

Small-Scale Sanitation in the Nile Delta:

Analysis of Costs and Cost-Effectiveness

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Executive summary

In 2015, more than 85% of the wastewater management in the rural areas of Egypt is informal, either via onsite systems with emptying by truck or sewer networks built by the communities. In official terms, it means that rural sanitation coverage is less than 15%, the concept of “rural sanitation” in Egypt encompassing 4700 villages and 30,000 scattered settlements (Abdel Wahaab, 2015). This situation means for the people quite high operational costs for poor service, only to move away the wastewater without treatment. To regain control of this situation which represents a substantial health and development risk seems indeed insurmountable in the middle-term. However, international experience shows that with the incremental implementation of standards and innovative management schemes, cost-effective solutions can be found to alleviate this burden.

This report looks at the financial side of rural sanitation. First, it looks at the costs of the current systems for the populations – onsite systems, bayara emptying, informal sewer networks, drinking water. Then, it looks at the cost-effectiveness factors that could lead to cheaper rural sanitation systems, and thus a quicker expansion of the sanitation coverage. In particular, it focuses on the costs and benefits of small-scale sanitation systems, and the economies of scale that could be driven if implemented on a large-scale. Small-scale systems could be a solution for villages or cluster of villages up to 5,000 inhabitants, which represents about 5 to 10% of the total population.

Currently, people in the unserved villages pay significant amounts of money for sanitation, sometimes 20 times more than those served by governmental conventional sewer systems. As shown on the table below, it is worth investing in an informal sewer system for people relying on bayaras - the investment is amortized in 6 months to 3 years according to the situation.

Table: Comparison of the water and sanitation costs in sewered and non-sewered villages

Costs	Unit	Averages per capita (for different villages)
Amount paid for the water bill	LE ¹ /cap/month	2-5
35% for wastewater services	LE/cap/month	0.7-1.7
50% for wastewater services	LE/cap/month	1-2.5
Amount paid for bayara emptying	LE/cap/month	7-28
Household connection to an informal sewer network	LE/cap	25-125
Main sewer line of an informal sewer network	LE/cap	25-140
Maintenance of an informal sewer network	LE/cap/month	0.3-3

¹ 1 USD = 7.8 LE (EGP) in December 2015

The high price currently paid for bayara emptying also means that there is a capacity-to-pay much higher than the established wastewater fee. In other words, households would be able to pay the 10-30 EGP per month to cover the O&M costs of small-scale sanitation systems, as it is less than what most people are currently paying. The fact that households pay less if they are properly served should be a major driver for small-scale rural sanitation in Egypt.

Sustainable cost recovery can be reached by collecting an extra fee, as the amount needed is 3 to 10 times higher than what is currently collected through the water bill. Cost-recovery for the O&M costs is thus possible if the systems are properly planned, if the community is involved in the planning and if the regulatory framework is adapted to the needs.

The capital costs (CAPEX) per capita for a small-scale treatment plant is similar to the one for a large centralised WWTP. The diseconomies of scale of small-scale systems are offset by major savings in the construction of the sewer system; the CAPEX of formal shallow sewer systems at village-level is much less than the CAPEX of a conventional sewer network leading to a large centralised WWTP. Major savings are realised with the lesser depth, lesser diameter, less manholes and less pumping stations, which advocates for small WWTPs at village level. The cost for sewers can then be reduced up to a factor 10.

Further savings could be achieved through phased implementation, shorter planning horizon and the use of prefabricated components, which lead to major savings on construction time and a better control over price and quality.

The table below synthesises the investment costs (CAPEX) and operation & maintenance costs (OPEX) for the different sanitation systems compared in this study.

Overall, this shows the complementarity between large-scale and small-scale systems in the Nile delta. Large-scale systems are cost-effective for large towns, but this cost-effectiveness decreases significantly when it comes to connect settlements of 5,000 inhabitants or less which are not in the immediate vicinity of a larger town or treatment plant.

Table: Comparison of cost estimations for different sanitation systems in the Nile Delta

System	CAPEX [LE/cap]	OPEX [LE/cap/month]
Bayara	N.A.	7-28
Informal sewer network	50-265	0.3-3
Formal shallow sewer network	250-700	0.3-2
Conventional large sewer network	1500 - 8000	4-8
Small-scale WWTP	400-700	3-8
Large centralised WWTP	500 - 1200	1 - 2.2

Recommendations

Scope for decentralised systems

The selection of the optimal level of decentralisation should be done as a master planning exercise with a focus on sewer network optimisation. Indeed, from a cost-efficiency perspective, the sewer network is the main factor, considering that it accounts for more than 70% of the costs of wastewater infrastructure. In a context such as the Nile delta which features a large-number of cost-increase factors such as a high groundwater table and multiple barriers (canals, drains, railway, code of practice), and where settlement patterns are highly variable, such an assessment should be made case-by-case.

These assessments should consider the implementation of shallow sewer networks wherever possible, and also the scenario of more permissive rules, especially regarding the distance between a settlement and a treatment plant. Especially the “rule” stating that a WWTP should be at least at 500 m. of a settlement often forces to group several villages together, thus implying a higher level of centralisation. If the construction of pumping stations and force mains are needed, cost-effectiveness drops.

Conventional or prefab?

The mass production of prefabricated components in Egypt can offer economies of scale and a better price & quality control. Prefabricated units can be used for different items of the collection and treatment chain. For each item, the choice between a prefabricated or conventionally-build item depends mainly on the capital price, but also the durability of the item, which is directly related to the skills and quality of work of the contractors. A key factor is also the construction time, which can be drastically reduced by using prefabricated components.

Regarding the treatment units, it is difficult to define a clear border until which prefabrication makes sense. Looking at the lessons learnt from the past small-scale initiatives in Egypt, it is clear that prefabrication definitely makes sense at least up to 1,000 inhabitants. For beyond, a good life-cycle analysis of the different options must be carried out.

A critical factor is the size of the module when considering a modular approach. The size of the module which can be produced and transported is often the limiting factor for prefabrication.

What is sure is that whether conventional or prefab, standardisation must be sought for. Prefabrication usually imposes itself as the solution in contexts with a rapid growing demand for small-scale sanitation systems.

At that stage, the estimation of the costs of locally manufactured treatment units should be pursued. The first estimations indicate competitive prices. However, the database is still too thin to draw conclusions, and more components and systems should be investigated.



Prefabricated units in Bangalore, India (CDD Society, BORDA DEWATS)

Reducing capital costs

Mechanisms should be put in place to avoid unrealistic prices and exorbitant added costs for the perceived risk linked with small-scale systems, which most consultants are not familiar with. With small-scale systems, it is very important to search for economies of scale, which means standardisation of the models proposed. Standardisation will also make it possible to regulate the market and ensure a quality control of production. Besides, adoption of staged (or modular) implementation strategies would lead to a quicker coverage in rural areas with investments which target the actual needs and not very uncertain future developments.

So far, the case studies show that some of the cheapest (and most sustainable) past initiatives are those designed, built and operated by the same person or organisation. In these three cases, the consultant/company/NGO worked closely in the field with several local contractors and suppliers, they divided their systems into different components and identified the best contractors and suppliers for each; they were not directly backed by big international donors.

Supporting communities

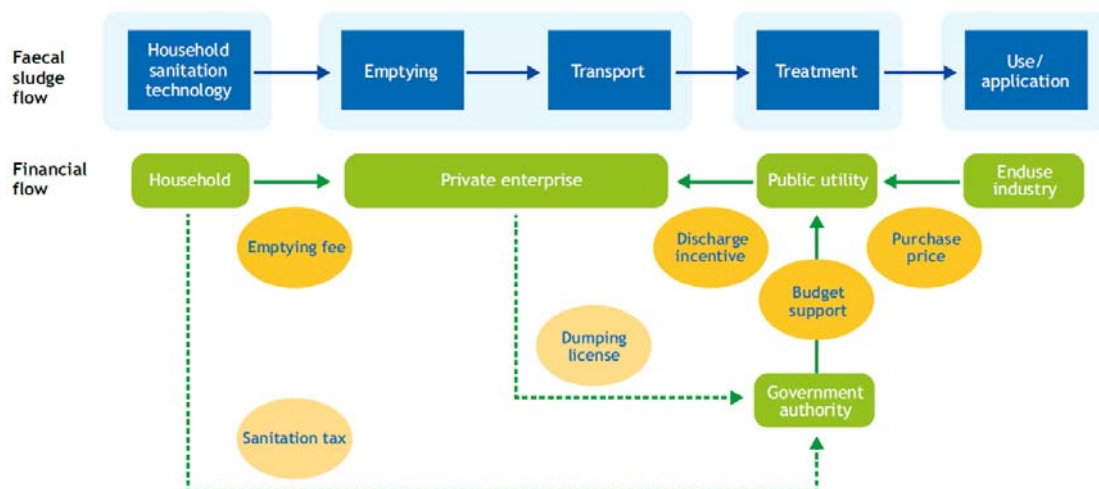
In small settlements, the most cost-effective collection system consists of shallow sewers. In order to avoid the high costs of bayara emptying, many communities decided to build their own “informal” sewer network. The data show that the investment is offset only in a few months to about three years, depending on the village situation. However, these sewer systems are usually badly designed, which leads to further problems. It is recommended that the government support them technically, to ensure that the network can be connected to a treatment plant later on; this measure would not cost much to the government, and save him substantial amounts of money needed for increasing sewer network coverage.

Treating septage

In the Nile Delta, the population pays a high price for the collection and transport of septage from the bayaras; the problem is made more acute in this context because of the high groundwater table. In such cases, the priority is to build a sewer network. However, it will never be possible to connect all houses. In such a case, it is recommended to apply a solidarity principle: all houses in and around a village should be provided with wastewater collection and treatment services, be with a sewer or with a truck, *at the same price*. Those connected to the sewer network would then cross-subsidise through their fees those that cannot be connected.

The septage would then be brought to the same treatment plant, or to a specific septage treatment units. The advanced primary treatment of septage all over Egypt would lead to a huge pollution reduction in the water bodies, at a limited cost for the government.

A thriving private sector is existing for bayara emptying all over Egypt. This sector should be built upon and be used as an arm for the governmental schemes. With proper management and financial arrangements, the septage could then reach treatment plants. There are different possible mechanisms, as shown below.



Incentivised discharge model (source: Tilley and Dodane, 2014)

How to build on this study

The exercise to calculate the opportunity cost of the current underutilized capacity in the Nile Delta should be made. The results would for sure advocate for a more decentralised and modular approach. So far, many uncertainties remain as for the costs of small-scale sanitation systems, especially after economies of scale are reached, both in terms of production as in terms of management. To follow-up on this study, the O&M costs with different management schemes should be assessed,

especially the benefits of a centralised management scheme such as described in the ESRISS project final report. Besides, a clear comparison between different scenarios based on life-cycle cost comparison should be elaborated.

Conclusions

Nowadays, most of the wastewater from the Nile Delta villages is collected by informal sewer networks or by truck and discharged into the drains, thus causing significant environmental and health issues and threatening the quality of agricultural products.

Small-scale sanitation systems are seen as a promising alternative for the small settlements that cannot be connected to the large centralized wastewater treatment plants. Such systems do exist and are not more expensive than the centralized ones. The population already pays substantial amounts of money for systems that are not satisfactory. There is capacity-to-pay to cover the operation and maintenance costs for small-scale systems.

If an incremental implementation of Law 48 is adopted, these systems will become much more cost-effective, while removing at least 60% of the pollution. An advanced primary treatment will in any case be a major improvement to the current situation where most of the wastewater of the delta remains untreated.

We estimate that such small-scale systems could contribute to treat up to 10 % of the wastewater from rural villages in the Nile Delta.

This report is a result of the *Egyptian-Swiss Research on Innovations in Sustainable Sanitation* (ESRISS), a parallel research component of the World-Bank funded *Integrated Sanitation and Sewerage Infrastructure Project* (ISSIP); this component is managed by the *Swiss Federal Institute of Aquatic Science and Technology* (Eawag) in partnership with the *Egyptian Holding Company for Water and Wastewater* (HCWW) and financed by the *Swiss State Secretariat for Economic Affairs* (Seco).

This report is primarily addressed to the stakeholders of the sanitation sector - decision-makers, governmental agencies, consultants and academics - who deal with rural sanitation and small-scale sanitation in general. It completes the two reports “*Small-Scale Sanitation in Egypt: Challenges and Ways Forward*” and “*Small-Scale Sanitation in the Nile Delta: Baseline Data and Current Practices*”. All documents can be downloaded on ESRISS webpage (www.sandec.ch/esriss).

