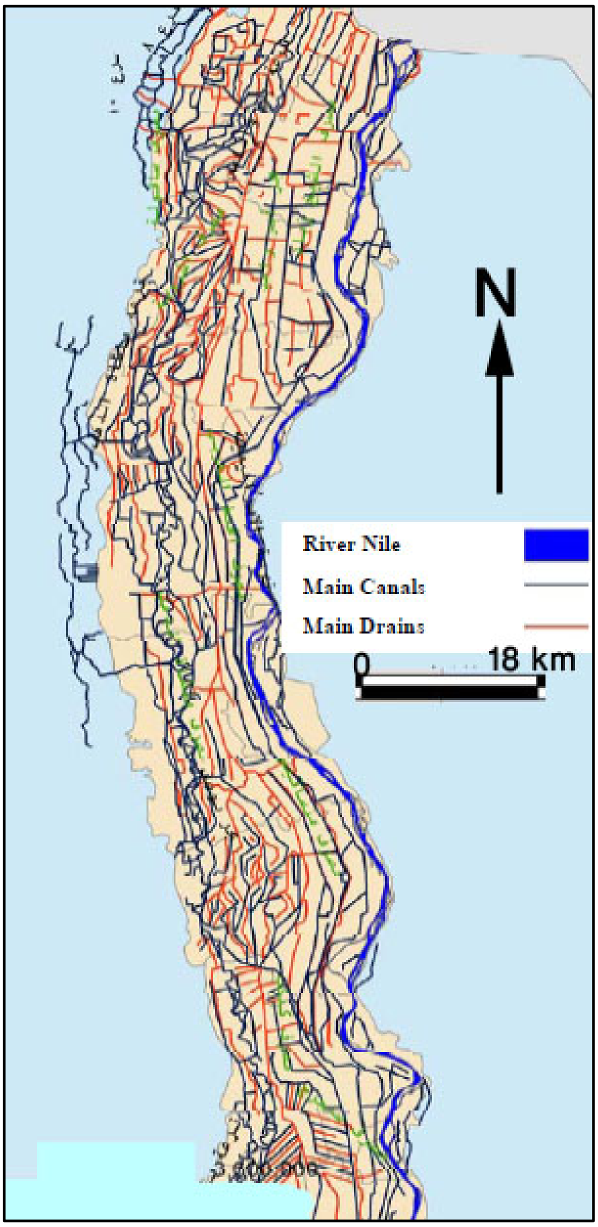

Figure 10 *Fresh water courses (River Nile & Canals) and Drains at Minya Governorate.*

3.7 Water Supply and wastewater treatment and reuse in Minya

The Ministry of Housing and Utilities and the urban development supervises all institutions in charge of providing water and sanitation services all over Egypt. Two main institutions are in charge of planning and supervision of infrastructure construction in Minya governorate:

- The National Organization for Potable Water and Sanitary Drainage (NOPWASD) excluding new communities, and;
- The New Urban Communities Authority is responsible for water supply and sanitation investments in new communities.

The **Holding Company for Water and Wastewater (HCWW)** and its 26 affiliated companies are in charge of operation and maintenance of water and sanitation infrastructure. The Holding Company owns all water and sanitation infrastructure in Egypt. Its affiliated company **(Minya Company for Water and Wastewater)** is responsible for providing service of water and wastewater to Minya governorate.

Egypt has been using treated wastewater to produce wood and other industrial products since the early 1990s. The MALR (Ministry of Agriculture and Land Reclamation) and the MSEA (Ministry of Sate for Environmental Affairs) have established 24 water-reuse projects across the country including one in Luxor where they grow African mahogany (*Khaya senegalensis*), mulberry (*Morus spp*), and physic nut (*Jatropha curcas*). So far, these projects have been exclusively government driven and private sector participation is absent. An inter-ministerial committee approved the Egyptian Water Reuse Code (Ministerial Decree No. 171/2005) in April 2005. Nowadays there are activities to produce new water reuse code that encourage and enhance reuse applications for economic value, sustainability and environmental protection.

Drinking water supply coverage percentage is about 100% of the population. Surface and ground water are the main sources of drinking water in the Minya governorate. The surface water supply (River Nile, Ibrahemia canal, El-Bahr El-Youssefy canal) represents about 76% of the total drinking water supply while groundwater contributes about 24%. Minya governorate has 78 filtration treatment plants and 161 artesian wells for drinking water supply. The average total production is around 433400 m^3 per day. The individual's share of the product was 94 litres/day. The loss of drinking from distribution system ranges from 20% to 25%.

The waste water treatment in the entire governorate is 138481 m^3 per day (table 5). There are 12 waste water treatment plants serving essentially all cities in Minya governorate and only three villages. There is no waste water treatment service for the rest of villages and towns of the governorate. The percent of waste water treatment coverage reaches about 20% of the whole population. People usually use their own methods; mostly cesspits and then discharge by trucks. Samaluat City has wastewater treatment plant that discharges its effluent into desert fringe and wood forest.

Table 5

The waste water treatment plants (WWTP) in Minya governorate

No.	WWTP	Construction Date	Coverage	Treatment Technology	Design Capacity m3/day	Average actual capacity for three months (Jan, Feb and March 2014)	Effluent Discharge to
1	Idwa	2005	Idwa city	Biological , activated sludge, Kroger oxidation trenches	2000	3029	Ain Shams drain
2	Maghagha	2008	Maghagha city	Biological , gravel filtration	20000	5240	Lamloum (Shalsh) drain
3	Bahnsa (Bani Mazar)	1999	Bahnsa village Bani Mazar	Natural, oxydation ponds, natural fixation lagoons	2000	476	desert fringe
4	Saaydia (Bani Mazar)	2005	Saaydia village Bani Mazar	Biological , gravel filtration	20000	7247	El-Rahab drain
5	Mattai	2008	El Bernsat village	Biological , activated sludge, Kroger oxydation trenches	10000	6269	Bardnoha drain
6	Tala	developed 2000	Minya City	Biological , activated sludge, airation basins	40000	72081	Etsa (Al Mohaet) drain
7	Abou Qurkas	1997	Abou Qurkas village	Biological , activated sludge, aeration basins	40000	8354	Al Deir al bahry drain then to Etsa drain
8	Mallawy	2009	Mallawy City	Biological , gravel filtration	40000	8458	Sengerg drain
9	Delga	2007	Delga City	Natural, oxydation ponds, natural fixation lagoons	12600	454	western desert fringe
10	Deir Mouaas	2005	Deir Mouaas City	Biological , activated sludge, Kroger oxydation trenches	10000	2461	talouf drain (Kebkab)
11	New Minya		New Minya City	oxydation ponds, aeration, fixation lagoons	20000	4412	Eastern desert fringe
12	Samaluat	2014	Samaluat City	gravel filtration	20000	20000	desert fringe (reused to irrigate 1000 feddan wood forest)
	total				236600	138481	

4 Site description of the visited sites and selection of the pilot

Minya Water and Wastewater Company has nominated five sites in Minya governorate that have urgent need for sewage disposal service. We have visited four villages out of five in Minya governorate and one site near new wastewater treatment plant for Minya City. The visited villages in Minya Governorate are; Deir Gabal El-Tair (Deir al-Adhra) – Samalout; the village of Deir Abu Hinnis – Malawe; the village of EL-Shaikh Masoud – El Edwa and the village of Sharuna - Maghagha, (Figure 6). All villages are characterized by serious environmental problems caused by discharging of raw sewage either to open areas or water environment (agricultural drains and groundwater). The common sewage disposal system at all villages is cesspits and open trenches.

4.1.1 Deir Gabal El-Tair (06-06-2014)

The village is located on top of the lime stone hill just besides the Nile Valley. Drinking water supply is through a PS taking from the Nile 60 l/sec. The village has about 5000 inhabitants. There is a Monastery that attracts 2 million visitors for one week once a year on June 1 to celebrate that the Holy Family has stayed in the village (Photo 1).

Photo 1 *The monastery including the cave were the Holy Family stayed.*

In the Wadi is some 20 feddan of land available for agriculture, but property of the Cement Factory. The groundwater is at 30 meter deep and the soil profile is 5 m of sand.
The current plan is to lift the wastewater about 20 m from the village to the WWTP and then again lift it to the area for agriculture (figure 11).

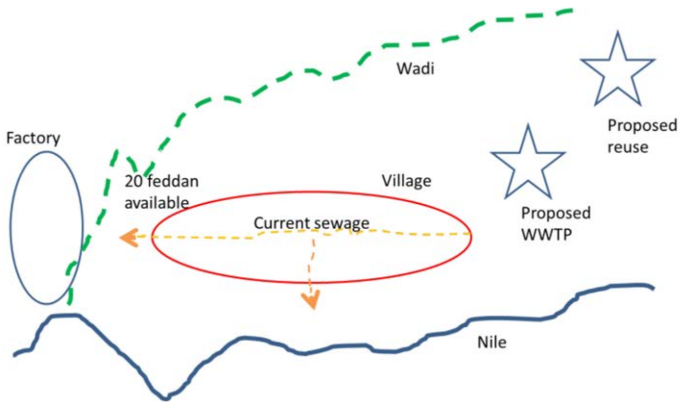

Figure 11 *Situation around the village.*

The village has a simple sewer system (Photo 2) which ends at the border of the village and discharges the water into the waste water pond. Photo 2 shows the discharge of the area around the monastery. The water falls down about 50 meter, following the lime stone wall and ends into a pond. Photo 3 shows the waste water ponds at the northern part of the village into. The overflow of these ponds is going into the Wadi (photo 4). Ponds and also the sewer system produce a bad smell in the village and people are living close to the ponds.

Sewer system.

Waste water pond below the monastery.

Waste water ponds at northern part of the village.

Overflow entering the Wadi.

Photo 2 *Waste water in Deir Gabal El-Tair.*

4.1.2 Deir Abu Hinnis (06-06-2014)

The village is less smelly then the previous one and at first sight there seems to be no sewage problem. There is 8 feddan of land available for agriculture not far away from the targeted location for the WWTP. The land still needs preparation (rubbish collection, stones, and sludge) and is near a graveyard (1 in photo 3).

Household water is discharged to latrine pits (infiltration tanks) of up to 5 m deep. The tanks function in the higher sandy area of the village (2 in photo 3), where it is necessary to empty them once a year. They do not function in the lower clayey area (3 in photo 3). In this part of the village, the groundwater level is 20 m deep, but the latrine pits are full every 20 days and need to be emptied then (30LE per event). The wall in the basement of the house, close to the infiltration tank also becomes wet by the waste water (4 in photo 3).

The latrine pits were designed as infiltration tanks. Better functioning is expected when they are designed as septic tanks.


1. Potential area for reuse


2. A well-functioning infiltration tank in the higher sandy area


3. A not functioning infiltration in the low clayey area


Wetting of the wall in the basement by waste water

Photo 3 *Waste water in Deir Abu Hinnis*

4.1.3 EL-Shaikh Masoud (07-06-2014)

Number of inhabitants 30,000. High groundwater table (1.5 m). Therefore emptying infiltration tanks is needed every 10 to 20 days (1 in photo 4). Costs are LE 120. At the Governmental building less frequent emptying is necessary, but there use is made of a two tank construction instead of one tank. Distance to Nile 25 km. Distance to desert (empty land for reuse wastewater 5 km; elevation 2 m

above current place. On the road to New EL-Shaikh Masoud near the desert road we saw shortage of water/fallow land and a potential area for reuse (2 in photo 4). Is reuse closer to the village possible? Groundwater was mentioned to have high salinity.
New Sheikh Masoud: 65 houses built for young graduates (3 in photo 4), which are connected to sewage system and potential septic tank. The design of the tank needs improvements 4 in photo 4). Young graduates will receive 5 feddans of new land each. It will take more than one year to start a pilot on this place.


1. A not functioning infiltration tank.


2. Potential area for reuse.


3. New Sheikh Masoud.


Septic tank (not well designed) to receive waste water of New Sheikh Masoud.

Photo 4 *Waste water in EL-Shaikh Masoud*

4.1.4 Sharona (07-06-20114)

Number of inhabitants is 35,000 to 40,000. Also this village does not have a sewer system. Infiltration tanks are used for the waste water. These are not functioning in the older part of the village due to a high water table (-20 cm) (1 in photo 5). The tanks are even filled by the groundwater. The high water table is also visible in the walls of the houses (2 in photo 5). This high water table is probably caused by the irrigation channel (3 in photo 5). In the rural area these channels are surrounded by clay and will not have a high impact on the groundwater. In this village it is surrounded by so called urban soil, which consists of the original clayey soil mixed with stones and other materials. Such a soil is more permeable for water, which will result in a high water table. In this village a better design of the infiltration tanks is not expected to be of benefit. First a solution must be found for the high groundwater level.

Outside the village 2380 feddan is available for reuse (4 in photo 5). This soil is silt and looks suitable for agriculture. Salt is present, but at 100 m also groundwater of good quality is available. Local people present, stressed the importance of safe crops.


1. A not functioning infiltration tank


2. Wet walls caused by the high groundwater level.


3. High water table in irrigation channel


4. Potential available area

Photo 5 *Waste water in Sharona.*

4.1.5 New Minya WWTP (07-06-2014)

On the way to EL-Shaikh Masoud we visited the new WWTP for Minya City in the middle of the desert (some 40 km north –west of Minya city). About 80,000 $m^3$of water is to be treated here on daily basis. The Engineering Company is responsible for finding a private sector to use the water in forestation on an area of 2,500 feddan to be provided by HCWW (1 in photo 6). The soil is good, fine sandy, suitable for potato growing. We visited a small farmer nearby, at the other site of the road (2 in photo 6). Groundwater at 50 meter deep, filter at 120 m. Salinity 1200 mS/m. He was growing tomatoes as a cash crop until the grape trees were large enough. He told that he would take the wastewater for fertilisation (alternating) if he could get it. Water is supplied by drip irrigation and sprinkling.

1. Potential area for reuse

2. Small farmer at close to the potential area

Photo 6 *Reuse area near new Minya WWTP.*

4.1.6 Emptying of infiltration tanks in villages

All villages visited, with the exception of Deir Gabal El-Tair had no sewer system. Trucks with tanks (1 in photo 7) are used to transport the waste from the infiltration tanks to outside the village. Dumping however is not controlled and can be even very close to a village (2 in photo 7), which is not a desired situation.

3. Truck with tank for transport of waste water (Sharona).

4. Dumping of waste water at the boarder of a village

Photo 7 *Transport and dumping of waste water*

4.2 Selection of the pilot

The pilot has been selected based on the criteria mentioned in chapter 2: 1) cheap cleaning technology, 2) quick start, 3) covering whole village. We added 4) possibilities for reuse, because this is one of the goals of this project. The scores for each site are given in table 5.

