CASE

Wastewater for fruit and wood production (Egypt)

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Supporting case for Business Model 17	
Location:	El-Gabal El-Asfar, northeast Cairo, Egypt
Waste input type:	Domestic and small industrial wastewater
Value offer:	Secondary treated wastewater reuse for cactus fruits (70%), lemon trees, and wood production; sludge sale for composting and construction (cement mix)
Organization type:	Public
Status of organization:	Secondary treatment level operational since 1998, commercial reuse of lemons and cactus fruits since 2007 with breaks
Scale of businesses:	Treatment: medium (450,000m^3/day); Reuse: small 10,000 to 30,000m^3/day on max. 147 ha.
Major partners:	Holding Company for Water and Wastewater (HCWW) through (the Greater Cairo Sewage Water Company); Ministry of Water and Wastewater Utilities; Undersecretariat for Afforestation and Environment of the Ministry of Agriculture and Land Reclamation (MALR), Ministry of Water Resources and Irrigation; Other Ministries (Housing, Health), Desert Research Center

Executive summary

The Greater Cairo Sewage Water Company (GCSWC) operates the El Berka wastewater treatment plant in the north-eastern part of Greater Cairo. Although the bulk of its wastewater is discharged back into the environment, about 5% of its secondary treated wastewater is used for irrigating lemon trees, cactus and trees for wood production, such as Khaya senegalensis, and, on pilot basis, industrial oilseeds including Jojoba and Jatropha. In addition, about 1,500 tenant farmers renting government land use approximately another 12% of the treated wastewater to irrigate about 1,000 hectares (ha) to support their livelihoods. This activity is informal and no fees are charged. The majority of the entity's revenue comes from household wastewater fees levied on around 1 million connected households, helping achieve a high cost recovery for the treatment of the wastewater. However, only about half of the households pay regularly resulting in USD 3.6 million revenues. The plant also raises revenue of about USD 0.6 million from selling one third of the generated sludge for composting and to the construction sector. There is significant potential for expansion into the agroforestry sector which is underused due to different challenges typical for the wastewater irrigation sector (not only) in Egypt. Therefore, compared with its potential, cost recovery through wastewater reuse is low, and the overall plant revenues subsidize the reuse system, in particular via household fees. This situation could be improved significantly with a change in the regulatory framework to support more progressive commercialization opportunities (choices of plants) and reuse standards, which is likely catalyzing private sector engagement.

KEY PERFORMANCE INDICATORS (AS OF 2014)

Land use:	42 ha for treatment plant, 210 ha available for afforestation of which so far only up to 30% were used					
Wastewater treated/reused:	0.4–0.5 million m^3/day of which 10,000–30,000m^3 are formally and 49,000m^3 informally reused; 50–60,000t sludge produced per year of which 20,000t are sold.					
Capital investment:	48 million (discounted to 1990 prices) for treatment plant; USD 1.6 million for plantation and irrigation system					
Labor:	About 270 persons at treatment plant; 110 at the plantation					
O&M costs:	USD 3 million/year for the treatment plant; USD 0.6 million/ year for the plantation (due to overstaffing) (2013)					
Output (revenue):	USD 3.65 million/year from household sanitation fees; USD 11,700–28,000/year from agroforestry system using 10,000–30,000 m^3/day; USD 609,000/year from sludge sale (unpacked, packed, largely for cement mix)					
Potential social and/or environmental impact:	Employment creation through afforestation programs; public health and environment protection; forest (fruits), wood, oilseeds products; benefit of research and outreach in wastewater reuse in agroforestry systems					
Financial viability indicators:	Payback period:	Depends on tree growth rate	Post-tax IRR:	N.A.	Gross margin:	N.A.

Context and background

Egypt has an arid climate with an annual precipitation in Cairo of only 26mm. The El Berka wastewater treatment plant and its wastewater reuse scheme is one of the smaller wastewater irrigated agroforestry plantations in Egypt. The total area allocated to the Holding Company for Water and Wastewater (HCWW) across Egypt for reuse is about 37,000 ha of which in 2013 about 4,622 ha were used. The El Berka wastewater treatment plant is managed by the Greater Cairo Sewage Water Company (GCSWC), a subsidiary company of HCWW. The plant is located in El-Gabal El-Asfar, in the north-east of Greater Cairo, in the Cairo Governorate, and employs about 270 permanent staff. Outputs from the secondary treatment (activated sludge) are sludge and water. While about 30% of the sludge is used for composting and cement production, only a minor part of the generated wastewater is formally used to irrigate fruits (lemons, cactus) and different wood producing trees (e.g. *Cupressus sempervirens*, *Kaya senegalensis*). At pilot scale oilseed/energy crops, like Jatropha and Jojoba, are being tested with promising results. The El Berka forest and horticulture plantation was established in 1998 by GCSWC and covers about 210 ha, of which so far 147 ha have been designed for irrigation offering jobs to 110 permanent employees at the plantation, 20 of them in support of irrigation. Since 2007, when lemon and cactus were commercialized for the first time, the actual area under irrigation varied between 21 and 60 ha.