Acronyms

BOD	Biological Oxygen Demand
BWADC	Beheira Water and Drainage Company
CAPEX	Capital expenditures
CDA	Community Development Association
COD	Chemical Oxygen Demand
EAWAG	Swiss Federal Institute of Aquatic Science & Technology
EGP = LE	Egyptian Pound = “Livre Egyptienne” (1 EGP = 0.13 CHF - <i>rate on 6.11.2015</i>)
ESRISS	Egyptian-Swiss Research on Innovations in Sustainable Sanitation
HCWW	Holding Company for Water and Wastewater
ISSIP	Integrated Sanitation & Sewerage Infrastructure Project
LE = EGP	Egyptian Pound (1 USD = 7.8 EGP in December 2015)
MFA	Material Flow Analysis
MOHP	Ministry of Health and Population
MWRI	Ministry of Water Resources & Irrigation
MWSU	Ministry of Water and Sanitation Utilities
NOPWASD	National Organisation for Potable Water and Sanitary Drainage
NPV	Net present value
NRC	National Research Centre (Markaz El Behoos, in Dokki)
OPEX	Operational expenditures
PE	Population-Equivalent
PIU	Project Implementation Unit (ISSIP)
PM/TA	Project Monitoring / Technical Assistance
PPP	Public-Private Partnership
SANDEC	Department for Sanitation in Developing Countries (Eawag)
SD	Standard Deviation
SECO	Swiss State Secretariat for Economic Affairs
WB	World Bank
WWTP	Wastewater Treatment Plant

Glossary

Bayara :	Local name used for the on-site sanitation facilities, as well as “ <i>tranches</i> ”. It can be translated as “vault” or “cesspit”.
Canal :	Water body, directly derived from the Nile, serving as a source of water for irrigation
Drain :	Usually referring to agricultural drains; drains in the Nile Delta are used as disposal point for any kind of waste.
Ezba :	Name used for small villages, usually < 1,500 inhabitants, in the Nile Delta
Informal sewer network :	Sewer network usually constructed by the inhabitants themselves. The lack of proper design very often leads to problems like clogging and flooding
Omda :	Community leader, assigned by the government, responsible for a small group of villages, within an “ <i>omodeya</i> ” (see also (Reymond, Demars et al. 2013))
Septage :	The liquid waste emptied from the <i>bayaras</i>
Sheikh baladi :	Informal community leader at village-level



Private stakeholder in charge of unclogging an informal sewer network, Beheira Governorate
(photo: Lukas Ulrich)

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This report and all other project documents can be downloaded on ESRISS webpage.

1 Introduction

Small-scale sanitation initiatives (here defined for settlements or groups of settlements of less than 5,000 inhabitants) meet various degrees of success around the world. Many initiatives exist but, in a lot of countries, remain isolated cases, which make them vulnerable and prone to failure. There is hardly any study investigating why, in a specific country, small-scale sanitation fails to be institutionalised and replicated on a wider scale. Besides, a systematic analysis of the enabling conditions and implications for the successful operation and management of scaled up small-scale sanitation systems is lacking.

Small-scale sanitation systems are currently at an inflection point. In the past decade they have proven to be a viable alternative to conventional large-scale centralised systems in certain contexts (Wilderer et al. 2000; Parkinson et al. 2003; Larsen et al. 2013). Some of their most significant advantages are flexibility, modularity, and cost-effectiveness (Massoud 2009; Libralato 2012). They can be implemented in stages and built as close as possible to the needs, reducing the possibility of accruing idle capacity costs (Maurer 2009). However in many countries they are still not considered as proper treatment systems and are, therefore, commonly not acknowledged as capable of providing a proper alternative to large-scale systems. Even where wide-scale replication has succeeded, like in Indonesia and India, small-scale systems often suffer from the lack of proper management and insufficient monitoring schemes (Parkinson et al. 2003).

Scaling up entails more than replicating a large number of discrete projects (Eales et al. 2013). It requires innovative management and institutional schemes, innovative financing plans and, often, inclusion of the private sector (Abey Suriya et al. 2007; Evans 2013). It requires different institutional arrangements depending on the location to make the most effective use of available resources. There is a need for mechanisms to strengthen multi-sectoral coordination, cooperation and accountability between sector departments. Furthermore, implementation approaches need to be aligned with funding and project implementation cycles, respective of government requirements. Governments often do not have the capacity and resources to shape and nurture a multitude of small projects in the way that an NGO network can when working at a modest scale (Eales et al. 2013).

Egypt, as many low- and middle-income countries, is symptomatic of these trends. Small-scale sanitation is seen as very promising alternative for the numerous isolated small settlements in the country as well as in the region (Bakir 2001; Engin et al. 2006; Afferden et al. 2010). However, initiatives so far failed to be institutionalised and replicated. The reasons for failure are usually multiple and rarely of a technical nature, but related to a poor enabling environment. The enabling environment is increasingly seen as the key for sustainable sanitation (Lüthi et al. 2011a,b; Parkinson et al. 2013), as the major barriers to progress in sanitation coverage lie within the institutions, policies and realities of low- and middle-income countries (Medilanski et al. 2007; Lüthi et al. 2011a).

This report investigates the financial side of small-scale sanitation in Egypt and provides a baseline for the costing of decentralised scenarios at village level.

2 Concepts

In what follows, a few general concepts of financial analysis are explained. They should be applied when comparing options in a comprehensive way.

2.1 Cost categories

Many different types of costs must be encompassed in a complete financial analysis, such as illustrated in

Figure 1 (WASHCost, 2012):

1. Capital expenditure
2. Cost of capital
3. Operating and minor maintenance expenditure
4. Capital maintenance expenditure
5. Expenditure on direct support
6. Expenditure on indirect support

These costs can be categorised into one time expenditure (the capital expenditure, i.e. the initial investment) and recurrent expenditures (all the other costs, especially O&M costs).

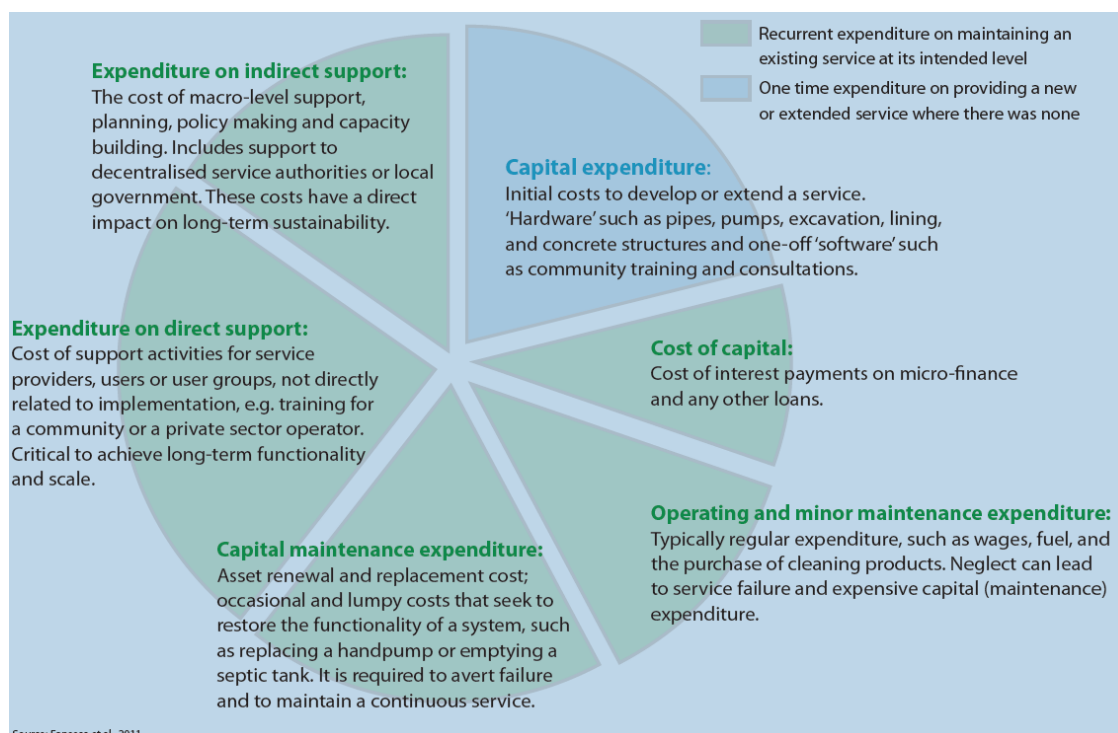


Figure 1: Life-cycle costs (source: WASHCost, 2012; Fonseca et al., 2011)

2.2 Life-cycle cost analysis

The life-cycle cost analysis is the analysis of all costs over the life duration of an infrastructure. It allows to compare different systems based on what they will actually cost to the Utility, and not only based on the capital investment costs, as unfortunately often seen in practice. To illustrate this approach, the example of cars can be taken: on a life-cycle cost analysis basis, an expensive but very robust car will often appear to be cheaper for its owner on the long-run than a cheap car that breaks down every year.

2.2.1 Net present value and discount rate

In order to calculate the cost of an infrastructure over its whole life time, all future costs must be brought to their present value, provided that the value of money changes over time (hence the concept of “time value of money”). There are two main methods to do that: the *net present value* and the *equivalent annual costs*. In both methods, there is one key concept to encapsulate the time value of money: the *discount rate*.

As explained by Pinkham et al. (2004), all other things being equal, one would rather have a given amount of money now than in the future, or expend a given amount in the future rather than now. This is because a dollar earned or saved now can be invested and will provide more value in the future, and a dollar spent in the future can be “paid for” with a smaller amount of current funds that grows to the needed value in the future. To reflect this, project analysts adjust nominal costs—current and future costs estimated in constant (non-inflated) or current (inflated) dollars—by applying a *discount rate*. The discount rate reflects a compound yearly rate of decline in the value of money over time. Discounting future costs equalizes costs in the future with those in the present and provides a uniform basis for comparing projects with differing cost streams over time. Project revenues that offset costs, such as the value of reclaimed water sold to water systems or customers, or sales of sludge, can be similarly discounted.

Discounting streams of costs occurring over time, depending on the particular approach used, yields either a figure for “net present value” (or “present worth”) or a figure for “equivalent annual costs” (or “annualized costs”). Both methods produce analytically equivalent results, but net present value is generally preferred. In any case, the full lifecycle costs of all alternatives must be evaluated. These include capital costs to build a facility, future capital costs to rehabilitate or upgrade the system, and ongoing operation and maintenance costs over the project’s lifetime. In addition, differences in the residual value of assets at the end of the project lifetime must be accounted for.

Planning horizons for centralised treatment plants are generally large, typically around 30 years. Forecasting the needs for such a long duration is very tricky and prone to large uncertainties. As a consequence, it commonly leads to overcapacities.

Depending on the growth rate, these can be quite substantial and raise the question as to the conditions in which it would be beneficial to apply modularisation. By breaking a given future capacity need into smaller units of capacity, decentralized systems allow costs for each increment of capacity to be pushed to the future, when the next increment is needed. In comparison, centralized facilities usually require larger “lumps” of investment up-front, based on a projection that a certain amount of service-area growth will occur and demand will “grow into” the excess capacity over time. Discounting future-loaded cost streams results in lower net present value, and thus lower costs, compared to a front-loaded cost stream of similar nominal cost. Moreover, a nominally more expensive future-loaded cost stream can also be cheaper.

Decentralized systems may for example be a “better buy.” Such a result can occur in areas where the density of development being served is around the “breakeven point” between the advantages of centralized systems in gaining economies of scale in treatment systems and the advantages of decentralized systems in avoiding diseconomies of scale in collection systems.

2.2.2 Specific net present value

Maurer (2009) argues that the commonly used NPV is not adequate to evaluate water treatment plants in a growth scenario. A new evaluation approach, known as the specific net present value (SNPV) method, is consequently introduced.

The specific net present value is an improved method for assessing modularisation costs in water services with growing demand. The SNPV expresses average costs, including the growth rate and plant utilisation over the planning horizon, factors that are excluded from a standard net present value approach. The use of SNPV favours alternatives that are cheaper per service unit and are therefore closer to the costs that a user has to cover. It also shows that demand growth has a similar influence on average costs as an economy of scale. In a high growth scenario, solutions providing less idle capacity can have higher present value costs and still be economically favourable. Two other factors are particularly important: (i) the interest gained by delaying part of the investment until the future, and (ii) the useful life of the stages implemented later, which may not end at the planning horizon, depending on the technology chosen for modularisation. Both factors favour modularisation. High (real) interest rates favour small-scale systems, especially in high-growth situations. We thus recommend that in future economic analysis, modular approaches are included and that comparison is made with the SNPV method.

3 Data collection

The data collection succeeded through interviews of sector experts, the evaluation of past small-scale sanitation initiatives in Egypt, household surveys and field observation, as well as data requests to designers and producers (see ESRISS Report “Challenges and Ways Forward”, “Baseline Data” and Appendix of this report).

A big challenge is to get the real price of a sanitation system, i.e. what it actually costs in terms of materials and human resources, without overheads. This is basically what communities or governmental agencies should pay if they want to implement a system. Next to that, it is very difficult to make full estimations for comparable systems. In order to be compared, sanitation systems should reach the same effluent quality.

Because data on existing systems was not available or not representative, we tried to estimate the costs of an anaerobic treatment system designed to treat 100 m³/day (which we assumed equivalent to the wastewater production of 1,000 inhabitants). Because we were interested in prefabrication, two scenarios were developed:

1. Prefabricated with fibre glass based on the model from BORDA.
2. Conventional fabrication out of concrete, based on the bill of quantities (BOQ) of an anaerobic treatment plant designed by a Swiss expert, consisting of a settler, anaerobic baffled reactors (ABR) and anaerobic filters (AF).