Table 5

Scoring of selected sites regarding criteria

Criteria	Deir Gabal El-Tair	Deir Abu Hinnis	EL-Shaikh Masoud	Sharona	Minya WWTP
Cheap cleaning technology	++	+	+	+	0
Quick start	++	0	0	0	++
Covering whole village	+	0	0	0	-
Possibilities for reuse	+	+	+	+	++
Total score	6	2	2	2	4

++ Easy to fulfil criteria

+ Possible to fulfil criteria

0 Not possible to fulfil criteria

- Not applicable for site

Important in the evaluation was the absence of a sewer system in Deir Abu Hinnis, EL-Shaikh Masoud and Sharona. This will not make it possible to start a pilot on the short term that will cover the whole village. All three villages have therefore a low score. Deir Gabal El-Tair has the highest score and is therefore selected for the pilot. In this village reuse of waste water will be possible, but did not get the highest score.

The highest score for reuse is near the Minya waste water treatment plant. This is however not a waste water from a village, it is coming from a town. We also expect that it will not take too long to have the plant working. It is a complete water treatment plan and cannot be considered as cheap technology. In spite of this, the site received the second height score. It can be considered as a site for demonstration of the applicability of waste water. This is further described in chapter 8.

During the investigation we experienced that there can be more reasons to select a village. An extra important reason to select Deir Gebel El-Teir was the presence of the Monastery included the cave where the Holy family has stayed. The village is constructed over a limestone formations called Minya Formation (Early Eocene, about 93 m) at the base and Samalut Formation (Middle Eocene, about 25 m) at the top. Both formations are characterized by presence of subsurface hidden sinkholes and caves. When water enters these weakness planes it lubricates them and facilitates the movements of rock mass. The effect of waste water is even stronger. This is not only theoretical, it happens also in real practise. In 2008, part of a limestone plateau in Cairo (Manshiyet Nasron) did fall down, causing 90 casualties (Photo 8). Main reason of the rock slide was destabilization of lime stone by absence of a sewer system and infiltration of waste water.

Photo 8 *Egyptians search for survivors under the rubble of homes at the site of a massive rock slide off (Aljazeera).*

Recognizing the extra reasons, we defined these as threat for health, and of national importance. These were both high in Deir Gabal El-Tair and confirms the selection. The criterion health was also high in Sharona, especially in the area with a high water table. A higher health risk was also present in clay areas, where the infiltration tanks had to be emptied frequently.

5 Field site investigations (26/06/2014) Deir Gabal El-Tair Village

Field survey has included GPS survey for geographic location; soil and water sampling, socioeconomic survey as well as other field measurements for environmental parameters. Laboratory and office work has included analysis of soil and water samples and projection of field data on satellite images. Soil and water analyses were done at both Minya Water and Wastewater Company and Suez Canal University laboratories.

5.1 The pilot activity site

The following description for the pilot project site is derived mainly from field site investigations (26-28/06/2014) Deir Gabal El-Tair Village, Samulat and El-Minya governorate. It stands on the east bank of the Nile some fourty kilometres north of the Minya Bridge in Middle Egypt and just east of the city of Samalut. The residential area is mainly aggregated around Deir al-Adhra (The Monastery of the Virgin) (Fig. 12). A simple nineteenth-century edifice encloses a rock-hewn church, reputedly founded in 328 by Helena, mother of the Byzantine emperor Constantine. Its sanctity derives from a tiny cave where the Holy Family is believed to have hidden for three days. The church receives nearly two million pilgrims during the week-long Feast of the Assumption, fourty days after the Coptic Easter. According to village residents and our survey; the village has about 2000 houses of average population, which means a population of 10,000. Other numbers for population count was also given before (5823 inhabitants). Considering average population of about 8000 we expect wastewater of about 1080 m^3/day (based on drinking water consumption (150 l/capita multiplied by 0.9 factor). According to the priest there are about 15,000 inhabitants. This order of magnitude will also be obtained having in mind that part of the houses is occupied by extended families. With 15,000 inhabitants 2040 m^3 of waste water will be produced. Population growth rate will be used (we may use average value for El-Minya governorate that is +2.33%/year) to predict future design capacity.

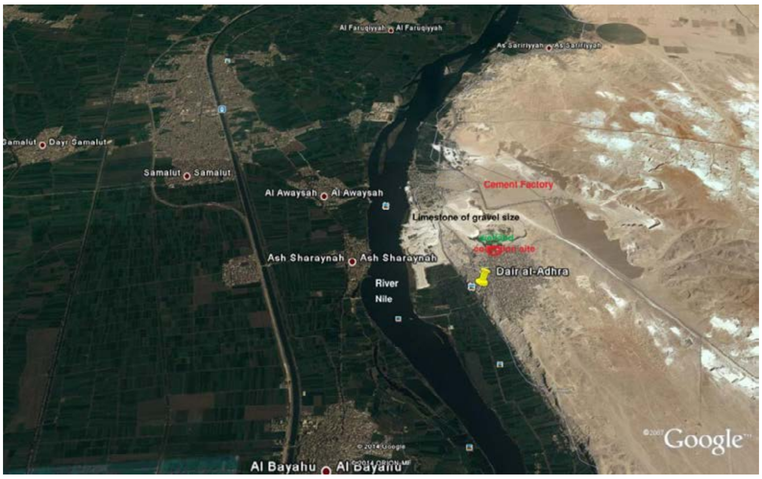

Figure 12 *Satellite image shows the landscape of Deir Gabal El-Tair Village (Deir al-Adhra).*

5.2 Sewage disposal system

The existing system made by local people depends on pits and primitive collection sewers (not pipes but built drains, excavated in limestone, sealed and covered) discharging into collection lake and then seeps into waterfalls that leads to wetland and weeds. We have observed separation at homes level between black water and grey water but when topography is suitable they mix both and discharge them into collection sewers (Photo 8 and 9).

Photo 8 *Left: Team identifying the sewage disposal system from bathrooms, toilets (solid waste and black water), kitchen, taps and other grey water (they have observed separation at large scale) Right: Pits for collection of solid waste and black water (discharged by cars once per year).*

Photo 9 *Left: Main collecting sewer (mostly for grey water and black water is partially mixed). It is excavated and built with limestone bricks, covered and extends along main road of the village, it drains by gravity into lake, waterfall and wetland.*
Right: Main collecting sewer before discharge into lake.

The collection lake is excavated in fractured limestone and then discharges through waterfall into wetland covered by natural weeds (photo 10 and 11).

Photo 10 *Left: Lake excavated shallow in upper weathered soil.*
Middle: Parts of the lake is dug relatively deep in fractured limestone.
Right: Water fall and wetland weeds (the last stage of the already existing system).

Photo 11 *Satellite image shows current collection site, wetland and potential land for reuse project.*

5.3 Sewers Discharge

We have observed and delineated **five primitive sewers** discharge directly into the collection lake and swamps. We have measured discharge at three of them (Q= V. A) and estimated the other small ones (table 6).

Table 6

Estimation of sewers discharge drain into collection site

Sewers Description	1 Relatively small	2 Strong and collects one of the main roads in the village	3 small	4 It is the widest and receives from two sewers	5 Small
Velocity (V) m/s		0.438		0.4	0.36
Cross sectional area (A) m^2		0.025		0.012	0.003
Discharge* (Q) m^3/day	**144**	**946**	**192**	**415** (from one side) and about **240** is estimated from the other side	**93**
Total discharge (Q) m^3/day			**2030**		

*Discharge is calculated when A & V are cited otherwise is estimated

The amount of 2030 m^3 is very close to the amount predicted based on 15,000 inhabitants (see 5.1). We have observed that the discharge is much less than what we saw during our first visit 6-9 June 2014 (it was just few days after the mass gathering during the holy week of visitors to the historical Monastery constructed on the limestone cliff. They have mentioned that about 2 million visitors come to the Monastery in one week annually (last week of May and first week of June 2014).

5.4 Wastewater quality

Four water samples representing different stages of the current situation for sewage collection and disposal were investigated. We have used the Field Guide to Water Quality Assessment and Monitoring in Middle Eastern and Northern African countries prepared by Magdy A. Salah El-Deen and Joop Harmsen (2006) to make qualitative assessment for water quality.
Moreover, WTW multi 350i device is used for field measurements (Photo 12) of electric conductivity (EC micro S/cm), pH, dissolved oxygen (O_2 mg/l) and temperature (T °C). We have managed to send four samples to El-Minya company central laboratory for detail wastewater quality analysis and have asked laboratory staff to provide average analysis for raw sewage in cities and villages in the last six months. The results are shown in tables 7 and 8.

Table 7

Wastewater quality indicators for samples representing different stages of the current situation for sewage collection and disposal at Deir Gabal El-Tair

Sample	 Sample 1	 Sample 2	 Sample 3	 Sample 4
Site and source	From strong sewer drain discharging into collection lake and swamp	Just before water fall on limestone cliff	Below wetland weeds	From shallow drilled borehole in weather layer of limestone just at the end of wet land (sample is white due to dissolved lime just drilled without filter)
Colour	Range from slightly coloured to brown	Slightly coloured	Yellow	White
Turbidity	Turbid	Turbid	Clear	Not clear
Mud particles	Bottom slightly covered	Not present	Not present	Solid lime residual
Smell	Smell not rotten eggs	Slight not rotten eggs	No smell	No smell
EC micro S/cm	787	807	877 & 881	1174
O2 mg/l	0.4	2.13	5.3	0.91
pH	7.3	7.27	7.66	7.13
Temp. C^0	27.6	31.1	28.5	Not measured
COD mg/l	380	220	150	135
BOD mg/l	320	140	110	90
TSS mg/l	220	150	100	270

Table 8

The average wastewater quality indicators at some wastewater treatment plants at El-Minya (for the period from 1/01/2014 to 1/06/2014

Plant	BOD mg/l		COD mg/l		TSS mg/l	
	In	Out	In	Out	In	Out
El_Adowa	285	55			240	44
Maghagha	480	28	600	43	310	28
Bani Mazar	340	33			350	40
Abou Qurkas	269	39	450	55	325	36
Malway	260	35			450	48

Photo 12 *Sample taken from wetland below weeds and measuring field parameters using WTW multi 350i device (EC, pH, dissolved oxygen and temperature).*

5.5 Geotechnical investigations, potential risk & soil type

We have used a hand auger to drill the weathered layer of limestone that constitutes the bed rock at the site. The white limestone is widespread in the study area with intercalation of brown dolomite. Both are fractured with different densities and directions. Gebel El-Teir Monastery is constructed over Limestone plateau that consists of two Formations called Minya Formation (Early Eocene, about 93 m) at the base and Samalut Formation (Middle Eocene, about 25 m) at the top (Said 1962; Geology of Egypt). Both Formations are characterized by presence of subsurface hidden sinkholes and caves. When water enters these weakness planes it lubricates them and facilitate the movements of rock mass. Collapse of terminal parts of the plateau is considered potential risk to important and unique historical and holy site “Deir al-Adhra”. The Monastery of the Virgin (Deir al-Adhra) sanctity derives from a tiny cave where the Holy Family is believed to have hidden for three days and which now contains an icon of the Virgin credited with miraculous powers.
El Minya Formation is composed of white hard cavernous and fossil ferrous limestone and chalk intercalated with thin beds of sandy, cherty and clayey limestone. El Minya Formation is conformably overlain by Samalut Formation which is composed of snow white moderately hard cavernous, fossil ferrous limestone. These two Middle Eocene units are characterized by karst geomorphology of shallow and deep caves, open fractures and connected old drainage channels (Photo 13). Most of site observed caves and sinkholes are controlled by the major faults and master joints oriented NW –SE (Abdeltawab *et al.* 1991, Abdel-tawab, 1994 and Abdel-Meguid *et al.*1998).
Solution features including midget caves are common in the limestone of the middle latitudes of Egypt (Said 1954). El Aref & Refai (1987) show that the carbonate country rocks exhibit surface solution features, surface to subsurface solution features and subsurface solution features (opening and cavities). The Karst geomorphology is a distinctive terrain developed on soluble rocks (carbonates and evaporites) with landforms related to efficient underground drainage. Disrupted surface drainage, sinkholes and caves, open fractures and pinnacles are the main diagnostic features that characterize these types of landforms. The geometrically complex natural cave passages create uniquely difficult ground conditions for civil engineering (Sowers, 1996 and Waltham *et al.*, 2003).

Photo 13 *At the base of the fractured shallow layer of limestone water stands.*

The hand auger drilling (Photo 14) has found the bedrock at shallow depth about 30 cm below the soil zone (weathered limestone). Three soil samples are collected distributed from surface to bedrock (one sample every 10 cm). The upper layer soil samples is yellow covered by algae residual and the other two samples have a white colour and different size of limestone residuals. Water has appeared in our borehole that is drilled about 1-meter away from wetland bank; probably it has seeped through fractures from the area below the weeds to our boreholes. Results of soil samples at the wetland area are shown in table 9.

Table 9
Soil analysis at the wetland area of the current sewage disposal site

Sr. No.	%CaCO3	Gravel size	EC dSm-1	pH	Cations meq/l				Anions meq/l			
					Ca	Mg	Na	K	Cl	HCO3	SO4	CO2
Surface	75.3	61.1	2.03	7.86	5	4	11	1	12.5	1	7.5	0
Sub Surface	95.9	66.6	0.323	8.25	1.5	1	0.5	0.3	1.5	0.5	0.3	1



Photo 14 *Hand auger drilling and collection of soil samples*

5.6 Quarries and availability of natural materials

The area is known for its limestone quarries and cement industry. In the closest vicinity of the wetland there are huge amounts of limestone of gravel size (Photo 15). These are by-products from the nearby cement factory Using these materials could reduce cost of treatment (for example material for filtration beds).

 

Photo 15 *Left: huge natural materials (Limestone of gravel size)*
Right: White colour patches refer to the distribution of limestone quarries in the close vicinity of the site

5.7 Questionnaire

Colleagues from Minya Company for Water and Wastewater did their routine survey accompanied with directive questions related to the project. The questionnaire done for scatter sample represent about 100 homes at Deir Gabal El-Tair Village, out of about 2000 homes. Analyses of these data were done by Minya company public awareness sector (table 10 & Annex 2). According to preliminary statistics for questionnaire they found that about 85% of village houses have pits for collection of solid waste and black water while 15% mix all and discharge direct to collection sewers. The conservative people (according to their location and/or commitment to separation of grey and black from source) have mentioned that they discharge their black water by cars either twice per month (80%) or once per month (20%).

All the interviewed people have mentioned that they are suffering from the widespread presence of mosquitoes and offensive smell (odour). They have rendered all their health problems to poor sanitation. They have problems to clean their streets from discharge of open and partly covered sewer system. Moreover they have observed severe impact of poor sewage disposal on surrounding environment and residential areas. Poor people of moderate houses are complaining from dissolution of their homes foundations.

Table 10
Result of Minya Company Questionnaire at Deir Gabal El-Tair Village

Sewage disposal into cesspits		Sewage disposal direct into sewers
85%		15%
frequency of cesspits discharge		
Once per month	Twice per month	
20%	80%	
One Truck tank discharge costs		
50 LE		

5.8 Elevationmap

For the design of sewer system and the waste water treatment it is important to have an elevation map of the village. This map is presented in figure 13. In addition an air photo is given in figure 14 which makes it easy to recognize the different sites in the village.