The water is pumped from the treatment plant to the land parcels and a drip irrigation system is installed for the wood trees (wastewater only), whereas lemon and cactus receive both wastewater and freshwater via flood irrigation. The daily consumption of treated wastewater within the plantation varied over the last years between approximately 10,000 and 30,000m^3, while farmers outside the plantation use informally about 49,000m^3. The variation in land area and water consumption were due to restriction placed on the sale of crops. After a successful production in the first years (2007–2010) the Ministry of Agriculture prohibited the commercialization of (already produced) products irrigated with treated wastewater in 2011 and 2012, while in 2013 commercialization was allowed with restrictions which led to a decrease in the managed production area. Efforts to harmonize and standardize regulations on wastewater use in agriculture culminated in the Egyptian Code for the Reuse of treated Wastewater in Agriculture (ECP 501/2005) by the Ministry of Housing, Utilities, and New Communities. These standards set in 2005 reference the 1989 WHO guidelines, not the updated 2006 revision and are considered as too strict especially in terms of crop choices for commercialization. Additional difficulties occur through lacking standards for laboratory analyses (different methods result in different values). Thus, although the reuse potential for land reclamation is high and there are many profitable cropping options, so far the legal framework and its dynamic is not attracting investors and requires substantial improvements (Soulie, 2013).

Next to land reclamation and productive reuse, another driver for water reuse is operational risk reduction. Discharging wastewater to the Nile, canals or drains are controlled by law through licensing which requires compliance with set discharge standards. Failure to comply can mean withdrawal of the licence; however, there is hardly any source control.

Market environment

The public Holding Company of Water and Wastewater (HCWW), established in 2004, owns all water and sanitation infrastructure in Egypt. It works through its 26 affiliated subsidiaries companies across all Egyptian governorates where its 126,000 employees serve 85 million citizens. In 2013, HCWW operated 2,690 water treatment plants, and 357 wastewater treatment plants in the country, with 80% of the latter providing secondary treatment. Today, Egypt produces about 7.6 billion m^3 wastewater per year, of which 3.8 billion are treated and about 0.7 billion formally reused (Abdel Wahaab, 2014). As regulations are difficult to enforce in the informal sector, direct and indirect use of (treated and untreated) wastewater is common.

Reuse in forestry systems is permitted by law and has been widely promoted by the government. According to HCWW around 63 man-made forests irrigated with treated wastewater occupy 4,622 ha. The total allocated land to HCWW (only) for reuse is about 37,000 ha which is about half of the size of all public and private forest plantations in Egypt. So far most plantations involving wastewater reuse have been government-driven. The government’s support for private sector participation in water supply and sanitation did not go much beyond build-operate-transfer (BOT) arrangements for wastewater treatment plants. To stimulate wastewater use, Egypt and other countries in Middle East and North Africa (MENA) adopted a low-pricing policy for reclaimed water. As in addition freshwater use is subsidized, also for irrigation, it is most common to set a price for treated wastewater below the price of freshwater, in order to increase its market share. Thus, cost recovery via the sale of wastewater is far from being a viable option. In fact, thus far the rule is that water is provided for free to the plantations. The generally low water tariff rates lead to overconsumption and wasteful practices. Water consumed by Egyptian citizens, as measured by litres per capita, exceeds international rates, e.g. in the EU by a wide margin (USAID, 2013).

Free supply of treated wastewater is a significant loss for those treatment plants where the plantation is run by a different entity like the Undersecretariat for Afforestation and Environmental Affairs. In plantations run by the same operator as the treatment plant, like in the case of El Berka, reuse offers at least some value creation to extend the revenue stream beyond household fees and sludge sale. In

2009, dried sewage sludge produced in El Berka was directly sold to farmers with a gate price of USD 8.20/m^3. In other plants, HCWW sells the produced sludge to contractors for (on average) USD 6.1/m^3 and the contractors sell it to farmers with a profit margin. Other organic fertilizer in the Egyptian market are sold at about USD 17.76/m^3 (Ghazy et al., 2009).

Little information is available about demand for plantation products. Market assessments and marketing strategies are urgently required. Rotational forest production and harvesting schemes are so far missing, but it is assumed that the market for fruits, industrial oil and wood is significant. However, several plantations show very inhomogeneous wood production and commercialisation to major wood manufacturing companies for wood chips, wood fibre or board production is doubtable, unless wood quality (i.e. plantation management) is improved and overall production is increased. Sale of carbon credits generated due to the increased carbon sink effect in biomass and accumulation of organic matter in the soil have not yet been explored (Becker et al., 2013).