Different companies were requested to submit an offer, out of which a few replied.



A small-scale prefabricated treatment plant (Al Raed Jetmaster Kimatech 2000)

4 Costing the current sanitation situation

The following section exposes the costs² that the inhabitants of the villages under investigation currently bear for drinking water and sanitation, both for bayara emptying and construction and maintenance of informal sewer networks. The study shows that the costs are highly variable and that people in villages have to pay much more for sanitation than people living in big cities like Cairo. This data is reproduced from the ESRISS “Baseline Data” report (2014).

4.1 Drinking water

The water consumption was computed in three villages through several readings of the same water meters. The price paid for drinking water, as well as its variation between summer and winter, was obtained with the household survey questionnaires.

It shows that the water bills are not directly linked to the building consumption. The water company reader comes from one time per month to one time every four month (answers from several household in K. Nuss) and seems to give fixed bills (i.e. lump sums). 20-25% of the interviewed households have water meters which are not readable or are just not working, which tends to prove the non-proportionality of water bills, and the sometimes random basis of the price.

Officially the price of water is digressive depending on the water consumption (Table 1). Prices may have increased a bit in 2013.

Table 1 Tariff system in the governorate of Beheira (Values in 2011)

Consumption [m ³ /month]	1-10	10-20	20-40	>40
Price [EGP/m ³]	0.23	0.35	0.45	0.5

The fees were checked in the three villages of the second field campaign. The computed amount is uncertain due to the approximate answers of villagers, but draw a general idea the prices. The average price vary between 0.7 (K. Nuss) to 1.1 (M. Nassar) EGP per cubic meter. Even if these values are highly variable (e.g. standard deviation of 0.54 in M. Nassar), they are systematically higher than the official price. Due to a high variation within the same village, no comparison between villages can be drawn.

On a per capita basis, the average fees for drinking water in villages vary from 13 (in Ashara) to 42 EGP per household per month (in M. Nassar) or between 2 and 5 EGP per capita per month.

² 1 USD = 7.8 EGP in December 2015

4.2 Bayara emptying

Emptying of the *bayaras* is a significant burden for the household budget in villages served by such on-site facilities.

One trip of a privately owned emptying truck costs on average 25 EGP (based on the answers of 30 households in 3 villages and of four bayaras emptiers). Public trucks are generally cheaper, but they are less frequent and they mostly stay in the mother-village. In Kabeel, a public truck (not from the village) cost 8 EGP/trip but was only used by 20% of the inhabitants. The public truck of Besentway cost 8.5 EGP/trip but add a tax for trips outside of the village. In Hadery none of the interviewees used or knew the price of a public truck.

80% of interviewees in Ashara and 60% in Hadery say that they empty completely their bayara each time. This implies that the truck makes 1-8 trips per bayara depending mostly on the size of the on-site sanitation system. On a village average, the truck makes 2-3 trips per bayara.

The frequency of emptying is high (on average, every 10-30 days). In some villages, there is seasonal variation with a lower frequency summer. In Ashara, emptying occurs on average every 20 days in summer and every 25 days in winter. This leads to an annual cost of 1050 EGP per house per year or 130 (± 60) EGP/cap/yr (based on the answers of 11 households). This is not the case in Hadery, which may be caused by constant infiltration of groundwater. There, emptying occurs on average every 10 days, there is an average of 3.1 trips per bayaras and private emptying costs 25LE/trip. This leads to an annual cost of 1800 EGP per house per year or 340 (± 150) EGP/cap/yr (based on 14 answers).

4.3 Informal sewer networks

In villages with an informal sewer network, the regular expenses related to sanitation are much lower. Even though such networks need very frequent maintenance works (mainly unclogging), the cost does not exceed 2-3 EGP per household per month.

The average expenses of a household related to the informal sewer network are:

- The share that each household pays for the installation of the main lines of the network, which varies a lot from one village to the other (150-1200 EGP/household); on average it amounts to about 530 EGP/household (based on the answers of 35 households in four villages).
- Installation of the household connection varies also from one village to the other (350-1000 EGP/household); on average, it is 550 EGP/household (based on the answers of 41 households in four villages).
- Costs for maintenance amounts from 0 EGP when villagers fix the problems themselves to 40-50 EGP/household/yr when there is a person responsible for maintenance.

Assuming a lifetime of 20 years for the main network and the household connection this amounts to less than 25 EGP/cap/yr.

4.4 Synthesis of water and sanitation costs

Table 2 compares the costs paid for water and sanitation in the six villages under investigation. **It highlights the very high costs that the villagers relying on traditional bayaras have to pay, sometimes 20 times more than those served by governmental sewer systems.** On the contrary, it shows how insignificant the amount paid for wastewater services from the water bills is.

Looking at these costs, it is well understandable that organised communities are willing to collect the amount of money needed to build a sewer network. The data show that the investment is offset only in a few months to about three years, depending on the village situation. It is however important to note that most of these “informal” sewer systems are not built according to the state-of-the-art, but are rather the cheapest and shallowest pipe networks able to transport the wastewater to the nearest drain. If villagers would build proper shallow sewer systems, the price would certainly be higher. However, on the medium term, in most cases, it would still certainly be more cost-effective than keeping the bayaras.

Case-by-case financial comparisons should be made in order to encourage villagers to invest. If the investment costs are too high to be paid at once, leasing mechanisms could be thought of, with monthly payments that are inferior with the amount currently paid for bayara emptying.

Table 2: Comparison of the water and sanitation costs in sewerred and non-sewerred villages

Costs	Unit	Averages per capita (for different villages)
Amount paid for the water bill	LE/cap/month	2-5
35% for wastewater services	LE/cap/month	0.7-1.7
50% for wastewater services	LE/cap/month	1-2.5
Amount paid for bayara emptying	LE/cap/month	7-28
Household connection to an informal sewer network	LE/cap	25-125
Main sewer line of an informal sewer network	LE/cap	25-140
Maintenance of an informal sewer network	LE/cap/month	0.3-3

5 Septage emptying business

Many villages rely on pits (or “bayaras”). Once the pits are full, they have to be emptied. The need for pit emptying is high, as shown in section 4.2, and the service expensive for the households; it is a significant burden for the household budget in villages served by such on-site facilities. The emptying business in the delta is mainly held by the private sector. It is a sanitation system in itself, with the drawbacks of the cost for the households and the uncontrolled disposal of the septage into the drains. It is however the source of **a lucrative business, employing a whole corporation of private sanitation workers**. In what follows, this business is analysed in order to check the conditions for its financial sustainability and, in a longer term perspective, to see how it could be integrated into a wider sanitation system including septage treatment plants.



Septage emptying operator in El Haderi village, Beheira

5.1 Initial capital investment

The capital expenditure (CapEx) of the four vacuum truck operators surveyed are second-hand components with the following cost-breakdown: the tractor is the most expensive investment item (EGP 80,000), while both cistern (EGP 30,000) and pump (EGP 3,000) account for less than a quarter of the total CapEx (see Figure 2). In theory, the tractor and cistern can have a lifetime of 20 years, the pump a lifetime of 15 years. The evaluation is derived from a single data set, which applies

both to private and public trucks. An in-depth investigation would be required to strengthen the baseline.

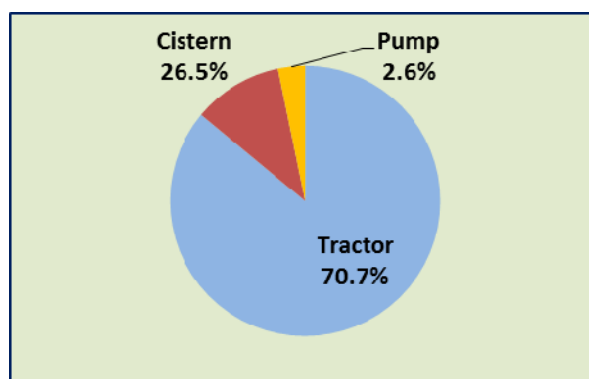


Figure 2: Proportion of the cost items in the capital investment for a vacuum truck

A new RAKOVICA tractor made in Serbia (circa 76 horsepower) costs around EGP 120,000, while an Egyptian brand like NASR (circa 60 to 65 horsepower) costs around EGP 40,000 to 45,000 on the second-hand market. An imported tractor of the BELARUS-type (60 horsepower) cost up to EGP 75,000 excluding import duties and shipment costs. The occurrence of brands and the availability of affordable spare parts varies from one governorate to the other, which influence the overall costs.

5.2 Operational costs

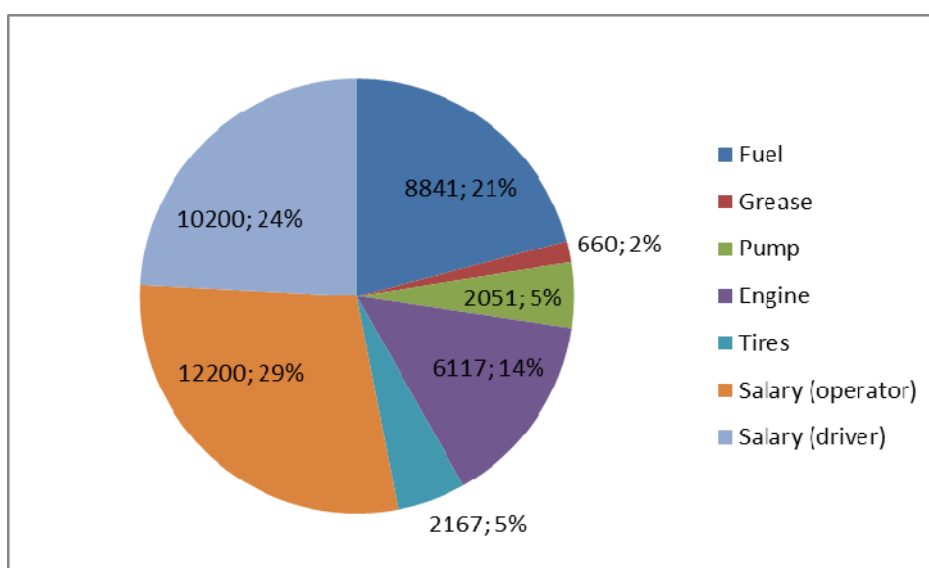
The available data for the operational costs (OpEx) is a mix of different sources. The cost items include the mechanical maintenance (engine, pump and tires), wages and fuel. The wages are the highest cost item followed by fuel expenses as shown in Table 3 and Figure 3. Public wages were found to be fix, while private wages fluctuate according to the amount of revenues collected.³ The limited amount of data collected (due to the private nature of the wage question often resulting in indirect answers) asks for further investigations.

The engine maintenance (tractor maintenance cost) represents a significant fraction of the average OpEx. The relatively small amount spent on fuel in comparison to other costs is explained by the subsidized fuel prices (EGP 1.1 per liter in 2012) and the rather short distances between the villages and the discharge points.

³ In this case the driver's wage was calculated by subtracting engine, fuel, tire and pump OpEx from the revenues (assuming a fee of LE 20; an average of max. 12 trips during the day; 20 working days during the month; 11month in the year including holidays and Ramadan). The wage for the helper was estimated to be approximately half the wage of the driver.

**Table 3: Average yearly operational expenditures of bayara emptiers
(mix from public and private trucks)**

	Average OpEx [EGP/year]
Fuel	8841
Grease	660
Pump	2051
Engine	6117
Tires	2167
Salary (operator)	12200
Salary (driver)	10200
TOTAL	42236



**Figure 3: Approximate distribution of OpEx cost items [in EGP per year]
of one of the bayara emptiers interviewed**

The number of trips per truck per day is highly variable and may be influenced by factors like the tank size and distances between collection and discharge points. One answer which was given for the frequency was 20 to 25 trips per day, another was 6 to 8. There is a difference in the working hours between the public and private service providers. Public trucks have often fix working hours; in one case a village council truck was found to be in service only for a limited time during the day (8 am to 2 pm). In other villages, the public truck driver has regular 8 working-hours day. On the contrary, private operators work on demand and, thus, have the potential for higher benefits.

As discussed in section 4.2, typical prices per trip lay between 20 and 25 EGP. Considering the total average amount of operational expenditures per year, as given in Table 3, the following calculation can be made to cross-check the plausibility of the data, providing that it is a financially sustainable business. For this calculation, we assume an average of 8 trips per day, 24 working days per month and 11 months of work in the year, including holidays and Ramadan:

Average daily income: $42236 / (24 \times 11) = 160$ EGP/day

Price per trip: $160 / 8 = 20$ EGP/trip

The amortisation of the capital expenditure is not explicitly taken into account here, because the condition of acquisitions are not clear and the extent to which the operators have to amortise is not clear either. In the case of public trucks, the investment in the truck itself may come from other budget, and it is not sure that it has to be amortised through the income it generates. In the case of private trucks, it is probable that the tractor was bought and used for other purposes before being used for bayara emptying. Besides, we consider here two salaries, one for the driver and one for the operator. Most of the time, the bayara emptier operates alone. In some cases he owns his truck, in some others not. Thus, if there is amortisation, it would be mainly included in the revenue for the operator.