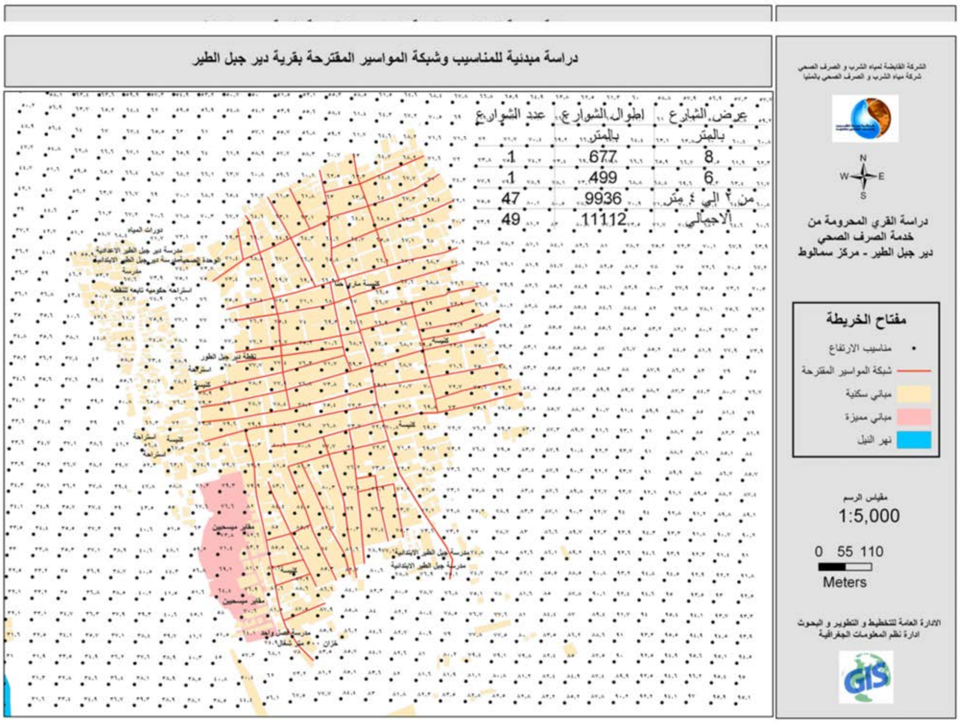

Figure 13 *Elevation map of Deir Gabal El-Tair.*

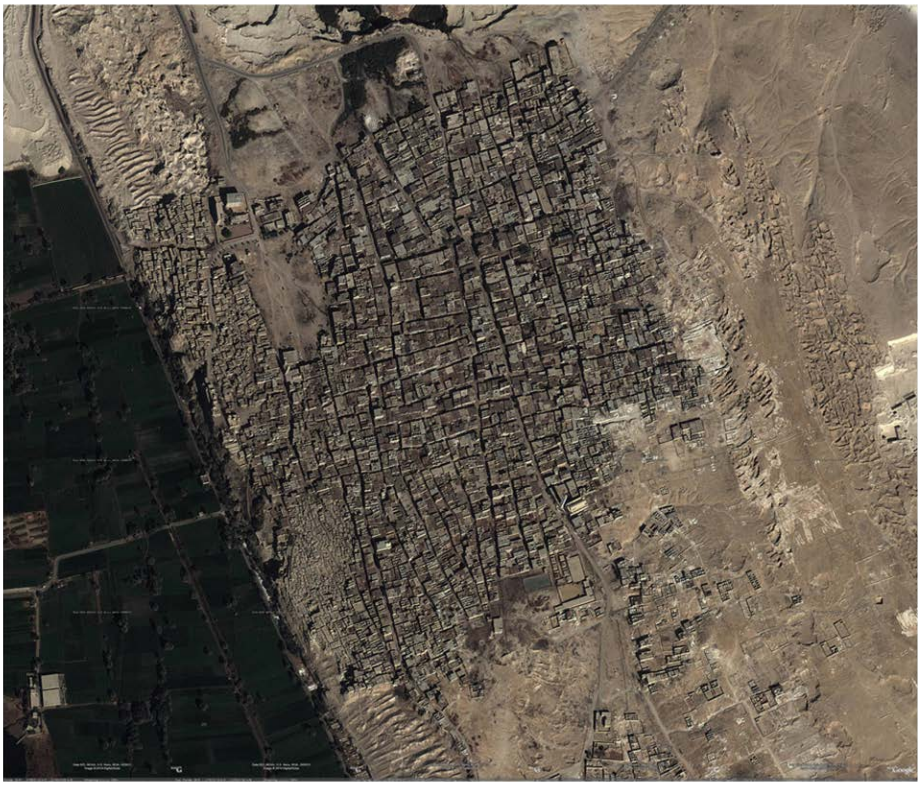

Figure 14 *Air photo of Deir Gabal El-Tair.*

5.9 Conclusion of the pilot investigation

We have documented all site investigations steps, running questionnaire, landscape, residential area, historical sites, current sewage disposal system etc.
The village is endangered by serious environmental pollution caused by discharging of raw sewage to open basins near residential area. There are many mosquitoes and other insects. The collection site produces offensive smells. Moreover, leaks from sewage system into cavernous limestone may cause serious problems such as mass wasting and collapse of historical and religious site. It is suggested to construct a wastewater treatment unit at the selected village making use of local conditions like the wetland present (Photo 15). The selected area is urgently in need of a safe sanitation system. However, an improvement to internal sewage network, connecting all buildings to the final point will be constructed through villager's participation. The local community has important role in such projects. In addition, land is available nearby the proposed site for wastewater reuse in agriculture.

Photo 15 *The wetland is grown on shallow soil weathered from limestone country rock in the background of the photo.*

6 Applicability of waste water

6.1 Egyptian Code for the Reuse of treated Wastewater in Agriculture

The Ministry of Housing, Utilities, and New Communities, supported by seven technical committees, issued the Code for the Reuse of Treated Wastewater in Agriculture (hereafter, "the Code"). The Code stipulates exact requirements in planning and approval procedures, responsibilities, permitted use according to effluent quality, and monitoring. The Code regulates only the direct use of wastewater, not the wastewater discharged into drains. According to the Code, the reuse of treated wastewater—irrespective of the treatment level—is prohibited for the production of vegetables, whether eaten raw or cooked; export-oriented crops (i.e. cotton, rice, onions, potatoes, and medicinal and aromatic plants); as well as citrus fruit trees; and irrigating school gardens.

Restrictions are in place for type of crops, irrigation methods, and health precautions. The existing reuse schemes are operated by public institutions, mainly ministries such as the Ministry of Housing, Utilities, and New Communities, MALR, and MSEA. Plants and crops irrigated with treated wastewater are classified into four agricultural crop groups that correspond to four different levels of wastewater treatment. Biological and chemical standards for these three levels of treatment are set as well. The Code further stipulates conditions for irrigation methods and health protection measures for farm workers, consumers, and those living on neighbouring farms.

The Egyptian code for wastewater reuse (WWR) (no.501 /2005) is revised due to the presence of too many restrictions comparing to WWR codes of other countries. According to the old code, no edible crops or export crops can be cultivated and irrigated on wastewater, regardless of the treatment level. About 40,000 hectares are available for WWR projects in different governorates in Egypt. The information in this chapter is obtained from the New Egyptian Code for Wastewater Reuse, 2014-Final Draft (personnel communication with Prof. *Rifaat Abdel Wahaab*; code committee member)

6.2 Degree of treatment permitted for agricultural use

By comparing the degree of treatment of both 2005 & 2014 code we found that in the old code there are three grades A, B, and C while in the new code there are four grades A, B, C, D (tables 10 and 11). There are no significant changes regarding irrigation methods; health protection against direct exposure to wastewater; institutional aspects relevant to the application of code and self-monitoring, inspection, corrective actions.

Table 10

Degree of treatment permitted for agricultural use (WWR Code 2005)

Requirements & Max. Limitations		Degree of Treatment		
		Grade A	Grade B	Grade C
Physical & Chemical Standards	TSS	20	60	250
	Turbidity, (NTU)	Undefined	Undefined	Undefined
	BOD5	20	50	400
Pathogens Standards	F. Coliforms MPN/100 ml	1000	5000	Undefined
	Intestinal nematodes/liter	1	1	Undefined

Table 11

Degree of treatment permitted for agricultural use (modified code 2014)

Requirements & Max. Limitations		Degree of Treatment			
		Grade A	Grade B	Grade C	Grade D
Physical & Chemical Standards	TSS	10	30	50	300
	Turbidity, (NTU)	5	Undefined	Undefined	Undefined
	BOD5	10	30	60	350
Pathogens Standards	F. Coliforms MPN/100 ml	100	1000	5000	Undefined
	Intestinal Nematodes Egg/liter	1	1	1	Undefined

The WWR Code 2014 gives possibilities to produce a specific grade of irrigation.

Grade (A)

- The *code allows* production of treated wastewater of Grade (A) in the treatment plant site only, or through doing additional treatment on the agriculture site.
- This *code allows* producing water grade (A) by mixing fresh water to grade (B) with suitable quality in case it is available.

Grade (B)

- The *code allows* producing water grade (B) through doing additional treatment for Grade (C).
- The code *does not allow* upgrading wastewater grade (C) to wastewater grade (B) through adding fresh water.

The WWR Code 2014 also gives limitations in using treated wastewater for specific plantation.

- The *code prohibited* to use treated wastewater -whatever the level of treatment is – in irrigating vegetable crops eaten raw.
- The *code prohibited* to use treated wastewater grade D in irrigating any food crops (vegetables, field crops, all types of fruits and medicinal plants).
- The *code prohibited* to use treated wastewater grades B, C, D, in irrigating green landscapes and educations establishments as well as public and private parks.

A List of plants and crops permitted for irrigation by treated wastewater is summarized in table 12**.**

Table 12

Plants and crops permitted for irrigation by treated wastewater

Grade of Treatment	Agricultural Group	Description
A (One Group)	Group 1-1: Green landscapes in Educational establishments, public and private parks المسطحات الخضراء للمنشآت التعليمية والمتنزهات العامة والخاصة	All types of grass and fence plants and all kinds of flowers النجيل بكافة أنواعه ونباتات السور والزهور بجميع أنواعها
B (3 Groups)	Group 2-1 Dry grains crops, cooked & processed vegetables	All Kinds of Vegetables (manufactured) and strategic dry crops of all types such as wheat - corn - barley - rice - beans - lentils – sesame القمح – الذرة- الشعير – الأرز – الفول – العدس – السمسم .
	Group 2-2: Fruit Crops	Fruit trees with sustained and deciduous leaves such as: citrus fruits - olive - palm - mango - pecan - pomegranate for the purpose of drying الموالح – الزيتون – النخيل – المانجو – الرمان بغرض التجفيف
	Group 2-3: Medicinal Plants	Anise - hibiscus - Cummins - Marjoram - Ammi - Fenugreek - moat - fennel - Chamomile – sage herb الينسون – الكركاديه – الكمون – البردقوش – الخلة – الحلبة – المغات – الشمر – البابونج - المرمرية
C	Group 3-4 Roses and Cut flowers	Roses farmyard – Rosa Canina - bulbs such as Algeladiols, bird of paradise and all kinds of ornamental plants. الورد البلدى – ورد النسر – مجموعة الأبصال مثل الجلاديولس وعصفور الجنة وكافة أنواع نباتات الزينة.
	Group 3-5 Trees suitable for planting in highways and green belts	Alcazurina - camphor - oleander - tamarisk - types of ornamental palms. الكازورينا – الكافور – الدفلة – الأثل – أنواع نخيل، الزينة
	Group 3-6 All types of fiber crops	Such as cotton - linen - Jute - kenaf. القطن – الكتان – الجوت – التيل.
	Group 3-7: Grassy forage crops and leguminous crops	Sorghum types and kinds of shamrock أنواع السورجم وأنواع النفل.
	Group 3-8 Mulberry to produce silkworm silk	All kinds of Berries جميع أصناف التوت
	Group 3-9 All plants and ornamental trees nurseries	Such as Ficus décor - Ficus Natda - Ambassndr – Acacia مثل الفيكس ديكورا – الفيكس نيتدا – السفندر – الأكاسيا
D (3 groups)	Group 4-1 Solid biomass crops	All crops for the production of bio-diesel fuel and energy oils such as: soybean - rapeseed - Jojoba - and Jatropha - Castor. فول الصويا –بذور اللفت – الجوجوبا –والجاتروفا – الخروع.
	Group 4-2 Crops to produce cellulose	All non-food crops for the production of glucose and its derivatives like ethanol and acetic acid - ethanol – Generation جميع المحاصيل غير الغذائية لإنتاج الجلوكوز ومشتقاته كالإيثانول وحمض الخليك – الإيثانول - الجيل
	Group 4-3 Timber trees	All trees for timber production such as Alcaaa - camphor - and mahogany جميع الأشجار لإنتاج الأخشاب مثل الكايا – الكافور - والماهونجى

According to the Code, the following irrigation methods are permitted when using treated wastewater:

- Flood irrigation (furrow irrigation), wetting almost all the soil surface;
- Basin irrigation, using irrigation pipes to deliver water to the basins;
- Strip irrigation, where water covers only part of the soil surface;
- Drip irrigation, which ensures the least contact of the treated municipal wastewater with the irrigated plants and the agricultural labourers;
- Sub-surface irrigation, which minimizes contact with the treated municipal wastewater used in irrigation;
- Pressurized irrigation, which is controlled by valves regulating the flow of treated municipal wastewater;
- Pop-up sprinklers, characterized by low pressure and high discharge at an angle of 11° with the horizontal plane.

The Code describes health and safety measures (article 7) to reduce public hazards related to water reuse in agriculture and recognizes five target groups:

1. Farm workers.
2. Harvesters and processors (workers) .
3. Consumers.
4. Public and other users of open spaces and gardens.
5. Passers-by and residents who live near the reuse sites.

The Code has defined mandatory safety measures for farm workers and harvesters.

Table 8 in 5.4 has shown the composition of waste water in several cities (or villages) and the quality of the water after treatment. Comparing this with the Egyptian code, the quality is grade C and sometimes grade B. With simple treatment it is possible that the value is higher and may become B. In the pilot we have also measured the quality on different places in the existing situation. Results are given in table 7 in 5.4. As expected the present situation, the not optimized natural treatment is less effective. Improving this situation as described in chapter 7 is expected to give a better quality, probably grade B.

7 The pilot in Deir Gabal El-Tair

7.1 The choice between new and existing technology

In preparing a pilot it is important to take new developments into consideration. The water sanitation of the future may differ from the present situation. In recently developed concepts, the whole content (nutrients, energy and water) in the waste water can be reused. It is also possible to limit to the nutrient and water cycle as presented in figure 15. These approaches can be considered as a challenge for Egypt. However, it needs introduction of separation toilets and a complete separation between waste streams from toilets and kitchen + washing. Experiences show that this is possible in individual houses or groups of houses in combination with highly motivated inhabitants. On the scale of a village this approach cannot be considered yet as proven technology. Although it is challenging, we do not expect that the ideas presented in figure 15 can be part of the plot to be started on the short term.

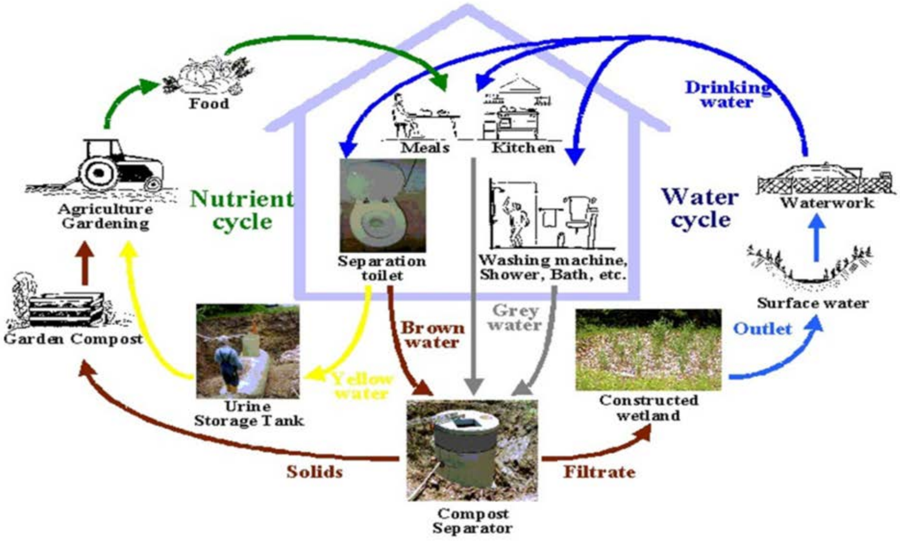

Figure 15 *Closing the nutrient and water cycle*

With the pilot we have following objectives:
- No infiltration of water into the limestone below the whole village;
- Cleaning of the waste water from the whole village using the local possibilities;
- Reuse of the cleaned water.

We expect that the pilot can be started soon, but a certain phasing is acquired to be able to include the whole village.

7.2 Effect of the festival on waste water discharge

The end of May, pilgrims are coming to Deir Gabal El-Tair to celebrate the stay of the Holy Family. In this week it is very crowded in the village (See photo 16). Estimations of 2 million visitors have been made. This will give a peak in the discharge of wastewater. We decided to treat this peak as a separate discharge and not to include it in the design of the treatment. In statistical terms it can be considered as an outlier and belonging to another population.

It is very difficult to give a proper estimate of the amount of wastewater produced. Parts of the visitors are only staying for several hours and will not produce waste water. People staying longer or overnight will produce waste water, but it is unclear if this is produced in the village or outside the village[1].

Photo 16 *During the festival it is extremely crowded in the village.*

7.3 The concept

For the treatment of waste water we will make use of the local natural system and locally available materials 1) the difference in elevation in de wadi and 2) the natural wetlands already present in the wadi. Doing this, costs will be saved, which increases the possibility to solve the waste water problem in Deir Gabal El-Tair. Our design will be according the 80/20 rule, simple and cheap. It is a pitfall to improve the treatment options. Instead of an investment of 20% this will lead to 100% investment, which is not within the scope of this project. It may also result in a return to the assessment circle as shown in figure 4.

We will build a construction to separate the waste water into a liquid and solid phase (sludge). The sludge will be used as a resource for compost and the liquid phase will be transferred to a trickling (stone) filter (new construction). At the end of the wetland the water can be reused (figure 15). Probably by a collection well on a strategic place to pump the upper part of the groundwater, which will consists of infiltrated treated waste water.

[1] It is uncertain how large the peak of discharge is during the festival. We advise HCWW to investigate this during next festival.
Question to be answered are:
- How many people are present. Counting on specific places and times and multiply by available surface
- How many people use the toilet and for what. And how often
- Do they use a toilet in the village or are they going to the desert

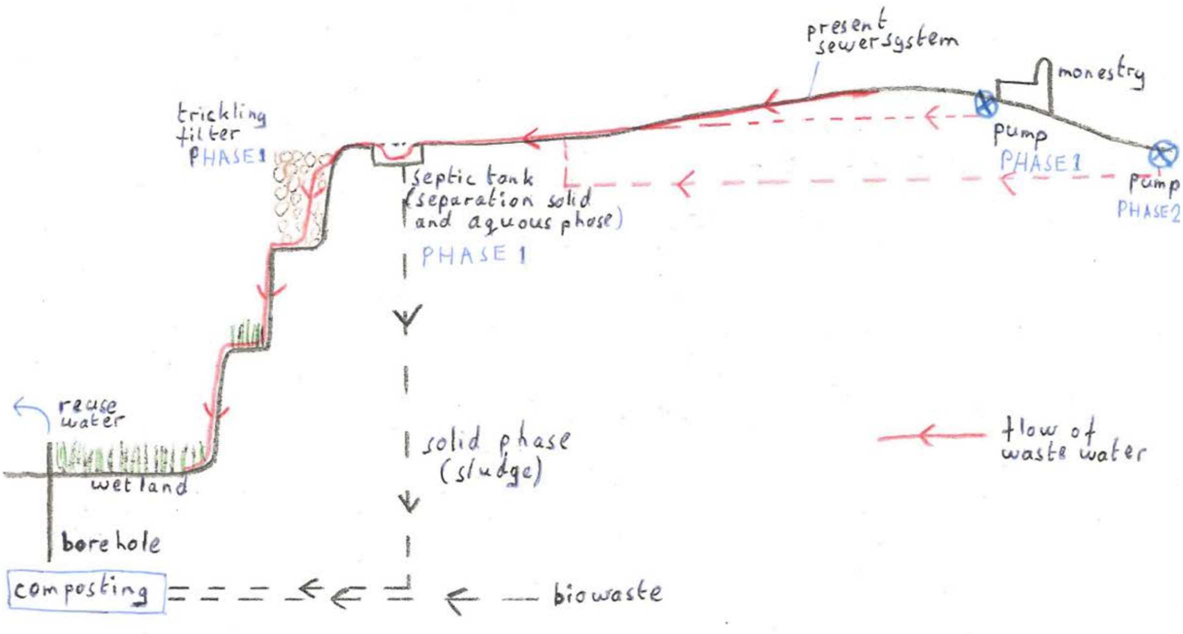

Figure 15 *Impression of the waste water treatment in Deir Gabal El-Tair.*

We will start with the wastewater leaving the village at the north side combined with the wastewater from the surrounding of the monastery, which is now discharged at the cliff. HCWW will build a small pumping station to do this. The amount of waste water is about 1000 m^3 per day. For the parts of the village discharging waste water to the east and west other pumping station will be added in phase 2.

After phase two all water discharged by the present sewer system can be cleaned and reused. However this system will leak and black water and waste is still present in storage system in the village. These systems are also leaking. In phase three it will be necessary to replace the present sewer by a new non leaking system.

As mentioned already, three phases can be distinguished

Phase 1.
- Construction of the separation tank;
- Construction of trickling filter;
- Building of pump station for water around monastery;
- Starting composting facility;
- Defining reuse.

Phase 2
- Building of pump station(s) for other part of the village.

Phase 3
- Renewing sewer system.

Summarized, the following constructions are necessary (see also Figure 16)
1. Non leaking sewer system.
2. Separation of solid and liquid phase in a simple septic tank.
3. Trickling filter based on local materials.
4. The present wetland.
5. Collection well.
6. Land where water is reused.
7. Composting facility.

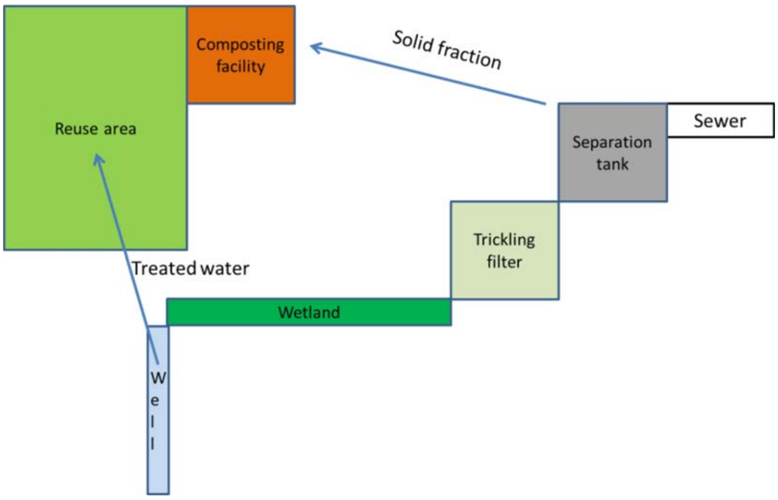

Figure 16 *Schematic view of the components for the treatment of waste water.*

The whole treatment chain will make use of gravity as shown in figure 17.

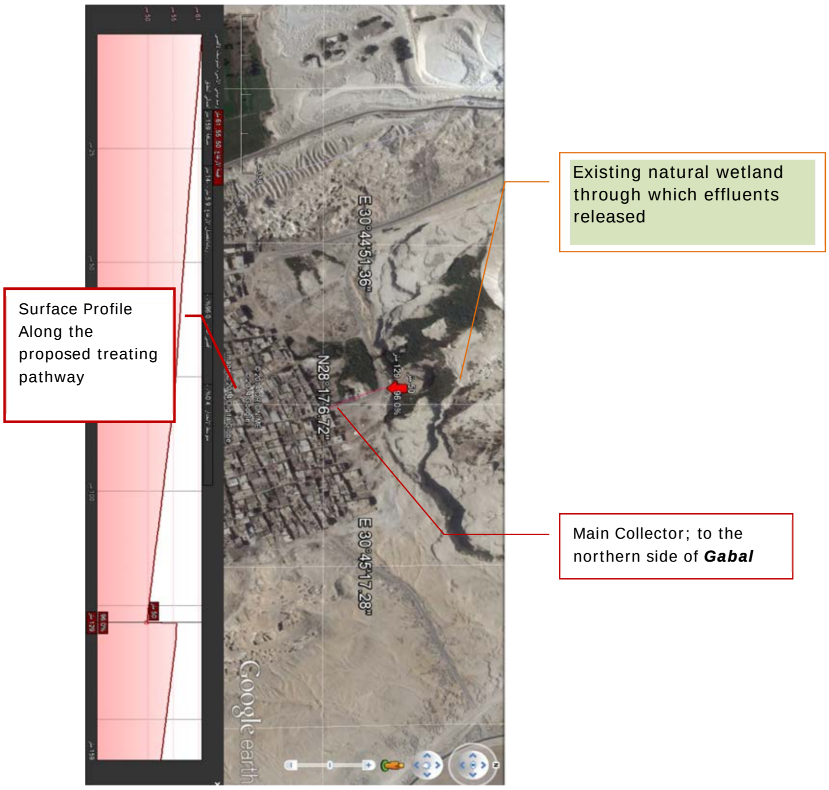

Figure 17 *Surface profile of the treatment site.*

7.3.1 Non leaking sewer system

It will be necessary to replace the present sewer by a non-leaking system to stop infiltration of waste water into the lime stone. This is possible with a tube system or to renovate the existing system by sealing the fractures with sea-cement. Renovation includes closure at the top to reduce the nuisance of mosquitoes. All waste water will be discharged using this sewer system. For houses and streets to be connected to the sewer system we advise to use tubes. To reduce the costs local people can contribute by doing the physical work. This can be considered as a contribution in kind. If inhabitants of the village will be enthusiastic, activities on the sewer system can also start earlier.

7.3.2 Separation of solid and liquid phase in a simple septic tank

There are several designs of septic tanks available. The most optimized ones contain filters and deliver a good quality of water. This goes often together with a high retention time. In our approach the separation tank is followed by the trickling filter and the wetland, which give extra cleaning potential. A high retention time goes together with a large volume of the tank. For instance a retention time of 2 days will ask for a volume of 2000 m3 to treat 1000m3. We have chosen for a retention time of 12 hours, which ask for a tank of 500 m3 on the place where 1000 m3 has to be treated. In dimension this means (l*w* h) 3*3*55m. We think such a tank should not be one piece but may consist of modules of approx. 250 m^3 (see Annex 3). For this place we will need two modules.

Advantage of a modular system is that if necessary, modules can be added. Modules can also be placed near other discharge points followed by pumping of the water phase to the following step in the treatment. Four modules will be necessary on these other places. In figure 18, a schematic scheme is given of a septic tank. The cost of the installation of one septic tank is estimated on LE 65,000. All 6 together will cost LE 390,000.

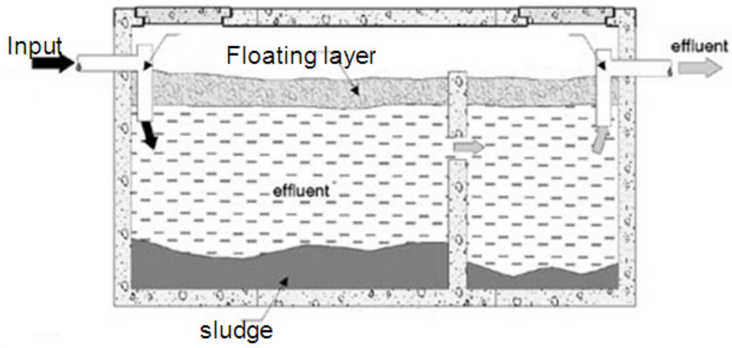

Figure 18 *Schematic presentation of a septic tank.*

7.3.3 Trickling filter based on local materials

In a trickling filter, the waste water passes a stone-like material. The filter is unsaturated, which makes it possible that oxygen from the air will be mixed with the waste water. This stimulates biodegradation and the micro-organism involved will form a film on the stones. Although several forms of manufactured media have been marketed for filters, crushed rock and hollow bricks may form the cheapest most effective ones. We expect that the limestone can also be applied and can be easily replaced. The main advantage, relative to crushed rock, is the high specific surface (m^2/m^3) with a corresponding high percentage of void volume that permits substantial biological slime growth without inhibiting passage of air supply oxygen. Other advantages include a uniform media for better liquid distribution, light facility construction of deeper beds, and the ability to handle high strength and unsettled wastewater. With this development, the term biological tower was introduced. Better results are achieved and greater organic loading can be applied when the beds are deep enough (>3.0 m), as illustrated in figure 19 for construction of a rectangular biological tower. Wastewater is piped to the top of the tower, spread over the packing, and trickles down through the bed. The under flow is conveyed by drains to an effluent channel. These towers allow a greater contact time and the liquid can be applied continuously by fixed distributors instead of by rotating arms. Figure 19 can be used to design the trickling filter In Deir Gabal El-Tair making use of local material. The height can be at about 4.9 m meter. We estimate the costs of such a filter on LE 100,0000. A more detailed description of the filter to treat the waste water in Deir Gabal El-Tair is given in annex 3.