5.3 Improved septage management schemes

The study shows that septage/faecal sludge emptying is a widespread and lucrative business in the Nile delta. The government should build on such practices. What is currently missing are septage treatment units located near the villages (max. 2 km). If the regulations allow, this units could be advanced primary treatment units placed next to the drains, if possible close to the current disposal points. Such units could probably be placed partially on land owned by MWRI. This is a great synergy to exploit, as pollution could be reduced up to 80% and the quality of drains improved significantly.

The location of the treatment units close to the villages is key for success (Reymond, 2014b). As this study shows, fuel costs are an important cost item for septage emptying service providers. The time needed for each trip is also a limiting factor. We can imagine that if the service providers are forced to go and discharge in a faraway treatment plant, such as suggested in a few strategy documents, the costs will be reported on the fees which are already high, thus making them unaffordable, or simply making the business not financially sustainable anymore. We can estimate that doubling the distance for discharge would imply an emptying fee increase of at least 50%. Consequently, requesting the service providers to go to existing WWTPs is most of the time not realistic. Besides, the WWTPs are often not designed to receive septage.

It is important that the government includes this private sector in its sanitation scheme, instead of trying to substitute them through other services. Different financial mechanisms are possible to ensure that the private service providers discharge in the septage treatment units and that the Utility get part of the fee to cover the O&M of these systems. We recommend to refer to the IWA Faecal Sludge Management book about this topic, in particular the chapter about *Financial Transfers and Responsibility in Faecal Sludge Management Chains* (Tilley and Dodane, 2014).

For example, in the case of multiple small-scale septage treatment units without permanent staff, a mechanism such as shown in Figure 4 could be applied.

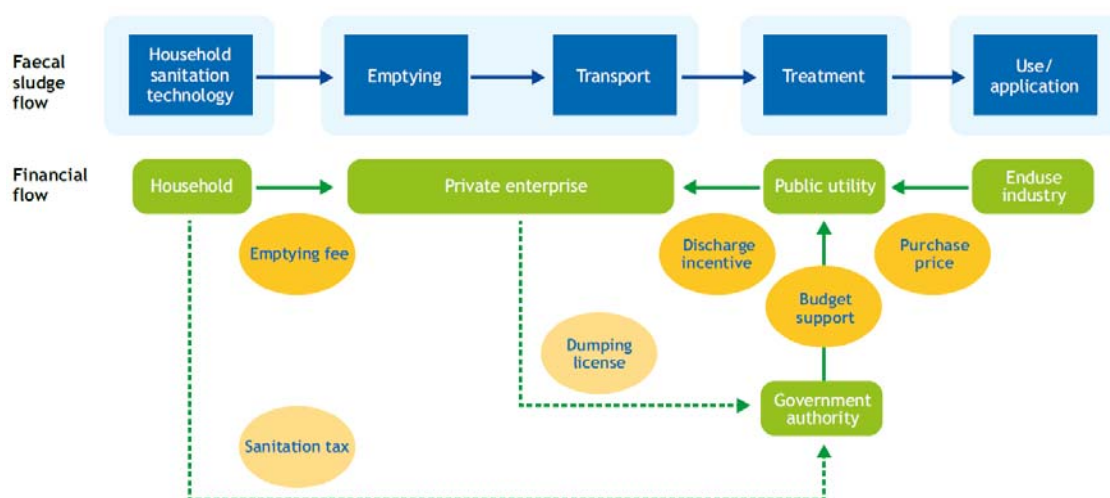


Figure 4: Incentivised discharge model (source: Tilley and Dodane, 2014)

6 Costing potential treatment options

In order to estimate the cost of different wastewater treatment options, unit prices were collected among different suppliers and practitioners. For those which are still not implemented in Egypt, like prefabricated anaerobic baffled reactors, the estimation was made based on the price of similar products, such as prefabricated tanks.

6.1 On-site construction with concrete

The system consisting of a settler followed by an anaerobic baffled reactor (ABR) and anaerobic filters (AF) was investigated, for a design capacity of 100 m³/day. The design and bills of quantities were provided by the Swiss company Autark, which builds such systems in low- and middle-income countries (www.autark.ch). The bills of quantities were then filled up by the Egyptian company Gama, and are provided in the Appendix 10.2. They can also be found in the Excel sheet *BoQ-settler-ABR-AF-Autark*, including one Excel sheet for the settler and one Excel sheet for the ABR and AF.

6.1.1 Design of the scenario

The design of the “high-rate anaerobic reactor” for 100 m³/day proposed by Autark was taken as a basis. Figure 5 and Figure 6 show the scheme and dimensions of the system, whereas

Table 4 features the design parameters and footprint. The bills of quantities are provided in the Appendix 10.2.

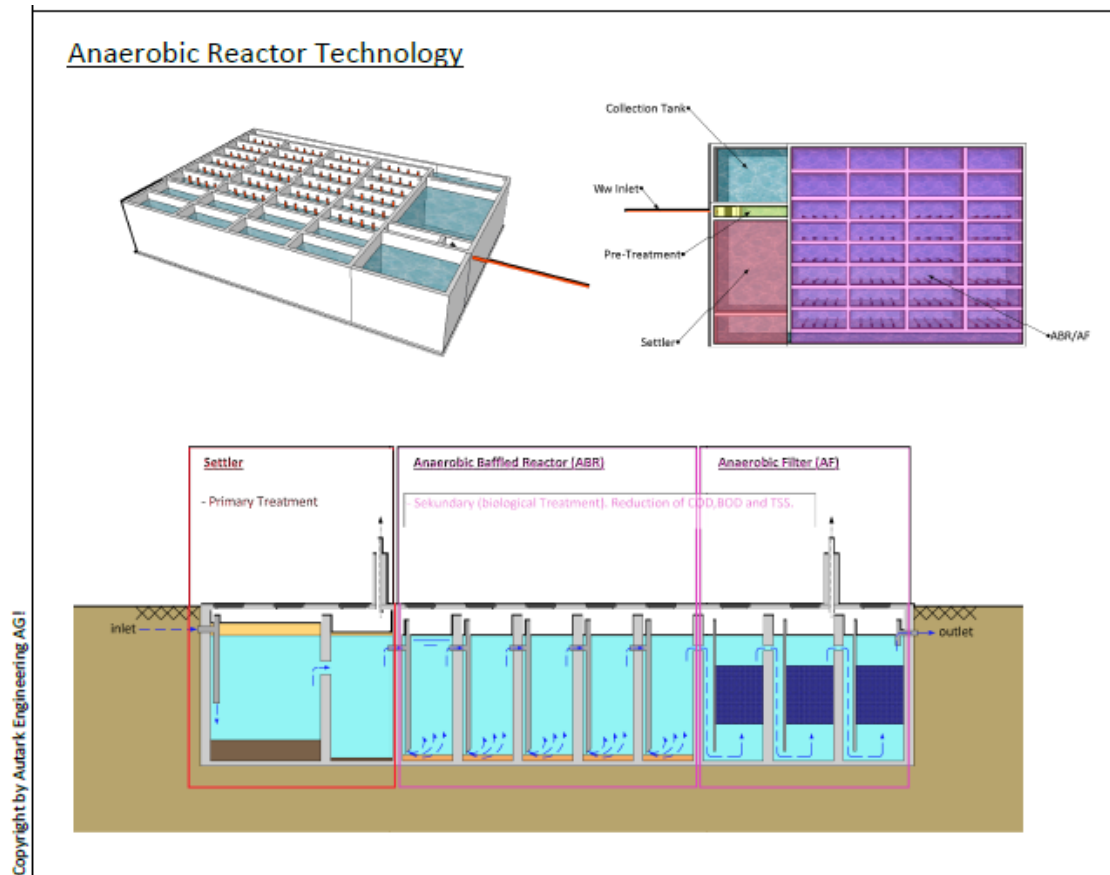


Figure 5: Scheme of the investigated scenario (settler followed by an ABR and AF) (©Autark)

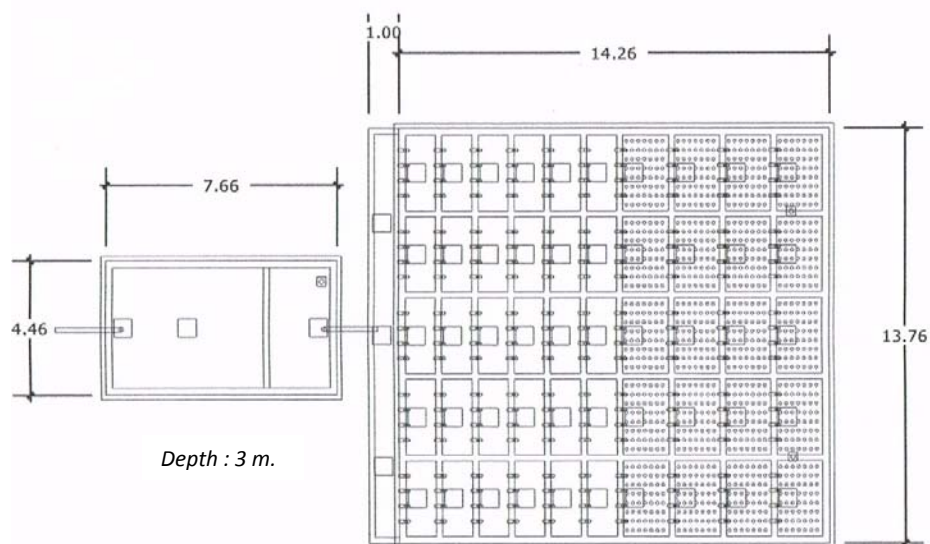


Figure 6: Dimensions of the investigated scenario

Table 4: Design parameters and footprint of the investigated scenario

Domestic ww Users: 750 ww production: 132L/p*d Q= 100m ³ /d CODin: 800mg/L BODin: 410mg/L CODout: <100mg/L BODout: <20mg/L BG: ca. 16m ³ /d (G 35kWh/d) SP: ca. 30m ³ /a	Model No	Plant Capacity	AD Reactor Footprint (Below Ground)	Treated Water Tank (Below Ground)	Backwash Water Tank (Below/Above Ground)	Plant Footprint (Above Ground)
		[m ³ /d]	[m ²]	[m ³]	[L]	[m]
	AD+ 5	5	10	1.4	250	1x3
	AD+ 10	10	20	3.9	300	1x3
	AD+ 15	15	30	6.8	500	1.5x4
	AD+ 20	20	38	9.9	500	1.5x4
	AD+ 30	30	55	14.7	1,000	2x5
	AD+ 50	50	90	22.8	1,000	2x6
	AD+ 75	75	135	33.4	1,500	2x6
	AD+ 90	90	162	39	1,500	2x6
	AD+ 100	100	180	42.5	2,000	3x6
	AD+ 125	125	225	47.4	2,000	3x6
	AD+ 150	150	270	54	3,000	3x8
	AD+ 200	200	360	66.6	3,000	4x8
	AD+ 225	225	400	72.6	3,000	4x8

6.1.2 Estimated costs

The information above was sent to three companies, out of which Gama company replied (cf. Appendix 10.1.2). The bills of quantities filled with the Egyptian unit prices are provided in the Appendix 10.2; the prices are from the year 2013.

The total estimated costs for this scenario amounts to around 680,000 EGP, divided in around 600,000 EGP for the construction of the ABR and AF and around 80,000 EGP for the settler. The bills of quantities are summarised in Table 5. This is equivalent to about 100,000 USD, which means a cost of about 100 USD per capita provided that 100 m³/day in Nile Delta conditions is equivalent to the wastewater production of about 1,000 inhabitants.

Table 5: Summary of the bills of quantities for the construction of a settler followed by an ABR and AF, for a design capacity of 100 m³/day (prices from year 2013)

Settler		Amount [EGP]
A	Earth Work	4698
B	Plain Cement Concrete (foundation)	2964
C	Reinforced Cement Concrete	51430
D	Masonry	1996
E	Inside plastering	4050
F	Pre-cast manhole covers	1296
H	Ventilation	4977
I	Wastewater pipes	6150
TOTAL SETTLER		77561

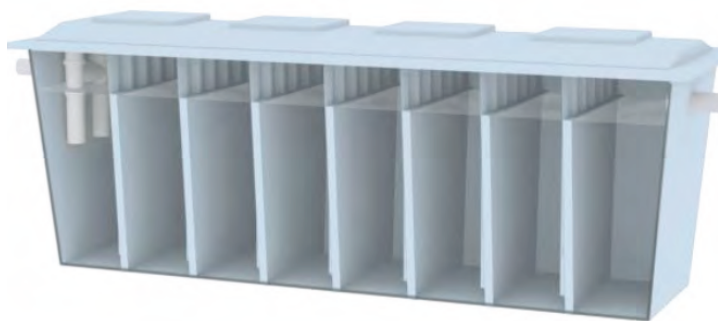
High Rate Anaerobic Reactors		Amount [EGP]
A	Earth Work	27945
B	Plain Cement Concrete (foundation)	16068
C	Reinforced Cement Concrete	194193
D	Masonry	38922
E	Inside plastering	51570
F	Pre-cast manhole covers	17172
H	Ventilation	19098
I	Filter Material	7875
J	Perforated slabs for FFR filter	0
K	Beams for perforated slabs	8580
L	Wastewater pipes	214680
TOTAL ABR &AF		596103

To be noted that the slabs are in fiberglass with four access covers for desludging.