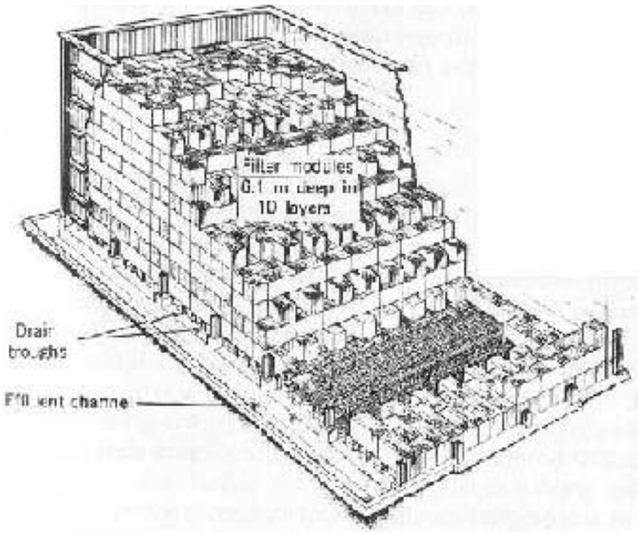

Figure 19 *Schematic drawing of trickling filter.*

In addition to the trickling filters the differences in height will be used to create free fall weirs along the effluents path to permit oxygen into the effluents, to activate and enhance biological reactions

7.3.4 The present wetland

We will make use of the present wetland. We expect that the distribution of the water over the wetland will be improved by the construction of the trickling filter. The water will be distributed over the full area of the wetland. Because the wetland is existing, no costs are involved.

One of the goals of the project is to act as an example for other villages. For water treatment wetlands are often constructed and this will be necessary in a lot of other villages. For instance in the other villages visited in this project no natural wetlands were present. We suggest to use this pilot to create on one of the discharge sites a constructed wetland. This constructed wetland will be used for demonstration purposes. In figure 20 a design of such a constructed wetland is given.

For the proposed demonstration plant a biological reed-gravel basin may be installed (Figure 20). This type of unit, referred to as a roughing filter, improves overall plant efficiency by reducing influent BOD, enhancing settle-ability by pre-aeration and levelling out (absorbing) shock loads.

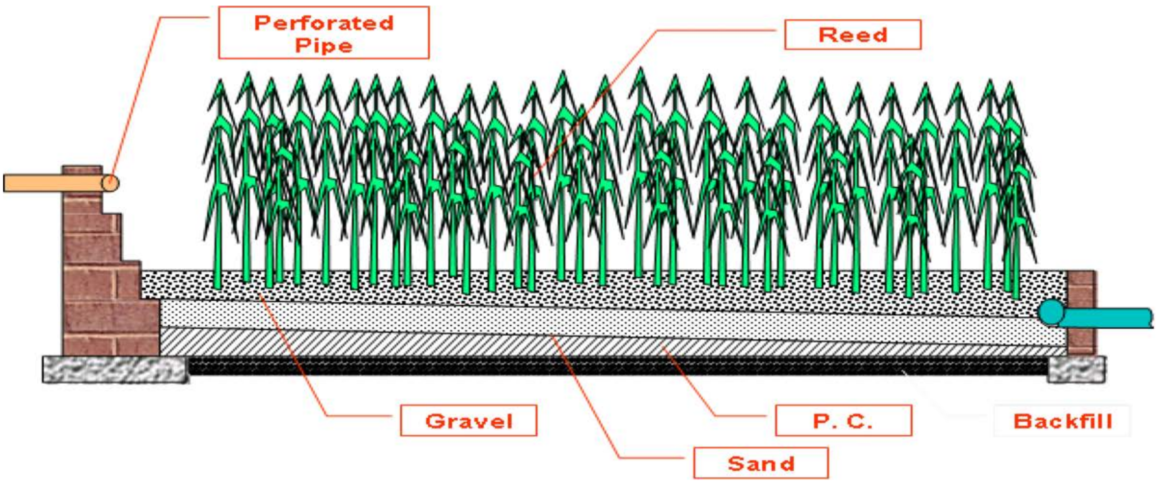

Figure 20 *A constructed wetland.*

7.3.5 Collection well

The waste water is infiltrating in the lime stone and at the end it was necessary to make a bore hole to subtract water. We suggest to make a well to be able to subtract the upper part of the ground water, which consisted of treated waste water. This well must be made on a proper place to be able to extract the proper water. Some hydrological research may be necessary.

7.3.6 Land where water is reused

The reusable land is situated at the east site of the wetland. Agricultural activity can be stimulated on this site

7.3.7 Composting facility

Composting may smell. Such a facility must be realized at some distance of the village. We suggest to do this also at the east side. Water needed for the process can be subtracted from the wells (7.3.5)

7.4 Potential support

Support can be expected from:

- The inhabitants: We will make use of the sewer system constructed by them and their activities to improve the sewer system;
- The Church;
- The factory: The treatment facilities are partly situated on an area belonging to the factory. We expect that based on their social responsibility this land will be made available.
- Ministry of Tourism;
- Ministry of Housing;
- Ministry of Agriculture;
- Ministry of Environment;
- HCWW.

7.5 Managing the peak discharge of the festival

To manage the waste water discharge during the festival we propose to develop a business case for mobile toilets. These are used on festivals all over the world, for instance the Pinkpop in The Netherlands with 60,000 visitors. Festivals are often organized in remote areas and people stay several days. Sanitary installations are not present and are hired for the period at specialized firms. People visiting the festival pay for using the toilet. The firms maintain the toilets during the festival, clean them after the festival and transport them to next festival. There are around 150 festivals in Egypt, so we expect a market.

Figure 21 *Mobile toilet units (Photo van Overbeek).*

Using these toilets the waste water stream during the festival becomes controlled. Waste water produced can be considered as black water (see fig 15) and can be separately treated, for instance anaerobic digestion followed by composting. Also in Egypt we expect that people are willing to pay for visiting these toilets.

The waste water stream is expected to be larger during the festival, because more people will stay in the village and use the toilets in the village. For this amount, we suggest to build an extra storage in the form of extra storage tanks in the form of septic tanks. These tanks can be emptied in the months after the festival, to give again extra storage during the next festival. During our visit, a week after the festival and special during our second field visit, we could not see any decline of the filter and except at the beginning of the filter no smell was present. This shows that the filter was not overloaded during the festival.

8 The pilot at Minya WWTP

The site near the Minya waste water treatment plant was defined as most promising regarding reuse of waste water. Reuse is possible on a large scale. Disadvantage of the site is that it will use waste water of a town and not of a village. However we think that having a pilot on this site is very important to solve the problems of the rural area. We expect that private investors will be interested in this pilot and a quick start of a pilot can be possible. Results can be shown to other interested parties.

Because the waste water treatment plant is very close, we can also use not treated and partly treated waste water to be expected in villages.

With success the approach can be replicated to other sites and translated to the application in villages. With these type of pilots down-scaling will be easier than up-scaling.

The more profitable the crops, the chance of success will be higher. Using the Egyptian Code, it is not allowed to produce high value crops with the water quality we expect. Therefore we propose an alternating use of waste water and groundwater. On the site groundwater of good quality is present. In the period treated waste water is applied a crop mentioned in the Code is used. In general this is a crop with a low value. In this period nutrients present in the waste water are added to the soil. After the harvest pathogens will not be present anymore and organic compounds are degraded or changed into natural organic matter comparable with a situation where manure from animals is used. In following period groundwater is used in combination with a high value crop. The amount of fertilizers used can be smaller because of the accumulation of contaminants in previous period.

Involvement of stakeholders and the economic feasibility is described in chapter 9.3.

9 Economic Evaluation

9.1 Stakeholder involvement

Concerning the financing scheme for Sanitation Projects, we have the following levels:

1. Village level.
2. Town level.
3. National level.

The potential of participation of stakeholders on these three levels have been investigated and positive reactions were obtained. For real participation, this report will have an important function to inform all experts and decision makers involved.

9.2 Deir Gabal El-Tair

There will be in-kind contribution by the villagers themselves. Improving of the sewer system is one of the possibilities. Other local contribution could be through charging the festival's visitors a certain amount of money like what we do on the users of the high ways. This Guest-Fee for the Festival (GFF) can be as little as one pound per guest. For this a by-law, which should be issued by the governor, is necessary. The local contribution is considered as very important for the sustainability of the project.

The church is convinced of the importance of sanitation and has expressed their concern in a letter (see Annex 4) which was addressed to the governor of El Mina. In the letter the church explained the dangers it is facing and the request to pay proper attention to the problem.

Within their Social Corporate Responsibility (SCR), certain local companies like Iron & Steel Company and the Cement Factory will participate financially as part of their attempts to show good will towards the society they are living with.

For Deir Gabal El-Tair, there are national official entities that are ready to participate partly in financing out of their governmental commitments. These entities are the ministry of Tourism, ministry of Environment, ministry of housing and ministry of Agriculture. Each one of them will participate in the finance with a certain percentage. The ministry of tourism has regular international festivals to celebrating the Holly Family trip to Egypt. They are waiting for this report and the final figure so that they can make a decision about their contribution. That applies also for all other three ministries. We can call it "Co-Governmental Finance". The final report will be submitted to them for their contribution.

Through the ministry of Agriculture, some of the small investors can participate on what is called "Barter Deal”. Barter deal stands for mutual benefits; the investor gets the treated water to use in irrigation while the project benefits by getting a certain amount of money based on the amount of treated water.

Composting and reuse of the solid fraction of the waste water is still a point for attention. This needs a facility and logistics for transport of the agricultural biomass and reuse of the produced compost.

9.3 Minya WWTP

For town level, the Minya Waste Water Treatment Plant, the government represented by both the ministry of planning and financial affairs should be involved in financing it. The other way is to place it on a BOT or BOOT scheme of financing to attract national and international investors. The third way is to offer certain incentives to the investors like a barter deal i.e. land for agriculture in return of financing. The investor will save the money necessary for pumping groundwater as water will be available without any electrical or petrol cost.

For the national level of this pilot, government should seek help from the regional and international donors by having supplier credit, buyer credit or soft or mixed financing. The good thing about buyer credit is that the quickness of the procedure as it does not need any approval from the people assembly.

9.4 Basic data

For the present costs for treatment of wastewater (120,000 m^3) the data given in table 13 are valid. These data can be used as an indication for the costs of waste water treatment in villages.

Table 13
The actual operation and maintenance cost in LE for wastewater in El-Minya governorate for the period from 1/7/2013 until 31/12/2013 (six months) (120000 m^3/day)

No	item	cost (LE)
1	Raw materials	280787
2	Fuel (petroleum products)	35856
3	Spare parts	388975
4	Operation Electricity	1696635
5	Water & Domestic electricity	11180
6	Writing materials (papers. etc.)	31968
7	Salaries & wages	19828594
8	Maintenance	70069
9	Advertising	16963
10	Transport & lodging	32763
11	Governmental expenses	10000
12	Other expenses	112060
13	Bought services	241856
14	Consumables	12118933
15	Indirect taxes	22299
	Total Cost	34898938
	Cost for one cubic meter	1.62

Level of uncertainty of the costing (10%)

Sanitation tariffs or revenues are calculated as 50% of the drinking water tariffs for residential areas and 75% for commercial areas. The drinking water tariff for residential areas is divided into classes based on monthly consumption rate Table 14.

Nowadays sludge is sold to local to local farmers at low price (6LE/1 m^3). There are plans to follow the neighbour company (Bani Souef Company) that sells sludge to cement factory for about 26 LE/ton.

Table 14
Sanitation tariffs based on monthly consumption

Class	Tariffs LE
From zero to 10 m^3	0.23
10 to 20	0.41
20 to 30	0.53
30 to 40	0.55
>40	0.6
For commercial areas	1.05

For Deir Gebel El-Teir It is still difficult to estimate the costs of all relevant items in much detail. A first estimate has been done in chapter 9.5 but time was too short to have proper capital costs relating to the most important budget lines.
- Collection;
- Treatment;
- Post-treatment and processing into reusable product.

This can be further divided into e.g. into civil works, mechanical works, electrical works which all are needed to run a basic financial model. In the situation of Deir Gabal El-Tair use is made of an existing situation (sewer system, wetland) and no information is available about the capital cost for the already existing systems.

The capital costs for Deir Gabal El-Tair are estimated to about 7 million LE for network, pump station and water treatment as follows:

Collection network (11 km, range from 8 to 14 inches)	5 million LE
Pump station & discharge pipe 1.5 km	1.5 million LE
Septic tanks	0.4 million LE
Trickling filter	0.1 million LE

The costs for the composting facility is not known yet

9.5 Model approach

9.5.1 Introduction

The model in this chapter provides insight into the financial feasibility of the proposed solution. Alternative solutions for the waste water problem can be compared and the financial effects of changes in design are made clear.

At first the setup of the financial model is explained. The following aspects are crucial for the right interpretation of the model:
1. The current version of the model 01g is a business case model focusing on the projected cash flows. No choice has been made as to the way of financing the pilot and the model therefore provides an aggregated overview of required funding.
2. When design and setup of the pilot become clearer the model should be adapted accordingly to more accurately reflect the amounts and timing of investments, funding, revenues and expenditures.

9.5.2 FAST Modelling

In this project an efficient modelling standard[2] is used that is internationally accepted and recognized as an effective and efficient way of gaining financial insight into complex projects: the FAST-Standard. The standard is open, freely available to everyone interested and based on a number of principles are essential to good modelling (Figure 22). FAST stands for:
- Flexible – Models are flexible and easy to change. Separating the inputs, calculations and outputs means that scenarios can be changed without impact on the actual calculations. Different configurations of business cases are therefore easily included in the existing model. Furthermore, by making use of so called flags, the timing of cash flows can be effortlessly manipulated from the dashboard and input sheet.

[2] For more information regarding FAST models see *www.fast-standard*.org and the free 31-day course Financial Modelling *http://www.rebelgroup.com/financial-modelling-nieuwsbrief*.

- Appropriate – Models can be extensive but the main goal is to reflect the business cases in enough detail without adding to the complexity (e.g. to keep the number of macro's to an absolute minimum).
- Structured – Strict rules with regard to layout and structure of the model insure integrity of the model and readability. A clear color coding scheme gives the user a quick insight into the functionality and workings of the model. For instance, input cells are clearly recognizable by a light yellow color.
- Transparent – Models are built up from small, easy to understand calculation blocks. Breaking up large and complex calculations into understandable steps ensures that modelers and non-modelers alike can review and use the model. This is especially important in sharing the models with the client.

Figure 22 *Structure of financial model Rural Sanitation in Egypt.*

The model is structured in a way that inputs are separated from the calculations and outputs Table 15.

Table 15
Sheets in use in the model

Inputs	Calculations	Outputs
InpC	Time	Dashboard
	Esc	FinStat
	OpRev	Ratios
	OpEx	Track
	Assets	Check
	Fin	

The most important sheets are the Dashboard and InpC sheets. These are the sheets that the user will interact with:
- InpC is the centralized place where data can be entered in different scenarios. Each light yellow cell can be edited and each column represents a separate scenario.
- Dashboards feature the most significant parameters for analysis and displays the important outputs like financial ratios. Like with the input tab, light yellow cells can be edited as well. In this case the dashboard will feature the option to change scenarios and do some light sensitivity analysis. There is a graph displaying the most important cash flows over the years and a figure that shows the relative percentages of income sources. On the right the project returns are displayed as well as the capital expenditure, subsidies and funding required. As the pilot gets more concrete other items can be added as well. Models of more developed projects feature more financial options as well.

Furthermore, the model has certain checks and alerts build in. Alerts indicate that something might not be optimal, but can be ignored. Errors however indicate a fault in the model or inputs. A balance sheet that is not balanced for instance would trigger an error.

FAST models use a colour coding scheme that helps the user navigate and quickly grasp the model (Table 16).

Table 16
Colours in use in the model

WORKSHEET TABS	
Cover	(black)
Inputs	(light yellow)
Calculations	(grey)
Outputs	(blue)
tmp (worksheet basis)	(yellow)
Checks	(pink)
TEKST	
Input from same worksheet	Black
Input from other worksheet	Blue
Export to other worksheet	Red
Placeholder / requiring attention	[brackets]
CELLS	
User input	(light yellow)
Macro or linked input	(light blue)
Input from later calculations or worksheets	(light grey)
Checks and alerts unfired	(green)
Checks and alerts fired	(red)
Placeholder / requiring attention	(yellow)
Corkscrew	(white, borders)
Header	(light blue-grey)

To get a proper feeling for the model, browsing through it is advised. For analysis the InpC and Dashboard are, as mentioned before, key sheets. In the InpC all data can be edited in the light yellow cells and new scenarios can be added (table 17). The created scenarios can then be selected on the dashboard to view the results.

Table 17
Colours in use in the model

InpC

	Constant	Unit	Name		<-- Each column is a scenario -->	
	-	Errors		[Don't (	[Don't delete col]	
	2	Alerts				
	24	Out Chgs				
	-	Inp Chgs				
Active scenario:	Base Case		2			
Compare to:	Base Case		2		1	
	Constant	Unit	Name	-	Base Case	Expensive net
MODEL TIMING						
Scenario description	Base case. Resident	name		-	Base case. Resid	Residents do
				-		
Development start date	01 jul 14	date		-	01 jul 14	01 jul 14
Development phase 1 period length	12	months		-	12	12
Development phase 2 period length	12	months		-	12	12
Development phase 3 period length	12	months		-	12	12
Operational period length	15	years				
OPERATIONAL REVENUES						
Population						
Current village residents	15.000	residents		-	15.000	15.000
Current village Households	2.000	households		-	2.000	2.000
Population annual growth factor	2,33%	%		-	2,33%	2,33%
Wastewater Discharge						
[Residential waste water discharge per day]	135,0	ltr / PE / day		-	135	135
Household waste water discharge per day	2.000,0	ltr / HH / day		-	2.000	2.000
Tariff Structure						
Sanitation tariff households per month	75	LE / HH / month		-	75	75
Composting						
Sell compost yes/no (1/0)	-	no				
Sludge output per day	0,4000	kg / resident / day		-	0,4000	0,4000
Compost m3 from 1 liter sludge	0,0040	m3 / ltr		-	0,0040	0,0040
Revenue per m3 compost	175	LE / m3		-	175,00	175,00

Insert column before grey line to make a new scenario

Scenario columns with data

9.5.3 Financial analysis of pilot design

The financial viability of the project has been assessed using the financial model. It is important to keep in mind that at this moment in time not all the financial inputs were available, that in cost estimates an important assumption is that local people contribute to the project (reducing costs) and that –on the revenue side- there is uncertainty whether there is payment readiness by amongst others households. Besides an investment of 4,910,000 LE the assumptions include a contribution by:

- The church/pilgrims (1,000,000 LE per year);
- Ministry (investment subsidy of 1,000,000 LE);
- Households (75 LE per month);
- Farmers (175 LE per m3 compost).

As a result of this one should understand that the uncertainty margins in the financial viability are relatively large. Annex 5 includes an overview of all assumptions used in the financial model.

The financial results of the base case are positive. The calculated IRR with and without governmental support relatively high and based on the current assumptions exceed the required return.

	Incl. Subsidies	Excl. Subsidies
Project IRR	**133,8%**	**90,0%**

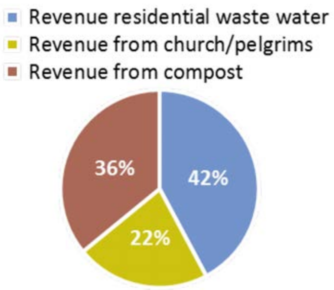

Figure 23 *IRR of the sanitation project in Deir Gabal El-Tair (based on data in annex 5).*

The cash flows over the project life time are presented in figure 24:

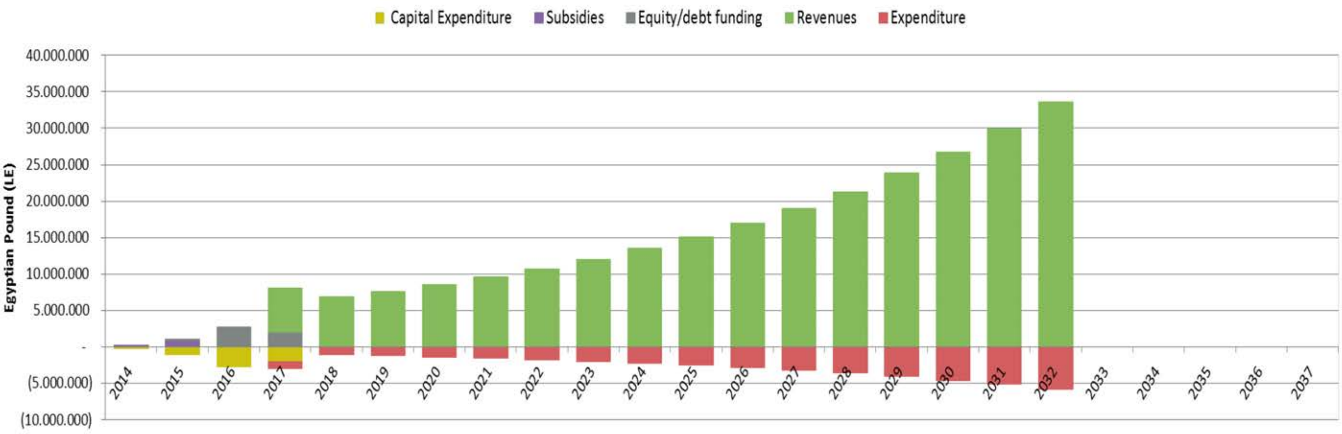

Figure 24 *Cash flows of the sanitation project in Deir Gabal El-Tair (based on data in annex 5)*

We have done a sensitivity analysis on the most important parameters. Considering the very positive IRR all scenarios are a deterioration of the current assumptions. The assumptions and results of the sensitivity analysis are presented in table 18.

Table 18
Sensitivity analysis

Parameter	Change	IRR (incl. subsidy Ministry	IRR (excl. subsidy Ministry
Base Case	-	133,8%	90,0%
Investment	CapEx +25%	99,8%	76,0%
	CapEx +50%	81,2%	66,2%
	No help residents with construction	94,8%	73,2%
Costs	OpEx +25%	127,6%	86,7%
	OpEx +50%	121,4%	83,2%
Revenues	No compost sold	79,0%	58,4%
	Compost -50%(87,5 per m3)	106,5%	74,8%
	No contribution church/pilgrims	101,4%	72,1%
	Household tariffs -50%	101,7%	72,0%
	Inflation 2% (instead of 10%)	121,1%	76,2%

It is clear from these scenarios that the business case is most sensitive to the assumptions of investments and the different forms of revenues (compost, church and households). If we combine several scenarios we get a feel for the range of the project returns.

Table 19
Project returns in the base scenario and a pessimistic scenario

Parameter	Change	IRR (incl. subsidy Ministry	IRR (excl. subsidy Ministry
Base scenario	-	133,8%	90,0%
Investment	CapEx +50%	28,8%	25,3%
Revenues	Compost -50%		
	No contributionchurch/pilgrims		
	Household tariffs -50%		

The cash flows over the project life time in the scenario as described above are presented in figure 25. The project is still economic feasible.

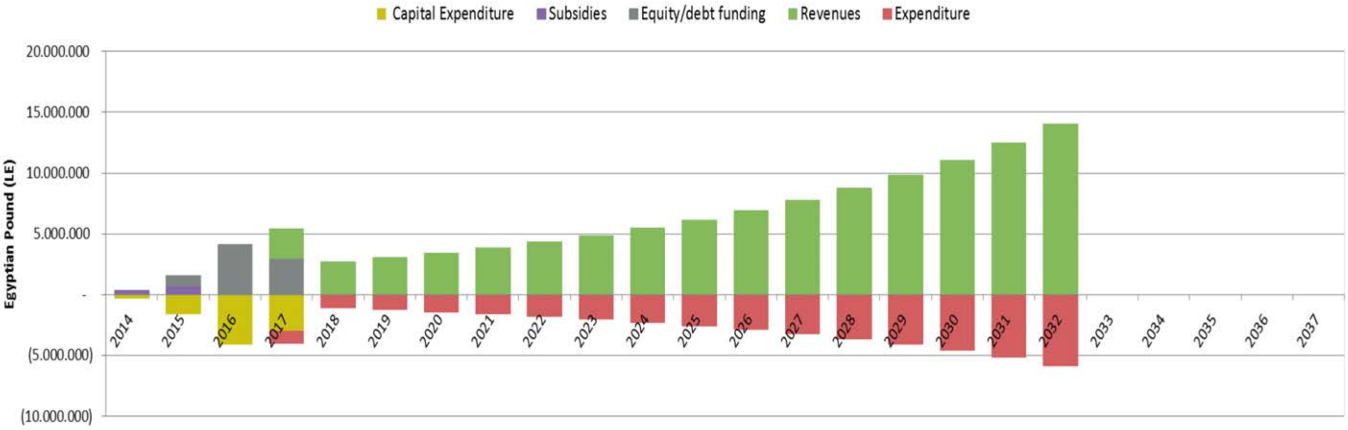

Figure 25 *Cash flows of the sanitation project in Deir Gabal El-Tair assuming higher costs and investment and lower revenues compared to the situation presented in figure 24.*

Considering the early stage of this project it is not unheard of that many financial factors will change, but the extreme case described in this chapter shows that even when pessimistic assumptions are made, the many revenues in this specific business do compensate those assumptions.

10 Other villages

The treatment of waste water in the other villages was limited to infiltration tanks or simple septic tanks. If no sewer system can be constructed followed by treatment and/or reuse of the water it advised to explain to the villages how a proper septic tank should look like. This is already shown in chapter 7 (Figure 18). It has chambers were the solid and liquid waste are separated and anaerobic treatment occurs. This is followed by infiltration.

It will be costly to create these types of septic tanks all around the villages in Egypt. In our approach, we want to make use of the existing situation and make use of the existing constructions. It is possible to split an infiltration tank into a settling chamber and chamber for the water phase with a much lower content of solid particles. This water can infiltrate in the soil. It will only be necessary to remove the sludge from the settling chamber.

In clay, infiltration will be difficult. In these cases we propose to connect several (5-10) septic tanks together with a mini sewer system and to create one deeper and effective infiltration tank. Later all these mini sewer systems can be connected together and the collected water can be further treated and reused in agriculture.

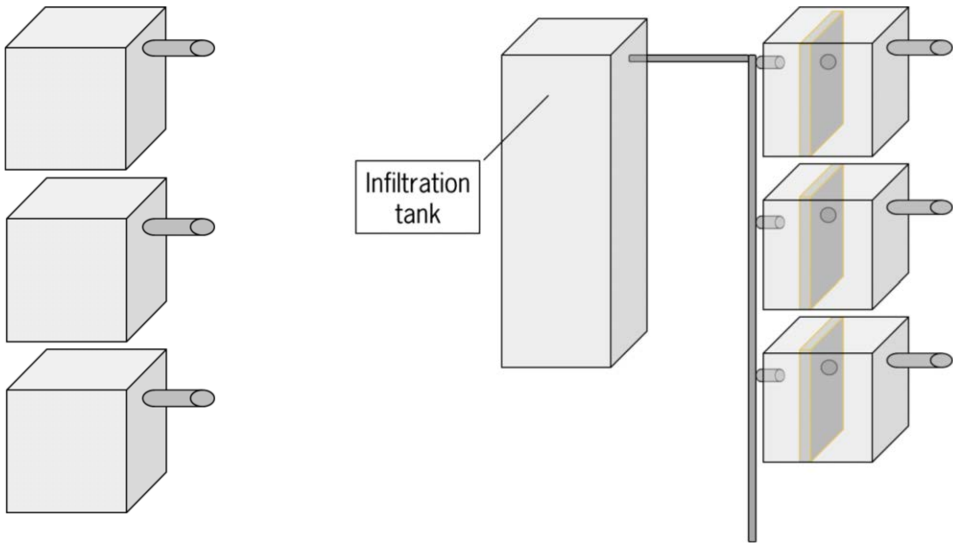

Figure 26 *Present infiltration tanks (left) and proposed improved system in which tanks are improved and connected by a small sewer system with a well-functioning infiltration tank (right).*

In Sharone it will be necessary to solve the problem of the high water table before improvement of the septic tanks or construction of a sewer system. A suggestion is changing the irrigation channel by a pipe. In discussions during the second workshop on August 5, it was mentioned that the problem of a high water table is present in more villages.

11 Conclusions and recommendations

Egypt has a serious problem on the sanitation of water and also on the availability of water for irrigation. The Holding Company of Water and Waste Water (HCWW) in Egypt has prioritized the treatment of waste water in the cities. No budget is available for the large number of villages in the rural area. In order to enable the treatment of wastewater in villages, we investigated possibilities in this feasibility study using:

- Key factor in the project is the reuse of waste water after a simple treatment. Use is made of the 80/20 rule: with 20% of the investment 80% of the desired result is obtained, which enables the application of simple solutions;
- Without extra benefits, it is not possible to pay the 20%. HCWW has made land available to be used in combination with the reuse of waste water, which can be very interesting for private investors. In Egypt there is a shortage of water, which gives also waste water a value. The other value of waste water is the nutrients present in the water.

In the project it appears that the reuse of waste water was not the only benefit and other benefits can be a more important driving factor.