6.2 Prefabricated fibre glass units

To estimate the cost of this scenario, the design of the prefabricated fibre glass ABR from BORDA was sent to several consultants. The dimensions of this modular unit is shown in Figure 7. Given these dimensions, a treatment plant with a design capacity of 100m³/ day, such as the one describe in Section 6.1 would consist of fourteen vessels, ten as ABR and four as settlers.

The price of such a unit could be estimated through the prices of similar prefabricated units available on the Egyptian market (i.e. in other materials but with similar characteristics).



Large Vessel

l/w/h: 5,5 / 1,75 / 1,8 m

Figure 7: Prefabricated fibre glass unit (©BORDA)

The inquiry was answered by two companies specialised in prefabricated fibre glass tanks, Al Dawleya and Al Rowad (cf. Appendix 10.1.2):

- The quote from Al Dawleya amounts to 25,900 EGP for a fibre-glass tank with the dimensions provided. The price for the fourteen units reaches 362,600 EGP, about 400,000 EGP with sales tax (10%). This price include transportation cost to the site and is valid for year 2013.
- The quote from Al Rowad amounts to 280,000 EGP for the fourteen units, without sales tax and transportation costs. We can assume that if these costs were included, the total would amount to about 350,000 EGP. The tanks are made from fibre glass with polyester which resist the sewage water (Isovetalic 7440) and coated.

To be conservative, the offer from Al Dawleya will be considered for the following calculations.

It can be assumed that the costs for the land preparation, excavation and plain concrete slab are similar to the conventional scenario above and amount to about 80,000 EGP. Thus, the total amounts to about 480,000 EGP. Considering the conventional scenario without the ventilation system and the filter compartments, it can be concluded that the hardware costs for the prefabricated scenario are about 15% cheaper.

Besides, the implementation costs are certainly much cheaper, as the time needed to implement prefabricated units is much shorter. For example, considering an implementation time of 1 month instead of four months, we can imagine implementation costs that are only about 25% of those with a conventional approach.

6.3 Al Raed's prefabricated metal sheet units

Al Raed is an Egyptian private company producing prefabricated wastewater treatment units out of metal sheets. Its "Jet Master Kimatech 2000" consists of prefabricated tanks made of steel epoxy sheets and functions as a series of batch reactors (see Figure 8 and the ESRISS Factsheet Report):

1. A *settling tank*, where sedimentation is accelerated through the addition of ferrochlorite, which increases the flocculation and coagulation;
2. An *oxidation tank*: the oxidation is done through calcium hypochlorite and sodium hydroxide; it kills also a big part of the pathogens;
3. Optional: a cartridge filled with activated carbon filter, a UV tube and a ultrafiltration membrane filter, which represent about 20-30% extra price.

The price estimation received in October 2012 for a compact wastewater treatment unit in the capacity of 100m³/day amounts to EGP 400,000, which includes the electro-mechanical works and sedimentation tanks and oxidation.

The price estimation for the civil works is the following:

Item	Cost
<ul style="list-style-type: none"> Concrete foundation (4*8) holding Tank in the capacity of 50 m³ sludge tank in a capacity of 15m³ fence 	<ul style="list-style-type: none"> EGP 50000 EGP 70000 EGP 45000 EGP 60000

The reported operation costs for the chemicals amount to the following:

No.	Type	Consumption Average		1Kg Price	Monthly
		Daily	Monthly		
1	Ferric chloride	8kg	240Kg	EGP 3.00	EGP 720
2	Sodium hydroxide	1.8kg	54Kg	EGP 3.00	EGP 162
3	Calcium hypochlorite	1.8kg	54Kg	EGP 3.00	EGP 162
Total cost for chemicals /month in the amount of EGP 1044, in case of full unit daily operation in the capacity of 100m3/day all the month with domestic sewage.					

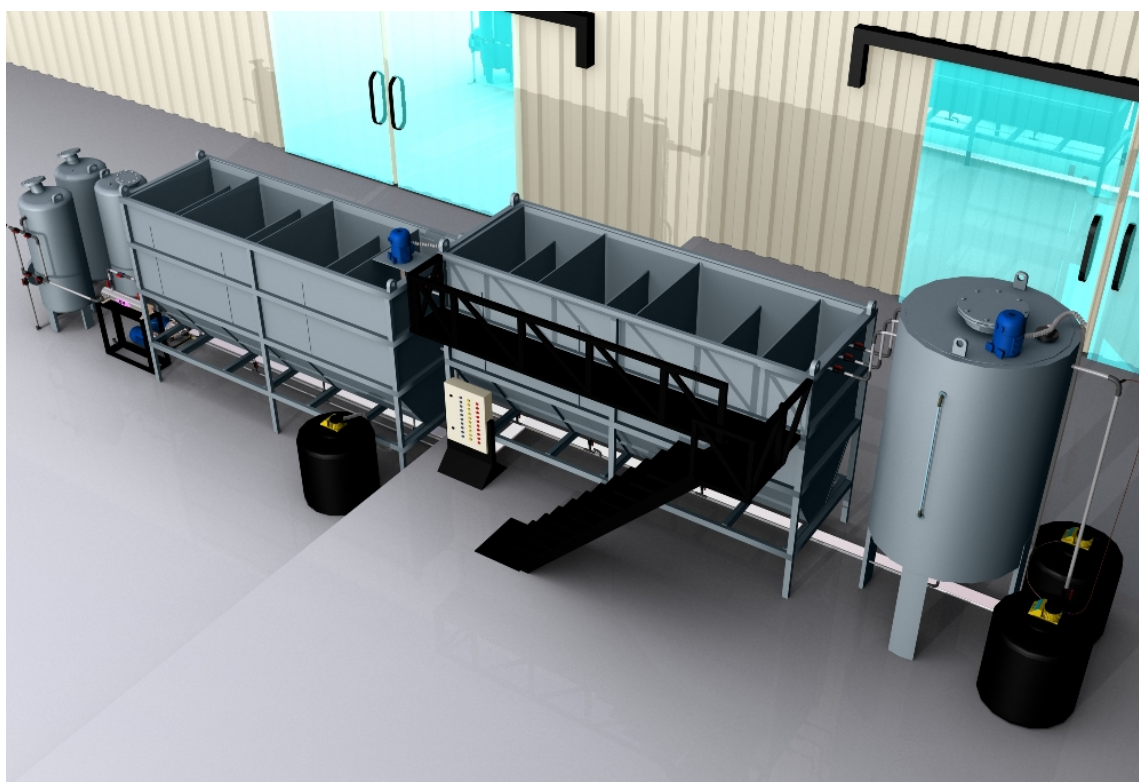


Figure 8: Al Raed Jet Master Kimatech 2000 (©Al Raed)

7 Towards cost-effectiveness

Cost-effectiveness is a main argument to select a system over another. However, many factors influence the costs of a system over its life cycle, making the comparison of scenarios difficult. The following paragraphs review different parameters to take into account and discuss the pros and cons of large-scale centralised vs. small-scale system and conventional implementation vs. prefabrication.

Treatment system capital costs typically reveal economies of scale (costs per unit decrease as size increases). This is well-documented, and obtaining economies of scale in treatment - and operations - is often the focus of facility planning. This focus must be carefully moderated, however, because diseconomies of scale (costs per unit increase as size increases) often occur in collection systems. **Because collection systems often account for 70–90 percent of total wastewater system capital costs, diseconomies of scale in a collection system can offset or overwhelm economies of scale in treatment plant size and O&M.**

What is more, there are a number of factors in the way to plan small-scale systems and the flexibility they offer which can lead to significant cost savings.

7.1 Modularity and incremental implementation

The financial benefits of small-scale systems are to be found on different aspects: reduction of the net present value of infrastructure (for a briefing on NPV, see section 2.2.1), incremental implementation through a modular approach, reduced planning horizon, to quote only a few. These factors were very well synthesised by Pinkham and al. (2004), as reproduced in the list below.

The main factors inducing a **reduction of the net present value** are the following:

- By (typically) moving capacity costs to the future, the net present value of costs for small-scale systems is reduced compared to centralized systems of similar or even somewhat higher nominal costs.
- Small-scale systems can reduce the net present value of wastewater system costs by deferring or downsizing the need for replacement systems.
- **The unit size of small-scale systems allows closer matching of growing demand for wastewater capacity**, as illustrated in Figure 9; therefore, less money is tied up in overbuilt capacity.
- Shorter lead-time and smaller size **reduce the planning horizon**, consequently decreasing the amplification of errors in forecasting demand with the passage of time.
- Small-scale wastewater systems provide alternatives to the engineering profession's traditional tendency to approach uncertainty and risk by overbuilding (see also section 7.9).

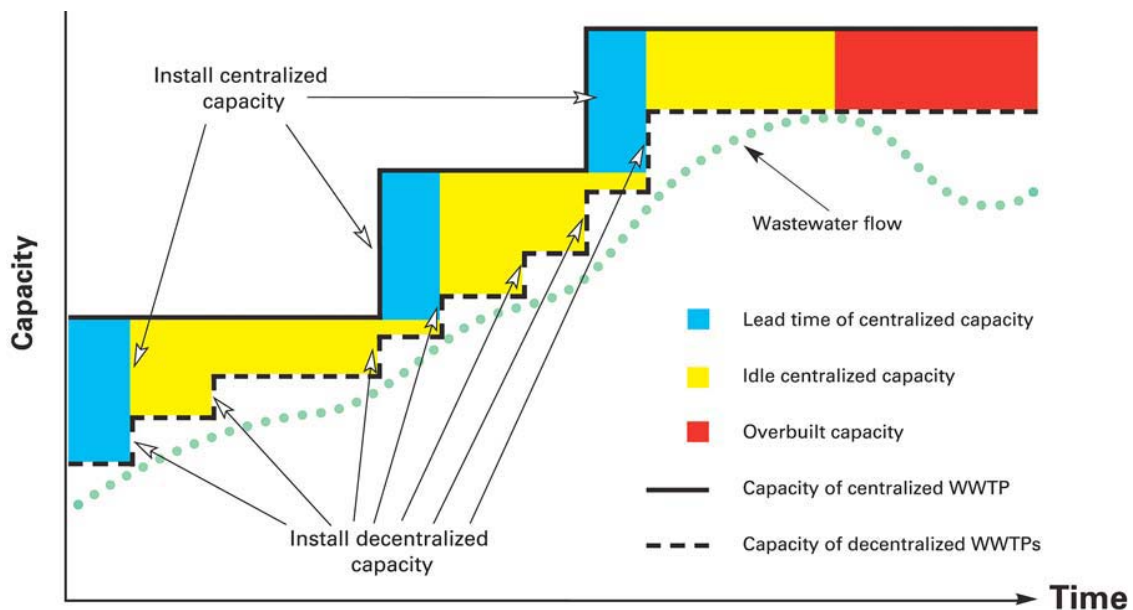


Figure 9: Reducing idle capacity and thus saving money with small-scale modular sanitation systems (© Rocky Mountain Institute, 2004 - *Valuing Decentralized Wastewater Technologies*)

Different factors lead to **more pragmatic and cost-effective implementation strategy, close to the actual needs:**

- Small-scale systems can shorten project lead time - e.g. the construction period - further reducing the cost of tying up funds unproductively.
- In cases when future demand fails to meet expectations, additional scheduled increments of small-scale capacity can be foregone, avoiding the cost of overbuilt centralized capacity.
- **Modular, short-lead-time technologies** valuably temporize: they buy time, in a self-reinforcing fashion, to develop and deploy better technologies, learn more, avoid premature decisions, and make better decisions. The faster the technological and institutional change, the greater the turbulence, and the more uncertain are future needs, the more valuable this time-buying ability becomes.
- Smaller, quick-to-build units of small-scale wastewater capacity offer flexible options to planners seeking to minimize regret, because capacity can be added or foregone to match actual demand.

These different benefits usually outweigh the diseconomies of scale proper to small-scale systems, such as (adapted from Pinkham and al., 2004) :

- Smaller systems miss economies of scale in wastewater treatment systems.

- Very small wastewater facilities require higher capacity per capita in order to manage variability in hydraulic loads produced per connection.
- High effluent standards tend to favour centralized treatment. In Egypt, it even “killed” small-scale systems so far, thus leading to a “all or nothing” approach and the current low rural sanitation coverage.

7.2 Benefits of prefabricated units

Currently, the private sector seems to be mainly playing against small-scale sanitation: high resistance to innovation, lack of know-how in that field, huge overheads, poor construction quality and very long implementation time.

A paradigm shift is needed to turn the private sector into an ally. The role of the private sector would be two-fold:

- **Designing, build and monitor** monthly the small-scale sanitation systems; the design-build-operate type of contracting is overly important here.
- **Manufacture prefabricated components** of the sanitation systems (treatment modules, manholes, etc.), in a first stage through joint ventures or partnerships with foreign companies specialised in this market.