Five locations in the Minya area (about 300 km south of Cairo) were visited in order to select a village for the first pilot. We have visited four villages in Minya governorate and one site near the new wastewater treatment plant for Minya City. The visited villages in Minya Governorate are; Deir Gabal El-Tair (Deir al-Adhra) – Samalout; the village of Deir Abu Hinnis – Malawe; the village of EL-Shaikh Masoud – El Edwa and the village of Sharona – Maghagha.

To be able to start a pilot on the short term, presence of a sewer system is essential, combined with the possibility to design a simple treatment system. Deir Gabal El-Tair was the only village with a sewer system and moreover it was possible to use local natural conditions to treat the waste water. In the other villages no sewer system was present and use was made of infiltration and septic tanks. Improvements of these systems are possible and advice is given in this report. In the village of Sharona the high water table has made the infiltration tanks less effective. The high water table is probably caused by infiltration through an irrigation channel in the village. Prevention of this infiltration should be the first step followed by improving the construction of the septic tanks.

The village of Deir Gabal El-Tair had a sewer system and a large problem with the collected waste water. Moreover the village has a monastery, situated at the edge of a lime stone cliff and guarding a cave where the Holy Family has stayed during their escape to Egypt. Infiltration of waste water will decrease the stability of the lime stone and may lead to a rock slide off, including this Holy Place. This increases the importance to have a clean, safe and healthy environment in the village. For the water treatment, use can be made of the natural differences in elevation and the presence of a wetland already created by the discharge of waste water. Measurements showed that this wetland is effective in cleaning of waste water.

We distinguished between the waste water produced in daily life and the waste water produced during the yearly festival at the end of May with 2 million visitors (peak discharge). The waste water produced during this festival asks for its own approach. There are possibilities by controlling it by a system of mobile toilets as in use on festivals in Europe and by creating buffer capacity.

Several stakeholders are willing to be involved in the solution, the inhabitants, the church and also organization, normally not involved in water sanitation like the Ministry of Tourism and industry within their Corporate Social Responsibility.

The solution has the following elements

- Improving the sewer system in cooperation with the inhabitants;
- Building of septic tanks to separate the aqueous and solid fraction;
- A trickling filter made of local material, in which use is made of the natural differences inelevation;.
- The natural wetland present;
- Reuse of the treated water;
- The solid fraction will be composted together with local available agricultural residues;
- Sanitary facilities and temporary storage during the yearly festival.

Although not all necessary input data are exactly known, the economic evaluation has shown that in Deir Gabal El-Tair the revenues of water sanitation are sufficient to defend the investments to be made. In this case the presence of a Holy Place mobilized a lot of stakeholders.

The solution presented is site specific, but the approach to come to the solution is generally applicable in rural and desert areas. Elements of the solution can also be used elsewhere.

For reuse of waste water the visited area near the new Minya WWWTP was most suitable for a pilot project. On this place private investors are interested and a pilot can be realized on the short term.

The contents of this report were discussed in a workshop in Minya on August 5, 2014 together with different stakeholders. The approach used, is new for Egypt. It was concluded that this approach, taking into account local conditions and use of simple and cheap treatment methods is applicable in a large number of villages all over Egypt. The site specific approach developed for Deir Gabal El-Tair is expected to be applicable in other villages situated on the lime stone cliff at the eastside of the river Nile.

It is recommended to start the pilot in Deir Gabal El-Tair as soon as possible, based on the steps, design and involvement of stakeholders as presented in this report.

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Annex 1 Cairo Rock slide

International Corner

2008 Cairo Rock Slide: A Lesson in Urban Geologic Hazards

Kholoud Mohamed Ali

Catastrophe struck Cairo, Egypt, at approximately 6 a.m. on September 6, 2008. Eight boulders — weighing 60 to 70 tons each — split from the edges of Muqattam Mountain. The rock slide destroyed at least 40 houses and killed over 100 inhabitants. Local residents estimate that the death toll may ultimately be as high as 600 people.

Historical Setting

Cairo's Muqattam Mountain is known for its quarries of limestone and other deposits that were worked during the Old Kingdom, about 2686 BC – 2134 BC. The limestone was quarried for the Great Pyramids of Giza that were built for Pharaonic burials.

Egyptians consider Muqattam Mountain to be the only real mountain in Cairo, though many visitors might consider it more of a hill. It is four or five hundred feet high and lies immediately to the east of the city. Muqattam Mountain is listed in most travel guides. It is a very interesting place to visit and a great location to scope out Cairo. Many great historical and geographic sites of Egypt can be seen from this location — including pyramids, the great Castle of Salaha Al Din, and even the Nile. The view from Muqattam Mountain is more than magnificent!

One of our international members, Kholoud Mohamed Ali, who teaches at Cairo University in Egypt, summarizes a recent catastrophic rock slide that occurred in Cairo. As Kholoud points out, understanding the geologic setting is extremely important in urban development.

Unfortunately, Muqattam Mountain is no longer as breathtaking as it once was. The mountain is not only the main garbage dump for Cairo, but it is also the area where many shanty towns have been established — mostly by the people who collect Cairo's trash. These people live in dusty squatter settlements with narrow dirt lanes. There they sort and recycle the garbage produced by Cairo's burgeoning population.

Geologic Setting

Beginning about thirty million years ago and until the end of the Miocene, the Tethys Sea covered upper Egypt and deposited a thick section of marl and limestone that is intercalated with soft clay. This section is the Muqattam Formation. The limestone units of the formation are highly porous and cavernous, showing evidence of having been greatly affected by water erosion. The clays within the Muqattam Formation are bentonites, and thus prone to expansion. In addition, the formation has become extensively cracked and faulted.

Muqattam Mountain Rock Slide – Cairo, Egypt. (Save the only exposed Oligocene-Miocene section in Egypt!)

Cause of the Rock Slide

There are natural weathering processes that cause slope and rock instability at Muqattam Mountain. Daily and seasonal cycles of dry-and-wet, acting on the formation's surface are causing aggressive deterioration of the limestone deposits. The numerous vertical and horizontal fissures in the limestone units may be due to these weathering cycles. Water rising by capillary action in the porous limestone from these fissures may also cause deterioration of the limestone, and lead to rock instability.

However, it is human activity that has accelerated the rock fall problem, making it bigger than it would have been otherwise. Since 1966, when the first shanty town was built, urban development has grown year by year until Muqattam Mountain has become densely populated. Currently, more than 350,000 people live in an illegal settlement area covering approximately 850 acres. There is no sewage system for this settlement, and their wastewater is eating away at the mountain. Perhaps more importantly, there is also sewage leaking into the mountain from luxury housing developments being built atop Muqattam Mountain. The wastewater indiscriminately leaks through the rock units, increasing pore pressure. Limestone blocks, particularly those at the mountain's edge have become weakly connected. Any move may trigger them to break loose. Other nearby human activities, such as quarry blasting, may also contribute to the rock instability of Muqattam Mountain.

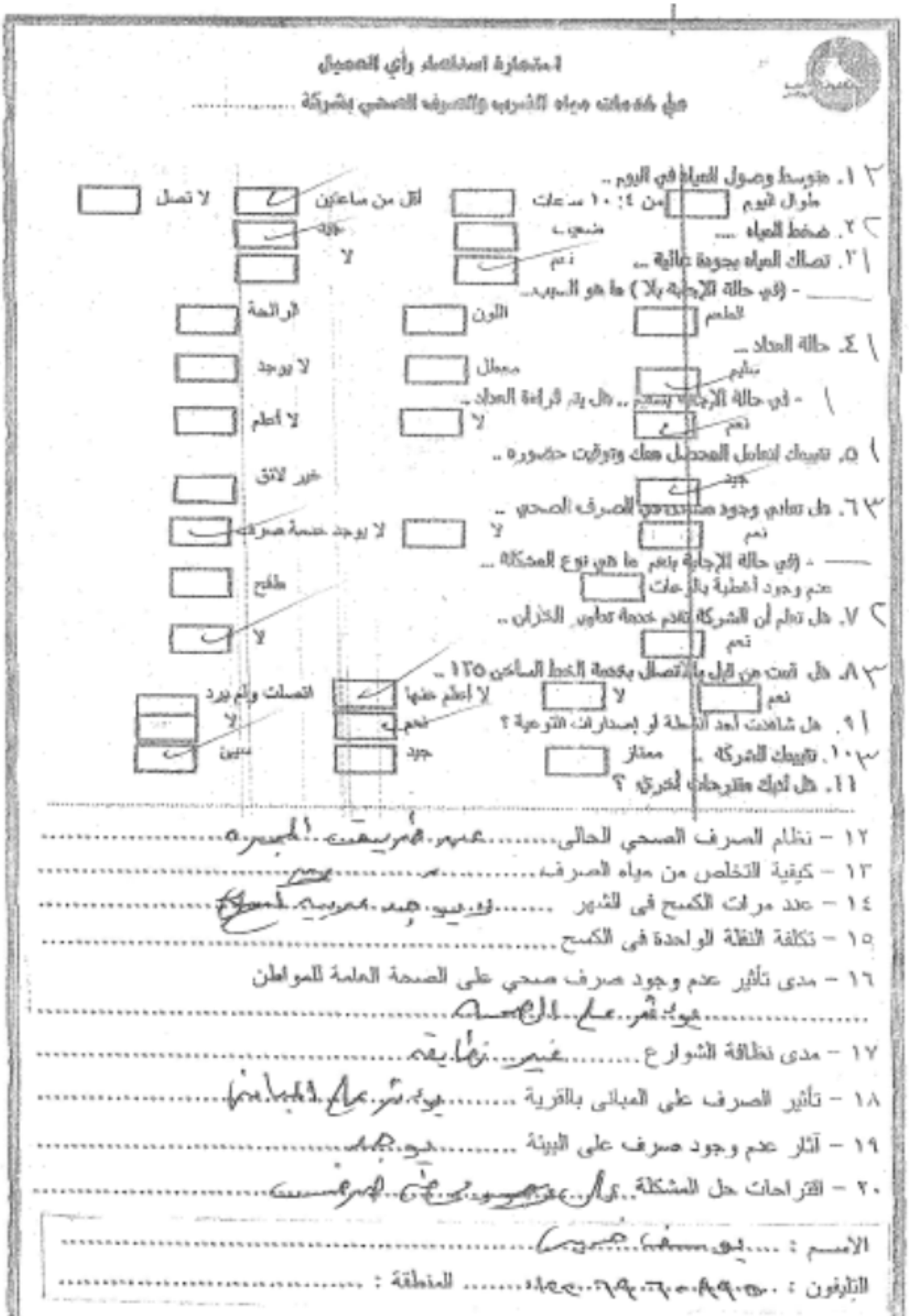
Summary

If we consider the events at Muqattam Mountain, we can imagine the great limestone blocks looking to the rest of the formation saying sadly, "I have survived more than 30 million years and was a great mark for geologists. How could I break down in only 40 years?!"

And on the immediate human level — a great number of people have no houses to live in, no place to put their shanties, and no sewage system. They found what seemed to be a good place with a mountain view, not understanding the potential hazards when they built their town. All seemed fine, until the day when, without warning, they were buried under many tons of rocks. This tragedy has become a lesson for why we need to understand urban geologic hazards including the impact of our own human activities.

You may contact Kholoud at kholoud-malii@yahoo.com.

Annex 2 Questionaire



استمارة استطلاع رأي العميل

على خدمات مياه الشرب والصرف الصحي بشركة ....

١. متوسط وصول المياه في اليوم .. طول اليوم / من ٤ : ١٠ ساعات / أقل من ساعتين / لا تصل

٢. ضغط المياه .... ضعيف / جيد

٣. تصل المياه بجودة عالية .. نعم / لا

- (في حالة الإجابة بلا) ما هو السبب.. الطعم / اللون / الرائحة

٤. حالة العداد .. سليم / معطل / لا يوجد

- في حالة الإجابة بسليم .. هل يتم قراءة العداد .. نعم / لا / لا أعلم

٥. تقييمك لتعامل المحصل معك وتوقيت حضوره .. جيد / غير لائق

٦. هل تعاني وجود مشاكل في الصرف الصحي .. نعم / لا / لا يوجد خدمة صرف

- (في حالة الإجابة بنعم ما هي نوع المشكلة .. عدم وجود أغطية بالبالوعات / طفح

٧. هل تعلم أن الشركة تقدم خدمة تطوير الخزان .. نعم / لا

٨. هل قمت من قبل بالاتصال بخدمة الخط الساخن ١٢٥ .. نعم / لا / لا أعلم عنها / اتصلت ولم يرد

٩. هل شاهدت أحد الأنشطة أو إصدارات التوعية ؟ نعم / لا

١٠. تقييمك الشركة .. ممتاز / جيد / سيئ

١١. هل لديك مقترحات أخرى ؟

١٢ – نظام الصرف الصحي الحالي..........

١٣ – كيفية التخلص من مياه الصرف..........

١٤ – عدد مرات الكسح في الشهر ....

١٥ – تكلفة النقلة الواحدة في الكسح..........

١٦ – مدى تأثير عدم وجود صرف صحي على الصحة العامة للمواطن

....

١٧ – مدى نظافة الشوارع ....

١٨ – تأثير الصرف على المباني بالقرية ....

١٩ – آثار عدم وجود صرف على البيئة ....

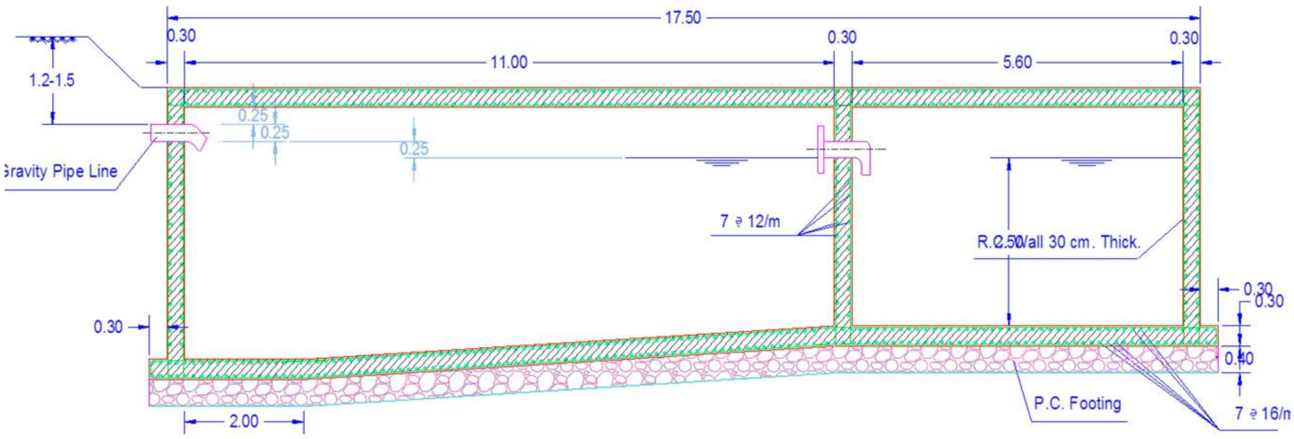
٢٠ – اقتراحات حل المشكلة..........