It is recommended to standardise the systems and prefabricate as many components as possible. Prefabrication leads to an increase in quality and reduction of costs, through the following mechanisms:

- Quality under control
- Costs under control; no price negotiation every time
- Monitoring of contractors
- Time saving in construction process
- Locally produced

Small-scale sanitation is a new market in Egypt, and, as such, it has a huge potential in terms of private sector development and job creation. For the creation of this market niche to succeed, it is critical to develop a solid business model. A feasibility study should be made to convincingly demonstrate that small-scale sanitation is a good business and that it is bankable.

To have the private sector on board, **a business-oriented policy is needed.** It is important to build an “incubator” or a “hub”, which can facilitate the private sector to enter this niche. The question is where to embed this incubator. At the government level, the Ministry of Investment seems well placed to take such a role, as it has the power and experience to facilitate the emergence of new markets. The national strategy should enable the creation of market niches and job opportunities.

Small-scale sanitation systems function in the touristic resorts, as the enabling conditions are obviously present for this market to work. As for rural sanitation, the enabling environment and the incentives still need to be defined for the private sector to get in.

It is recommended to determine which stakeholders have the ability to encourage the private sector, and which stakeholders have an interest in developing the local industry. When looking at rural sanitation, both the demand side and the supply side should be considered and a dialogue between the different concerned institutions and the private sector should be initiative.



Small factory for prefabricated anaerobic treatment components in fibre glass, Bangalore, India (CDD Society, BORDA DEWATS)

7.3 Border between conventional and prefab

Prefabricated units can be used for different items of the collection and treatment chain. For each item, the choice between a prefabricated or conventionally-built item depends mainly on the capital price, but also the durability of the item, which is directly related to the skills and quality of work of the contractors.

Regarding the treatment units, it is difficult to define a clear border until which prefabrication makes sense. Looking at the lessons learnt from the past small-scale initiatives in Egypt (cf. ESRISS report “Challenges and Ways Forward”), **it is clear that prefabrication definitely makes sense at least up to 1,000 inhabitants. For beyond, a good life-cycle analysis of the different options must be carried out.**

A critical factor is the size of the module when considering a modular approach. The size of the module which can be produced and transported is often the limiting factor for prefabrication.

What is sure is that whether conventional or prefab, **standardisation must be sought for**. Prefabrication usually imposes itself as the solution in contexts with a rapid growing demand for small-scale sanitation systems, as was the case in Indonesia (BORDA, 2012).

7.4 Border for the selection of centralised and decentralised systems

The selection of the optimal level of decentralisation should be done as a master planning exercise with a focus on sewer network optimisation. Indeed, from a cost-efficiency perspective, the sewer network is the main factor, considering that it accounts for more than 70% of the costs of wastewater infrastructure. In a context such as the Nile delta which features a large-number of cost-increase factors such as a high groundwater table and multiple barriers (canals, drains, railway, code of practice), and where settlement patterns are highly variable, such an assessment should be made case-by-case.

These assessments should consider the implementation of simplified sewer networks wherever possible, and also the scenario of more permissive rules, especially regarding the distance between a settlement and a treatment plant. For example, the experience of ISSIP has shown that the current regulations (especially this “rule” stating that a WWTP should be at least at 500 m. of a settlement) often force to group several villages together, thus implying a higher level of centralisation. It is probable that such a grouping, which implies the construction of pumping stations and force mains, is not the best option from a cost-effectiveness point of view.

7.5 Reducing the costs of sewer systems

Simplified sewer systems are cheaper and contribute to reduce one or more of the following trenching cost components: depth, width, de-watering, and trench box use. Note that these cost sources are often reinforcing: e.g., deeper trenching for conventional gravity sewers is more likely to require de-watering and trench boxes. Specific conditions such as high water tables, shallow bedrock, presence of other utilities, and other conditions can increase the construction costs of sewers considerably. Cluster systems may avoid some of the most difficult areas, or provide construction savings through reduced trench lengths, reduced trench depths, or other factors.

Besides, smaller systems may **need fewer manholes or none at all**; manholes are a very important cost factor in the overall sewer implementation bill.

Smaller systems often have **lower requirements for pumps** than larger systems. Because gravity sewer lines must be sloped, as distances between services and a plant increase, more pumping units must be in place to bring the sewer water back up to economic trenching depths for line continuation.

The notion of underutilized lines should also be taken into account. First, since sewer capacity is typically planned on the basis of a long-term planning horizon, most sewer capacity is underutilized for many years. Second, in many places codes specify minimum pipe sizes. At the neighbourhood level, these specifications are typically larger than truly necessary, so large amounts of pipe in the network are permanently utilized below their capacity.

Last but not least, **simplified sewer systems may be partly built by the communities and can be managed by them**. Management of the sewer network by the community, which is already widely practiced in the Nile Delta, offers a reactive and cost-effective service, at no-cost for the government.

7.6 The benefits of anaerobic systems: sludge and low O&M costs

Anaerobic systems are much more compact than aerobic ones, reduce significantly the sludge volume through digestion and deliver a stabilised sludge which is easy to dewater and has good agronomical properties. It is thus a very good option on the financial point of view. Sludge dewatering/drying does not need to be done on site. As desludging needs to occur only at large intervals, transport to neighbouring centralised WWTP is the most cost-effective option. Mobile sludge dewatering could also be an option to be investigated.

The low operating costs of many small-scale technologies, especially the anaerobic baffled reactors and filters, expose a utility and system users to less financial risk from variation and escalation in energy and other operating costs. The probable rise in energy cost is a critical issue in Egypt.

7.7 Improve project planning

The assessment of past initiatives (see ESRISS “Challenges and Ways Forward” report) showed **that cost-effectiveness and sometimes even success is impeded by under- and over-dimensioning**. The lack of village-specific design parameters and forward planning are seen as the main causes. Indeed our studies showed a high variability in wastewater quantities and characteristics from one village to the other (see ESRISS “Baseline Data” report).

It is thus important to provide local consultants with tools which help them get:

- Relevant assessment of the initial situation
- Good data analysis
- Estimation of design parameters on a context-specific basis

Over-dimensioning is costly: in capital expenditure, because infrastructure is built without need, and in O&M expenditure, because the O&M of bigger installation is more costly and the performance often lower. Under-dimensioning is also costly, as it leads to poor performance and sometimes to failure.

Dimensioning for a consultant is a matter of risk. **Most of the time, he/she will protect behind the Code of Practice, even if not adapted.** For that reason, cost-effective small-scale sanitation is linked to the optimisation of Codes of Practice, as well as the development of tools which facilitate the case-by-case assessment of wastewater quantities and characteristics (see ESRISS tool).

7.8 Dealing with “special” wastewater producers

Decentralization can be used to **isolate waste generators that produce high hydraulic or mass loads** (e.g., BOD loads of restaurants, hydraulic and pollutant loads of industrial facilities) in order to reduce the capacity and treatment needs such facilities place on public systems.

Questions of technical efficiency and of equity may arise if some connections produce particularly large hydraulic loads, high-strength wastewater, or wastewater with special constituents not contributed by other users (e.g. animal farms and small-scale dairy production units). It is possible to centralize treatment for all the various users, or to centralize treatment for most users and use onsite or cluster systems for connections that produce divergent loads. The latter strategy can reduce costs for most users and place any above-average costs directly on those whose wastes require extra capacity or special treatment.

However, two other strategies are far more commonly used. One is to **require onsite pre-treatment of high-strength or unique loads prior to disposal to a common sewer**. Another is to implement **rate structures that charge users according to the quantity and/or the quality of their waste loads**. Determining the most economic strategy will depend upon the location and amounts and types of the various loads.

In a village setup, pre-treatment units could be considered as part of the sanitation system, and thus built with funds of the project itself. It seems illusory in the current circumstances to try to force special wastewater producers to build a pre-treatment system at their own costs.

7.9 The costs of unfamiliarity

It has been observed that small-scale sanitation technologies may have higher construction costs due to contractor unfamiliarity with the installation requirements of the technology. Contractors may try to cover the risk with price hikes, which then threaten the replicability of the system (cf. ESRISS “Challenges and Ways Forward” report). For this reason, **at the beginning, it is important to bring expertise from outside for technology transfer**. This will benefit both the quality of the systems implemented and their price.

7.10 Benefits of an incremental implementation of the effluent standards

The current effluent standards of the Law 48/1982 are seen as a major impediment for the large-scale replication of small-scale sanitation systems. They force the implementation of very costly aerobic polishing steps. A more pragmatic approach is recommended, such as in other countries of the region like Jordan and Morocco, with an incremental implementation of these standards. This would materialise by starting with advanced primary treatment only, and upgrade the systems in a later stage.

Dr. Rifaat Abdel Wahaab listed the main reasons why primary treatment only is currently recommended as the way forward for small scale sanitation in Egypt (presentation, 2015):

1. Limited resources available
2. Speed of sanitation service to the un-served villages as the primary treatment stages take up much less time to implement
3. All settleable solids (organics and in-organics) are removed in the primary treatment stage; it also removes all flotation materials and oils & greases that prevent self-purification process when discharge onto agricultural drains.
4. At least 45 % of organic loads are to be removed during primary treatment stage, which helps the oxidation of the remaining ones by the processes of self-purification in drains.
5. All mechanical equipment required are manufactured locally and therefore there is no need to provide foreign exchange. It promotes the expansion in manufacturing, with the related job creation potential.
6. Electrical equipment required are limited and available in local market. No need to provide backup generators. Electricity-cut does not affect the efficiency of the primary treatments.
7. The energy required for the operation of primary treatment is very limited, at a time when the country is suffering from scarce energy resources
8. Achieve the principle of social equity/justice, where all villages will be served with sanitation services at the same time.
9. The design of secondary treatment units is currently based on hypothetical/theoretical characteristics and/or raw sewage from similar villages, which threatens the performance and the cost-effectiveness of the infrastructure.
10. This approach will allow to have a clear picture about: (i) the raw sewage characteristics; (ii) appropriate secondary treatment technology selection; (iii) develop the correct design parameters for the secondary stage, based on the actual effluent from the first stage; (iv) Improve WWTs performance

Many countries in the world have applied the same approach, including the western countries.

8 Conclusions

Nowadays, most of the wastewater from the Nile Delta villages is collected by informal sewer networks or by truck and discharged into the drains, thus causing significant environmental and health issues and threatening the quality of agricultural products.

Small-scale sanitation systems are seen as a promising alternative for the small settlements that cannot be connected to the large centralized wastewater treatment plants. Such systems do exist and are not more expensive than the centralized ones. The population already pays substantial amounts of money for systems that are not satisfactory. There is capacity-to-pay to cover the operation and maintenance costs for small-scale systems.

If an incremental implementation of Law 48 is adopted, these systems will become much more cost-effective, while removing at least 60% of the pollution. An advanced primary treatment will in any case be a major improvement to the current situation where most of the wastewater of the delta remains untreated.

We estimate that such small-scale systems could contribute to treat up to 10 % of the wastewater from rural villages in the Nile Delta.

8.1 Think at scale !

Economies of scale are a key for success, both for cost-effectiveness as for sustainable management. When dealing with small-scale sanitation, it is thus crucial to think at scale. New approaches need to be implemented with a critical mass of projects which allow a centralised management scheme and a standardised production and implementation. A significant amount of the cost associated with past initiatives was due to long implementation time, risk coverage from contractors or overinvestment due to the pilot nature of the initiative. This per se hinders the replication of the systems.

For that reason, one should start to think from the supply side or business perspective. Thinking in terms of economies of scale and critical mass means thinking how to standardise the units and the management of the multiple systems and how to involve the private sector. Small-scale sanitation is a new market, with all the associated opportunities and job creation potential.

“Pilots never fail, pilots never scale”... Getting out of the trap of the isolated pilot is the way forward. The selection of a system over another goes beyond the cost comparison; it is much more about the enabling environment that is associated with each system. Enabling effluent standards and Codes of practice, and economies of scale in terms of production and management have the potential to bring a pragmatic and cost-effective answer to the current rural sanitation dilemmas in Egypt.

The final report of the ESRISS project provides more insight into how to get to scale.

8.2 Follow-up: compare scenarios

This study puts together the cost data collected within the ESRISS project. It provides an estimation of the costs incurred in different sanitation scenarios and the money flows between sanitation stakeholders. It also analyses how more cost-effectiveness can be achieved, and the advantages of small-scale systems to bring costs down. However, what it still does not do is to provide a clear comparison between different scenarios based on life-cycle cost comparison.

For example, serving a small settlement with its own small-scale sanitation system could be compared with connecting the same settlement to a large-scale wastewater treatment plant. Different scenarios could be developed to determine the border from which small-scale systems are more cost-effective. Such life-cycle cost comparisons were hindered within the framework of this project because of the lack of financial data, but also the difficulty to estimate complete costs (sewers, WWTP, O&M) for scenarios which are comparable. Indeed, in order to be comparable, the different scenarios need to deliver the same effluent quality and be linked to a sustainable management scheme. Besides, the real cost of large-scale centralised systems is difficult to access, but also to assess as significant amounts are actually wasted during the implementation process, and the O&M costs are largely subsidised (especially the energy costs).

The data collected builds however a good basis. Besides, the factors influencing the cost-effectiveness are exhaustively listed, arguing for the benefits of small-scale/decentralised sanitation. **It shows that the comparison of systems on a settlement basis is not enough, but that comparison of systems implemented at a large-scale should be made, thus taking into account the economies of scale that are made possible by a proper planning, production, implementation and management of small-scale sanitation systems.**

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10 Appendix

10.1 Contact of suppliers

The suppliers were selected and contacted by Eng. Sayed Mohamed, in the framework of his short mandate for the ESRISS Project.

10.1.1 Pump suppliers

The following was requested:

- Cost estimation for pumps serving for raw wastewater intake
- Pumps type: submersible pumps, centrifugal horizontal pumps, airlift pumps and vacuum air pumps.
- Pump capacity:
 - o 5 m³/hr. (= 1.39 l/s) with pump head of 7 m.
 - o 10 m³/hr. (= 2.78 l/s) with pump head 10 m.
- Price for two pumps (1 in duty + 1 in standby)

In what follows, the list of the suppliers contacted is provided. The following offers were received: (4) Submersible pump suppliers, (1) Horizontal pump supplier and (1) Air lift pump supplier.

Submersible pumps:

1. Company Name : Imag Company – Imag - Italy
Contact Person: Eng. Kadry Khatab
Tel.: 02-25902326, 02-25882705, 02-25926435
Fax: 02-25934773
Email: Imagcompany@yahoo.com
2. Company Name : Al Shark Company – Kalbida - Italy
Contact Person: Eng. Mohamed Koteb
Tel.: 02-25914279, 012-3986098, 012-5588967
Fax: 02-22704187
Email: elshark@gaga.net
3. Company Name : Al Dehipy Company – Grandfos - Sweden
Contact Person: Eng. Soheer Badwey
Tel.: 02-22730796, 016-8829148
Fax: 02-25907807
Email: soheer@eldiheby.com
4. Company Name : EWM Company – Salmson - France

Contact Person: Eng. Mohamed Gewily
Tel.: 02-24054990, 02-24054991, 02-24054992, 02-24054993
Fax: 02-24054995
Email: ewmcairo@gega.net

5. Company Name: Modern water service MWS Company – Grandfos - Sweden
Contact Person: Eng. Islam Moustafa
Tel.: 02-24734026, 02-24734027
Fax: 02-24729213
Email: info@mwspump.com

Centrifugal horizontal pumps:

1. Company Name : Imag Company – Imag - Italy
Contact Person: Eng. Kadry Khatab
Tel.: 02-25902326, 02-25882705, 02-25926435
Fax: 02-25934773
Email: Imagcompany@yahoo.com
2. Company Name : Al Shark Company – Kalbida - Italy
Contact Person: Eng. Mohamed Koteb
Tel.: 02-25914279, 012-3986098, 012-5588967
Fax: 02-22704187
Email: elshark@gaga.net
3. Company Name : EWM Company – Salmson - France
Contact Person: Eng. Mohamed Gewily
Tel.: 02-24054990, 02-24054991, 02-24054992, 02-24054993
Fax: 02-24054995
Email: ewmcairo@gega.net
- 4- Company Name : Modern water service MWS Company – Grandfos - Sweden
Contact Person: Eng. Islam Moustafa
Tel.: 02-24734026, 02-24734027
Fax: 02-24729213
Email: info@mwspump.com

Air lift pumps:

1. Company Name : Heliopower Company – Wilden - Italy
Contact Person: Eng. Mahmoud Radwan
Tel.: 02- 22905244, 02-24157240, 02-24157241
Fax: 02-22909001
Email: heliopwr@tedata.net.eg
2. Company Name : Segma Company – Wilden - Italy
Contact Person: Eng. Yasser Hosney
Mobil: 01001712200
Email: yasserhosni@link.net

10.1.2 Prefabricated tank suppliers

In a first stage, suppliers were contacted to provide cost estimation for prefabricated tanks in different materials and different sizes. The targeted materials were fibre glass and steel epoxy.

In a second stage, several companies were requested to provide a cost estimation for modular units treating a total of 100 m³/day (which we assumed equivalent to the wastewater production of 1000 inhabitants).

Two scenarios were provided:

1. Prefabricated with fibre glass according to BORDA model: we assumed that 14 units were necessary for the settlers and anaerobic baffled reactors (ABR). We got two offers from companies specialised in plastic and fibre glass tanks (Al Dawleya and Al Rowaad).
2. Conventional fabrication out of concrete: for that one, we sent the bill of quantities (BOQ) of an anaerobic treatment plant designed by a Swiss expert, consisting of a settler, anaerobic baffled reactors (ABR) and anaerobic filters (AF).

Fibre glass tanks:

The estimation of the production cost of fibre glass tanks with a capacity from 10 m³ to 100 m³ was requested, with possibility to make internal partition into the tanks. The companies contacted are the following:

1. Company Name: Al Dawleya tank Company for fibre glass
Contact Person: Eng. Ramadan Elbasyony- Sales Director
Tel.: +20 224029331, 02-22619735
Fax: +20 224029331
Mob: +20 1007621523
E mail: Ramadan1299@yahoo.com
2. Company Name: Al Rowaad fibre company
Contact Person: Eng. Ibrahim Esmat - General Director
Tel.: +20 249226825
Fax: +20 249226825
Mob: +20 1273744417
E mail: Ibrahim@alrowadfiber.com
3. Company Name: AGA Company for plastics products
Contact Person: Eng. Ibrahim El shinawey - General Director
Tel.: +20 506456526
Fax: +20 506451526

Offers were received from Al Dawleya and Al Rowaad, while AGA Company did not submit any offer as they are working only with plastics, not fibre glass.

Steel epoxy coated tank:

The estimation of the production cost of steel epoxy coated tanks with a capacity from 10 m³ to 100 m³ was requested, with possibility to make internal partition into the tanks. The companies contacted are the following, out of which only Alsabah Company submitted an offer:

1. Company Name : Technomatic Company – Egypt
Contact Person: Eng. Fathey Elmarkeshy
Tel.: 02-24022953, 02-24018412
Fax: 02-22605695
Mobile: 01006057596
Email: technomatec96@yahoo.com
2. Company Name : Alsabah Company – Egypt
Contact Person: Eng. Sayed Atalah
Mobile: 01226995542
Email: (shaaban.noaman@gmail.com)
3. Company Name : Osman Sons Company – Egypt
Contact Person: Eng. Mohamed Osman
Mobile: 01223741221
Email: mohamedosman26100@yahoo.com

Conventional building in concrete:

The bill of quantities in the form of an Excel sheet was sent to several civil Egyptian contractors in order to get the Egyptian prices. The companies contacted are the following, out of which only Gama company submitted an offer:

1. Company Name: Gama for Trading & Contracting Company
Contact Person: Eng. Halim fansa - Commercial Director
Tel.: +20 22600322 – 22600342/3/6 Ext 114
Fax: +20 22600379/80
Mob: +20 12 06 7777 36
E mail: h.fansa@gama-construction.com.eg
2. Company Name: Banas Company for Construction
Contact Person: Eng. Abd Alghany Nda - General Director
Tel.: +20 26240593
Fax: +20 226217585
Mob: +20 1006684276
E mail: banas@banasconstructions.com
3. Company Name: Arabian Company for civil Construction
Contact Person: Eng. Khaled Hosien - General Director
Mob: +20 1001393138, +20 1210659542
E mail: Arabian_central@yahoo.com
4. Company Name: Elrowad contractor Company for Construction
Contact Person: Eng. Yasser El Saadany - Projects Director
Mob: +20 12299880581
E mail: yelsaadany@rowad-rme.com

10.2 Bill of quantities for an anaerobic treatment system out of concrete

Project: 100 m³/day - Simple Plant HRAR (High Rate Anaerobic Reactor = Settler + ABR + AF)

Date: 9.3.2012

Autark Engineering AG, Nanchoz Zimmermann

Bill of Quantities					
Settler		Units	Qty.	Rate	Amount
A	Earth Work			[EGP]	[EGP]
1	Excavation work for foundation; removing the excavated earth to a distance not exceeding 50m, spreading, leveling etc., completed wherever necessary.	CUM	116	21.0	2'436
2	Earth filling to the foundation with new approved earth including watering and compacting in layers of 150mm thk with all lead and lift as directed by the engineer-in-charge.	CUM	17.40	45.0	783
3	Removal of excess earth/debris from the site including loading/unloading and transportation.	CUM	98.60	15.0	1'479
total for A					4'698
B	Plain Cement Concrete				
1	Providing and laying plain cement concrete 1:4:8 (one cement, four sand, eight coarse aggregate) using 40mm coarse aggregate, for foundation , laid in a 100mm thk layer. Rate shall be inclusive necessary shuttering and well compacted, curing etc., complete.	CUM	3.8	780.0	2'964
total for B					2'964
C	Reinforced Cement Concrete				
1	Providing and laying cement concrete 1:1.5:3 (one cement one and half sand three aggregate) for foundation , using 20mm and down size coarse aggregate, clean and dry sand and cement 43 grade. THK 150mm . The rate shall include all labour, material, plant and machinery, curing etc.	CUM	5.2	738.0	3'838
2	Providing erecting and removing shuttering formwork for foundation , including all necessary supports, scaffolding, bracings etc., using steel plates/water proof shuttering plywood /timber (silver oak) for the following R.C.C works.	SQM	3.64	65.0	237
3	Providing and laying cement concrete 1:1.5:3 (one cement one and half sand three aggregate) for walls , using 20mm and down size coarse aggregate, clean and dry sand and cement 43 grade; THK 230mm . The rate shall include all labour, material, plant and machinery, curing etc..	CUM	13.4	746.0	9'996
4	Providing erecting and removing shuttering formwork for RCC walls , including all necessary supports, scaffolding, bracings etc., using steel plates/water proof shuttering plywood /timber (silver oak) for the following R.C.C works.	SQM	115.6	106.0	12'254
3	Providing and laying cement concrete 1:1.5:3 (one cement one and half sand three aggregate) for cover slab , using 20mm and down size coarse aggregate, clean and dry sand and cement 43 grade. THK 150mm . The rate shall include all labour, material, plant and machinery, curing etc..	CUM	5.2	746.0	3'879
4	Providing erecting and removing shuttering formwork for cover slab , including all necessary supports, scaffolding, bracings etc., using steel plates/water proof shuttering plywood /timber (silver oak) for the following R.C.C works.	SQM	33	85.0	2'805
5	Providing steel reinforcements consisting of high yield strength ribbed and cold twisted steel bars (Fe415 grade) conforming to IS:1786 for reinforced concrete work. The work includes cutting, bending, tying and placing in position according to structural drawings.	KG	1904	9.7	18'421
total for C					51'430

D	Masonry					
1	Providing and constructing of inner tank walls with cement block masonry of THK 200mm with crushing strength of 50kg/sq.cm and CM 1:5. The rate to be inclusive of necessary scaffolding, curing etc., completed all leads and lift as directed by the engineer-incharge.	CUM	2	998.0	1'996	Hollow concrete block
	total for D				1'996	
E	Plastering					
	Providing inside plastering; thk 20mm, water tight.	SQM	75	54.0	4'050	
	total for E				4'050	
F	Manhole covers					
2	Providing pre-cast manhole covers, 600mmx600mm.	NOS	4	324.0	1'296	
	total for F				1'296	
H	Ventilation					
1	Providing and fixing 4"PVC pipes ISI marked 6kg/cm ² .	RMT	6	180.0	1'080	
2	Providing and constructing single brick wall (square) for supporting structure of ventilation pipe, THK 100mm, inklusive plastering.	RMT	1.5	98.0	147	rate for m2
3	4" ball valve for opening and closing the ventilation.	NOS	1	3'750.0	3'750	
	total for H				4'977	
I	Wastewater pipes					
1	Providing and fixing 4" and 6" PVC pipes ISI marked 6kg/cm ² with solvent cement/rubber ring joints Including any cutting & making good of floors / walls that may be necessary clamps and stays as per requirements.					
	a) 4" dia. 6kg/cm ²	RMT			-	
	c) 4" dia. Tee 6kg/cm ²	NOS			-	
	c) 6" dia. 6kg/cm ²	RMT	15	270.0	4'050	
	d) 6" dia. Tee 6kg/cm ²	NOS	4	525.0	2'100	
	total for I				6'150	
J	Misc					
1	Cow dung for developing appropriate innoculum.	CUM	4.2	0.0	0	
	total for J				-	
	Total Settler				77'561	