الاسم : ....

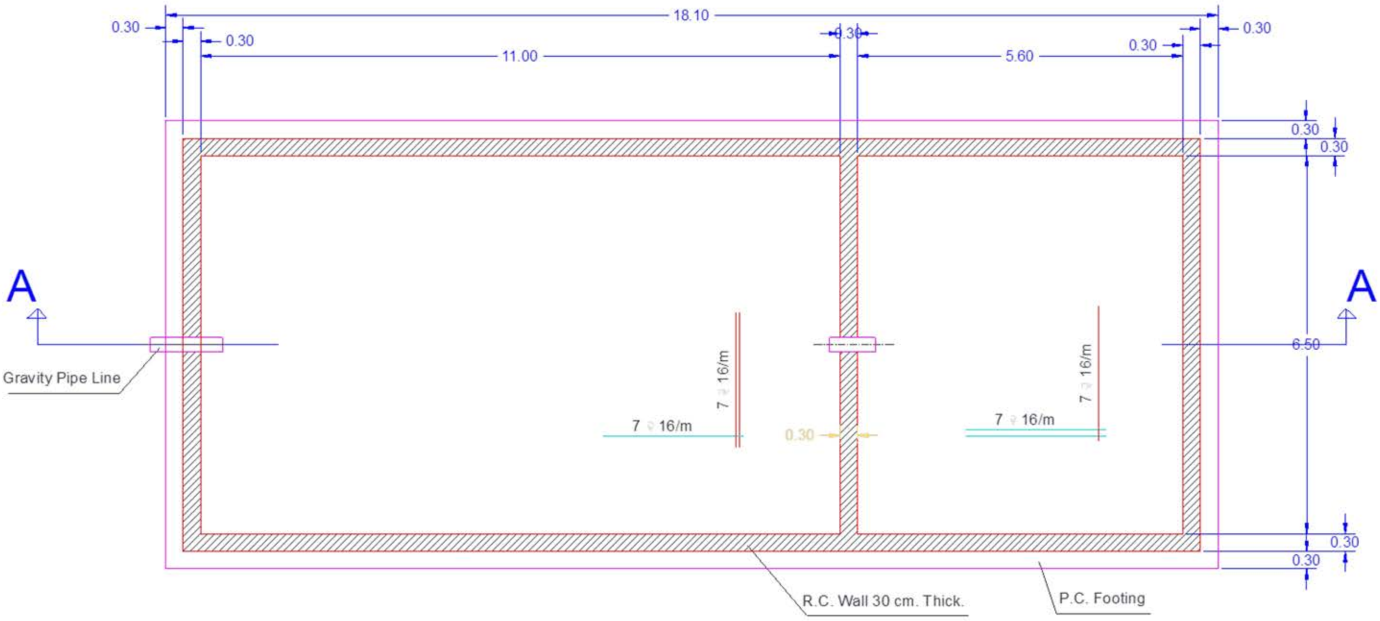
التليفون : .... المنطقة : ....

Annex 3 Technical details septic tank and Trickling filter

Collective Septic Tank , with
Settling Sand & Oil Excluder
Chamber SEC. ELEVATION



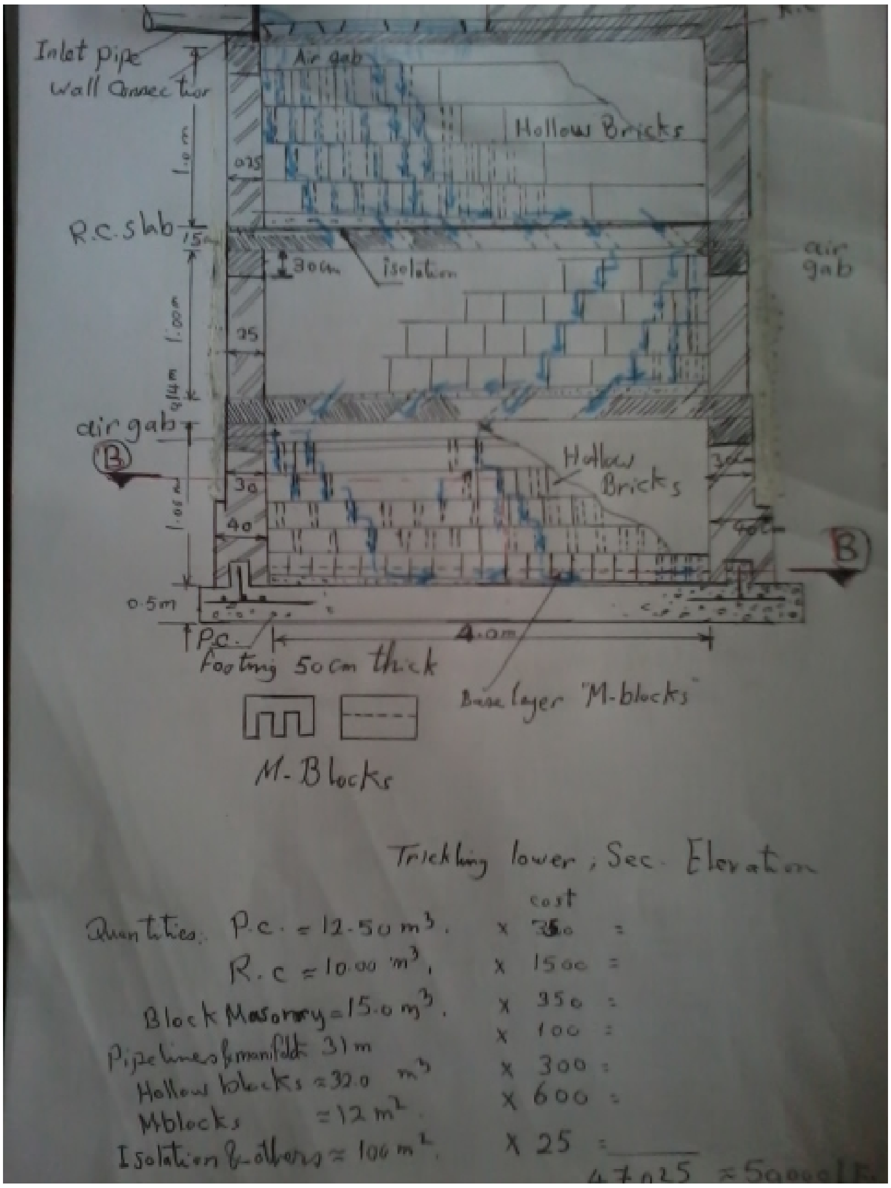
Sec. Elev.(A-A)



Plan

Plain Concrete; 65 m3/ tank
Reinforced Concrete; 140 m3/tank
Excavation = 750 m3
Other works, & pipelines:

Trickling filter



Annex 4 Letter from the church to the governor

مطرانية سمالوط للأقباط الأرثوذكس

سمالوط في ٢٠١٤/٦/١٣

السيد اللواء / صلاح الدين زيادة محافظ المنيا

تحية طيبة وبعد

دير السيدة العذراء بدير جبل الطير مركز سمالوط أحد المحطات الرئيسية التى مرت بها العائلة المقدسة وتعتبر الكنيسة أثرا فريدا من حيث :-

١- بنيت الكنيسة على المغارة التى أوت إليها العائلة المقدسة .

٢- الكنيسة نفسها منحوتة بأعمدتها ومشتملاتها فى صخرة الجبل .

٣- بنيت الكنيسة فى نفس العصر الذى بنيت فيه كنيسة القيامة بالقدس التى بنتها القديسة هيلانه والدة الإمبراطور قسطنطين .

٤- يتوافد لزيارة الكنيسة الاثريه الملايين من الزائرين المصريين والأجانب .

ورغم ذلك فان الكنيسة تتعرض للانهيار بسبب عدم وجود صرف صحى حيث تقع على قمة الجبل المكون من الحجر الجيرى مما أدى لتسرب المياه تحت الصخرة المبنى عليها الكنيسة واحدث بها شرخين طوليين (الصورة المرفقة) وحرصا على سلامة الأثر التاريخى العالمى فى مصر نأمل التكرم بإصدار الأمر بسرعة عمل اللازم بإقامة نظام صرف صحى متكامل لإنقاذ هذا الأثر الفريد حتى لا يحدث له مكروه لا قدر الله ، وأيضا نقضى على الأمراض التى يعانى منها الاهالى والزائرين .

وتفضلوا بقبول وافر التحية ،،،،،

الأنبا بفنوتيوس

بفنوتيوس

أسقف سمالوط

٠١٢/٧٣٣٣٩٦٠ إلى ٠١٢/٧٣٣٣٩٤٠ ٧٧١١٧١٦ إلى ٠٨٦/٧٧١١٧١١

Annex 5 Base case assumptions financial model 01g

	Unit	Base Case	Notes / comments (refers to Base Case)
MODEL TIMING			
Scenario description	name	Base case. Resider	Inputs based on mails and shopping list
Development start date	date	01 jul 14	
Development phase 1 period length	months	12	
Development phase 2 period length	months	12	
Development phase 3 period length	months	12	
Operational period length	years		
OPERATIONAL REVENUES			
Population			
Current village residents	residents	15.000	Phonecall Joop Harmsen 13-aug-2014
Current village Households	households	2.000	Phonecall Joop Harmsen 13-aug-2014
Population annual growth factor	%	2,33%	Report Rural sanition Egypt-2.pdf
Wastewater Discharge			
[Residential waste water discharge per day]	ltr / PE / day	135	Not in use. Report Rural sanition Egypt-2.pdf ; PE = people equivalent = 1 average person.
Household waste water discharge per day	ltr / HH / day	2.000	Phonecall Joop Harmsen 13-aug-2014
Tariff Structure			Per huishouden (10-15 personen) betalen 50-100 per maand
Sanitation tariff households per month	LE / HH / mo	75	50-100 according to Phonecall Joop Harmsen 13-aug-2014
Composting			
Sell compost yes/no (1/0)	yes		
Sludge output per day	kg / resident /	0,4000	900gr per PE per day, after drying 400gr. 1kg = 1 ltr. Phonecall Joop Harmsen 13-aug-2014
Compost m3 from 1 liter sludge	m3 / ltr	0,0040	Per m3 sludge 3 m3 organic matter is added. Phonecall Joop Harmsen 13-aug-2014
Revenue per m3 compost	LE / m3	175,00	From: Answer to notations and rest data of shooping list.doc from Sherif Tony.
Other			
Sell compost yes/no (1/0)	yes		
Annual total contribution church/pelgrims	LE	1.000.000	Yearly income from pelgims: e.g. tax levied by church. From phonecall Joop Harmsen 13-aug-2014
OPERATIONAL EXPENDITURE			
General			
Salaries & wages expenditure	LE / m3	0,2993	Phonecall Joop Harmsen 13-aug-2014. Lower because of simplicity of the system, it is not a full blow WWTP.
Treatment Plant			
Raw materials expenditure	LE / m3	0,0127	Source: El-Minya WWTP 120.000m3/day second half of 2013 (184 days)
Spare parts expenditure	LE / m3	0,0176	Source: El-Minya WWTP 120.000m3/day second half of 2013 (184 days)
Water & domestic electricity expenditure	LE / m3	0,0005	Source: El-Minya WWTP 120.000m3/day second half of 2013 (184 days)
Writing materials (paper, etc) expenditure	LE / m3	0,0014	Source: El-Minya WWTP 120.000m3/day second half of 2013 (184 days)
Maintenance expenditure	LE / m3	0,0032	Source: El-Minya WWTP 120.000m3/day second half of 2013 (184 days)
Advertising expenditure	LE / m3	0,0008	Source: El-Minya WWTP 120.000m3/day second half of 2013 (184 days)
Transport & lodging expenditure	LE / m3	0,0015	Source: El-Minya WWTP 120.000m3/day second half of 2013 (184 days)
Governmental expenses	LE / m3	0,0005	Source: El-Minya WWTP 120.000m3/day second half of 2013 (184 days)
Other expenses	LE / m3	0,0051	Source: El-Minya WWTP 120.000m3/day second half of 2013 (184 days)
Bought services	LE / m3	0,0110	Source: El-Minya WWTP 120.000m3/day second half of 2013 (184 days)
Consumables expenditure	LE / m3	0,1000	Phonecall Joop Harmsen 13-aug-2014. Some pumps, but it's a natural system, therefore lower than WWTP.
Indirect taxes	LE / m3	0,0010	Source: El-Minya WWTP 120.000m3/day second half of 2013 (184 days)
Pump-station			
Fuel (petrolium products) expenditure	LE / m3	0,0016	Phonecall Joop Harmsen 13-aug-2014. Some pumps, but it's a natural system, therefore lower than WWTP.
Operation electricity expenditure	LE / m3	0,0100	Geen actieve beluchter, gebruik zwaartekracht
Collection network			
Maintenance workers collection network	FTE	1	Phonecall Joop Harmsen 13-aug-2014. 1 FTE to keep an eye on network quality and make repairs.
Salary per maintenance worker	LE / FTE	18.000	FTE = full time equivalent ; email Joop Harmsen 8-10-2014

CAPITAL EXPENDITURE			
Treatment plant investments	LE	210.000	Gravity Trickling tower cost estimate incl sceptic tank, mail Tony Sherif 8 oktober 2014 and phonecall Joop Harmsen 8-10-2014
Post-treatment investments	LE	200.000	Compost ; Raw estimates, needs refinement. Phonecall Joop Harmsen 8-10-2014
Pump-station & discharge pipe (1,5km) investments	LE	1.500.000	From: Shopping list for Rebel.docx 7-jul-2014 Joop Harmsen
Collection network (11km) investments	LE	3.000.000	5mln LE from: Shopping list for Rebel.docx 7-jul-2014 Joop Harmsen. 3mln LE from Joop Harmsen phonecall 13-aug-2014 (locals help
Depreciation phase 1 investments	years	15	
Depreciation phase 2 investments	years	15	
Depreciation phase 3 investments	years	15	
FINANCING			
Discount rate	%	20,00%	Inflation + 10%. Needs input.
Subsidies			
Subsidy from ministry amount	LE	1.000.000	Investment support from the ministry. Phonecall with Joop Harmsen 13-aug-2014
Subsidy from ministry availability date	date	01 jan 14	
Subsidy 2 amount	LE	-	
Subsidy 2 availability date	date	01 jan 14	
Subsidy 3 amount	LE	-	
Subsidy 3 availability date	date	01 jan 14	
Subsidies amortization period	years	15	
ESCALATION			
CPI Escalation Factor			
CPI reference date	date	01 jan 14	
CPI step up frequency in months	months	12	
CPI annual indexation rate	%	10,00%	Rough average from Answer to notations and rest data of shooping list.doc from Sherif Tony.

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Alterra report 2584
ISSN 1566-7197

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