Bill of Quantities					
High Rate Anaerobic Reactors		Units	Qty.	Rate	Amount
A	Earth Work			[EGP]	[EGP]
1	Excavation work for foundation; removing the excavated earth to a distance not exceeding 50m, spreading, leveling etc., completed wherever necessary.	CUM	690	21.0	14'490
2	Earth filling to the foundation with new approved earth including watering and compacting in layers of 150mm thk with all lead and lift as directed by the engineer-in-charge.	CUM	103.50	45.0	4'658
3	Removal of excess earth/debris from the site including loading/unloading and transportation.	CUM	586.50	15.0	8'798
total for A					27'945
B	Plain Cement Concrete				
1	Providing and laying plain cement concrete 1:4:8 (one cement, four sand, eight coarse aggregate) using 40mm coarse aggregate, for foundation , laid in a 100mm thk layer. Rate shall be inclusive necessary shuttering and well compacted, curing etc., complete.	CUM	20.6	780.0	16'068.0
total for B					16'068
C	Reinforced Cement Concrete				
1	Providing and laying cement concrete 1:1.5:3 (one cement one and half sand three aggregate) for foundation , using 20mm and down size coarse aggregate, clean and dry sand and cement 43 grade. THK 150mm . The rate shall include all labour, material, plant and machinery, curing etc.	CUM	31.5	738.0	23'247
2	Providing erecting and removing shuttering formwork for foundation , including all necessary supports, scaffolding, bracings etc., using steel plates/water proof shuttering plywood /timber (silver oak) for the following R.C.C works.	SQM	9	65.0	585
3	Providing and laying cement concrete 1:1.5:3 (one cement one and half sand three aggregate) for walls , using 20mm and down size coarse aggregate, clean and dry sand and cement 43 grade. THK 230mm and 200mm . The rate shall include all labour, material, plant and machinery, curing etc..	CUM	31.7	746.0	23'648
4	Providing erecting and removing shuttering formwork for RCC walls , including all necessary supports, scaffolding, bracings etc., using steel plates/water proof shuttering plywood /timber (silver oak) for the following R.C.C works.	SQM	276	106.0	29256
3	Providing and laying cement concrete 1:1.5:3 (one cement one and half sand three aggregate) for cover slab , using 20mm and down size coarse aggregate, clean and dry sand and cement 43 grade. THK 150mm . The rate shall include all labour, material, plant and machinery, curing etc..	CUM	32	746.0	23'872
4	Providing erecting and removing shuttering formwork for cover slab , including all necessary supports, scaffolding, bracings etc., using steel plates/water proof shuttering plywood /timber (silver oak) for the following R.C.C works.	SQM	205	85.0	17425
5	Providing steel reinforcements consisting of high yield strength ribbed and cold twisted steel bars (Fe415 grade) conforming to IS:1786 for reinforced concrete work. The work includes cutting, bending, tying and placing in position according to structural drawings.	KG	7616	10.0	76'160
total for C					194'193

D	Masonry					
1	Providing and constructing of inner tank walls with cement block masonry of THK 200mm with crushing strength of 50kg/sq.cm and CM 1:5. The rate to be inclusive of necessary scaffolding, curing etc., completed all leads and lift as directed by the engineer-in-charge.	CUM	39	998.0	38'922.0	Hollow concrete block
	total for D				38'922	
E	Plastering					
	Providing inside plastering; thk 20mm, water tight.	SQM	955	54.0	51'570	
	total for E				51'570	
F	Manhole covers					
2	Providing pre-cast manhole covers, 600mmx600mm.	NOS	53	324.0	17'172	
	total for F				17'172	
H	Ventilation					
1	Providing and fixing 4" PVC pipes ISI marked 6kg/cm ² .	RMT	18	195.0	3'510	
2	Providing and constructing single brick wall (square) for supporting structure of ventilation pipe, THK 100mm, inklusive plastering.	RMT	6	98.0	588	rate for m2
3	4" ball valve for opening and closing the ventilation.	NOS	4	3'750.0	15'000	
	total for H				19'098	
I	Filter Material					
1	Filter Material 1 - Plastic chips (diameter = 4 cm)	CUM	52.5	150.0	7'875	
2	Filter Material 2 - Plastic corrugated sheets	CUM			-	
3	Filter Material 3	CUM			-	
	total for I				7'875.00	
J	Perforated slabs for FFR filter					
1	Providing perforated RCC filter slabs as per design drawing	NOS	20	0.0	-	
	total for J				-	
K	Beams for perforated slabs					
1	Providing and constructing single brick masonry beams of 80mm thk, for carrying the perforated slabs for FFR filter.	SQM	60	143.0	8'580	
	total for K				8'580	
L	Wastewater pipes					
1	Providing and fixing 4" and 6" PVC pipes ISI marked 6kg/cm ² with solvent cement/rubber ring joints Including any cutting & making good of floors / walls that may be necessary clamps and stays as per requirements.					
	a) 4" dia. 6kg/cm ²	RMT	526	180.0	94'680	
	c) 4" dia. Tee 6kg/cm ²	NOS	400	300.0	120'000	
	c) 6" dia. 6kg/cm ²	RMT			-	
	d) 6" dia. Tee 6kg/cm ²	NOS			-	
	total for L				214'680	
M	Misc					
1	Cow dung for developing appropriate inoculum.	CUM	9.4	0.0	-	
	total for M				-	
	Total ABR & AF				596'103	
	Total Settler				77'561	
	Grand Total				673'664	

OPEX and replacement costs

	INR	EUR	Faktor	Date				
Umrechnung INR-EUR	1000	15.1229	0.0151229	06.03.2012				
Opex		Power	Consumables	Spare Parts	Operation	Maintenance	Total	
		[INR/a]	[INR/a]	[INR/a]	[INR/a]	[INR/a]	[INR/a]	[EUR/a]
Primary Treatment	HRAR						-	-
Secondary Treatment	Raw Water Pump	32'206	500	2'500	0	5'000	40'206	608
	Tank		4'928		10'000		14'928	225.75
	Dosing Pump	1'369		1'500	-	1'000	3'869	58.51
		1'369	4'928	1'500	10'000	1'000	18'796	284
Auto Controll	Control Panel			1'500	2'000	1'000	4'500	68.05
	Auto MPV System			750	2'000	1'000	3'750	56.71
	Pressure Gauge			750	2'000	1'000	3'750	56.71
							12'000	181
Replacement cost		[INR/a]	[EUR/a]					
Primary Treatment	HRAR	84'838	1'283					
Secondary Treatment	Raw Water Pump	2'500	38					
		87'338	1'321					
Disinfection	Transfer Pump	2'500	38					
	Tank	100	2					
	Dosing Pump	2'000	30					
		4'600	70					
Auto Controll	Auto MPV System	2'000	30					
	Control Panel	3'000	45					
	Pressure Gauge	1'500	23					
		4500	68					
		[INR/a]	[EUR/a]					
Opex		30'796	466					
Replacement		96'438	1'458.42					
		127'234	1'924					

10.3 Cost catalogue of treatment and conveyance systems

The following data was collected by Romuald Bolliger during his Master thesis.

Conventional Sewer System

Sewer length	CapEx (EGP)	CapEx/m	OpEx (EGP)	OpEx/m	Reference
3,000	2,250,000	750	150,000	50	Chemonics Egypt
10,000	7,000,000	700	450,000	45	Chemonics Egypt

Table 1: cost estimation conventional sewer system in 2012

The conventional sewer systems take into consideration the pumping stations required to convey water over the selected distances (see Table 1). In Egypt, the average distance between villages and WWTP (CT1 and CT2) varies between 3 and 10 kilometers (Chemonics, Al Shorbagy, personal communication, 10.12.2012). Network and force main are included.

Shallow Sewer System

Sewer length	CapEx (EGP)	CapEx/m	OpEx (EGP)	OpEx/m	Reference
800	320,000	650	24,000	30	Chemonics Egypt
1500	600,000	400	45,000	30	Chemonics Egypt

Table 3: cost estimation shallow sewer system in 2012

The shallow sewer system is a key-technology chosen for small-scale sanitation in Egypt with no major breakouts in terms of maintenance unlike the small bore network.

Settler

Conventional :

m3/day	CapEx (EGP)	CapEx/m3	OpEx (EGP)	OpEx/m3	Reference
50	45,000	900	7,200	144	Chemonics Egypt
100	75,000	750	14,400	144	Chemonics Egypt
200	160,000	800	28,800	144	Chemonics Egypt

Table 4: cost estimation conventional settlers in 2012

Prefab in steel epoxy with ferrochlorite (see also Al Raed brochure):

m3/day	CapEx (EGP)	CapEx/m3	OpEx (EGP)	Reference
50	90,000	1800	-	Al Raed Jet Master
100	160,000	1600	-	Al Raed Jet Master

Table 5: cost estimation prefabricated (Prefab) settler with ferrochlorite in 2012

Imhoff Tank

m3/day	CapEx (EGP)	CapEx/m3	OpEx (EGP)	Reference
100	104,775	1047.7	-	ISSIP, Sept. 2012 ✓

Table 6: cost estimation Imhoff tank in 2012

Prefabricated tanks

Material	m3	CapEx (EGP)	CapEx/m3	Reference
Fibre glass	10	24,000	2400	Al Dawleya Company
	20	46,000	2300	Al Dawleya Company
	50	154,000	3080	Al Dawleya Company
Steel epoxy	10	37,400	3740	Al Sabah Company
	20	74,800	3740	Al Sabah Company
	50	123,200	2464	Al Sabah Company

Table 7: cost estimation prefabricated (Prefab) tanks (capacity in m3)

Prefabricated tanks made out of fiber glass are produced by Al Dawleya company and are slightly more expensive than prefabricated steel epoxy tank produced by Al Sabah company.

Anaerobic Baffled Reactor (ABR)

m3/day	CapEx (EGP)	OpEx (EGP)	Reference
25	132,464	-	Pref. BORDA
100	529,857	-	Pref. BORDA
100	460,000	-	Prefab. (fiber glass) ESRIS
200	1,059,715	-	Pref. BORDA
200	706,040	-	ISSIP, Sept. 2012 ✓

Table 8: cost estimation prefabricated (Prefab) and conventional ABR in 2012

Borda's ABR CapEx comprises a large vessel, medium vessel and the installation costs. OpEx are not included and were evaluated according to specific cost-assumptions. One large vessel with a volume of 17.32 m³ treats around 10 m³ per day (Borda 2009). By applying the available dimensions/capacities of prefabricated tanks (Borda 2009) to the features of locally prefabricated tanks (see Table 7) it is possible to get a preliminary estimation of an ABR made in Egypt: a fiber glass tank of 20 m³ costs EGP 46,000 per unit. Hence, around 10 tanks would be needed to attain a treatment capacity of circa 100 m³ per day, therefore the whole ABR would cost about EGP 460,000.

High Rate Anaerobic Reactor (HRAR)

m3/day	CapEx (EGP)	OpEx (EGP)	Reference
100	391,347	23,695	Autark, Nanchoz Zimmermann ✓

Table 9: cost estimation HRAR in 2012

The HRAR was designed to be implemented in Indian rural areas.

Sequential Batch Reactor (SBR)

Material	m3/day	CapEx (EGP)	OpEx (EGP)	Reference
Prefab.	100	387,000	-	EMAS, Mohsen Shazly ✓
Prefab.	200	478,000	-	EMAS, Mohsen Shazly
Concrete	200	1,046,750	49,197	ISSIP, 2012
Concrete	370	5,934,265	281,709	UFZ, Smart project Jordan

Table 10: cost estimation prefabricated and conventional SBR in 2012

Anaerobic Compact Tower (ACT)

m3/day	CapEx (EGP)	OpEx (EGP)	Reference
100	500,000	84,000	(steel ACT) Tarek Sabry ✓
100	400,000	84,000	(concrete ACT) Tarek Sabry

Table 11: cost estimation ACT in 2012

The data collected was qualified as rough estimation by the designer in the absence of a pilot project that already tested the steel and concrete designs (Tarek Sabry, personal communication, 22.12.2012).

Chemical Oxidation Tank (COT)

m3/day	CapEx (EGP)	OpEx (EGP)	Reference
50	370,000	31,824	Al Raed, Mohammed Mahroos
100	525,000	50,088	Al Raed, Mohammed Mahroos ✓
150	620,000	109,620	Al Raed, Mohammed Mahroos
200	720,000	151,056	Al Raed, Mohammed Mahroos
1000	2,250,000	257,760	Al Raed, Mohammed Mahroos

Table 12: cost estimation COT in 2012

Moving Bed Bio Reactor (MBBR)

m3/day	CapEx (EGP)	OpEx (EGP)	Reference
250	1,750,000	-	HCWW, Rifaat Abd El Wahab ✓
500	2,750,000	-	HCWW, Rifaat Abd El Wahab

Table 13: cost estimation MBBR in 2012

Sludge Dewatering Unit (SDU)

m3/day	CapEx (EGP)	OpEx (EGP)	Reference
100	92,000	-	EMAS, Mohsen Shazly ✓
200	135,000	-	EMAS, Mohsen Shazly

Table 14: cost estimation SDU in 2012

Sludge Drying Bed (SDB)

m3/day	CapEx (EGP)	OpEx (EGP)	Reference
50	160,000	72,000	Chemonics Egypt
100	320,000	144,000	Chemonics Egypt
200	640,000	216,000	Chemonics Egypt

Table 15: cost estimation SDB in 2012

The ESRISS project deals with the sanitation planning gap in Nile Delta villages which cannot be connected to large centralised treatment plants. Led by the Swiss Federal Institute of Aquatic Science and Technology (Eawag-Sandec) in partnership with the Egyptian Holding Company for Water and Wastewater (HCWW) and funded by the Swiss State Secretariat for Economic Affairs (SECO), it aims to provide baseline data, policy recommendations and planning tools for the scaling-up of small-scale sanitation in Egypt.

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