Macro-economic environment

Egypt, like other MENA countries, offers great opportunities for large-scale afforestation projects due to the availability of significant amounts of sewage water and wide areas of desert land. Given the lack of any substantial natural forests, aggressive desertification and the dependency of the national wood industry on imported raw materials, the productive reuse would serve multiple benefits for society and nature, and help the national wood industry. Following basic treatment, sewage water can be efficiently used as a resource for the production of wood, woody biomass and biofuel crops. The HCWW supports this vision through its 25 subsidiary companies, plans to stronger encourage private sector investments in reuse projects via tenders and to establish an affiliated company dedicated to the management and operation of wastewater reuse projects. While the production of edible and non-edible crops is in line with the Egyptian Code for the Reuse of treated Wastewater in Agriculture (ECP 501/2005), adjustments are in discussion to support stronger the cultivation of industrial crops, like cotton, and selected edible crops that are not eaten raw (Abdel Wahaab, 2014).

The Egyptian Water Regulatory Agency estimates the degree of overall cost recovery in 2012–2013 at 62%, and the recovery of operation and maintenance costs excluding depreciation at 76%. Although low water fees deprive treated water from its potential value, the free water supply to plantations supports their cost recovery potential. However, until now private sector participation in plantations is missing. Challenges are complex institutional arrangements with inadequate communication and coordination among authorities; unclear regulations for commercialization, land ownership issues and limited initiation of public participation in reuse to promote its value. Efforts have been made to establish a new policy to sell or lease desert land adjacent to wastewater treatment plants to private investors for forest plantations (Loutfy, 2011).

Business model

The value proposition is to create commercial and amenity value by turning desert soils with the help of secondary treated wastewater into a plantation for the commercial production of wood and fruits (Figure 207). This transformation entails significant economic benefits for nature and society if it can be replicated across all 350 to 370 wastewater treatment plants operated under the umbrella of HCWW (reduced wastewater discharge into other water bodies, reduced dependency on wood import, wind breaks/microclimate improvement, carbon sink, fresh water savings, employment, etc.) given the lack of any natural forests in the country.

Key factors in support of this proposition are full government support, the advantages of a central coordination (HCWW) and that the required land and water inputs are free. However, the already

FIGURE 207. BUSINESS MODEL CANVAS FROM THE OPERATORS' PERSPECTIVE (HCWW/GCSWC IN EL BERKA)

KEY PARTNERS

- Ministry of Water and Wastewater Utilities
- Under Secretariat for Afforestation
- Ministry of Water Resources and Irrigation
- Egyptian Environmental Affairs Agency
- Farmers (informal use)
- Connected urban households

KEY ACTIVITIES

- Collection and treatment of wastewater for safe water and sludge reuse or disposal
- Plantation management and sale of fruits and wood
- Collection of fees

KEY RESOURCES

- Wastewater and sludge, land and labor
- Expertise in irrigation and plantation management
- Capital investment

VALUE PROPOSITIONS

- To transform wastewater and sludge into safe products for reuse in agro-forestry, cement production and safe environmental disposal

CUSTOMER RELATIONSHIPS

- Government to government contracts
- Government to private sector contracts
- Automated system for tariff payment to the Gov./HCWW

CHANNELS

- Tender for reuse
- Water via pipeline
- Wood via direct delivery or collection at plant/plantation
- Fees via online payment (Cairo)

CUSTOMER SEGMENTS

- Wood and cement industry
- Fruit market

Under discussion:

- Cotton market
- Industrial oil market
- Biofuel market
- Export market

COST STRUCTURE

- Treatment plant OPEX, CAPEX
- Agroforestry system labor and machinery
- Opportunity costs of idle reuse capacity
- Customer service and fee collection

REVENUE STREAMS

- Household wastewater fees (via water bill)
- Sale of sludge for compost and construction
- Sale of fruits, wood and potentially other plant products
- Sale of wastewater to informal reuse sector (potential)
- Governmental subsidy; carbon credits (potential)

SOCIAL & ENVIRONMENTAL COSTS

- Possible long-term risk for groundwater but limited costs if safety protocols are followed

SOCIAL & ENVIRONMENTAL BENEFITS

- Reduced water pollution from wastewater disposal into streams
- Creating forest and farmland from desert
- Microclimate benefits; carbon sequestration
- Reduced dependence on wood imports and freshwater resources
- Employment and amenity values

installed reuse systems, like at El Berka, operate significantly under capacity in terms of planted land, used water, marketing and actual sale volumes, while staffing reflects design capacity, resulting in high operational costs and negligible revenues. A key reason for the mismatch relates to insecurity in the choice of crops which can be commercialized under the governing regulatory framework and other, mostly institutional challenges. This insecurity translates into scaling back in the planted area, limited investments in forest management (sustainable planting-harvest rotations) and across similar locations lack of private sector engagement.

The revenues to cover the expenditures of the afforestation efforts come from the sewer surcharges on the water bill, with some additional revenues from the sale of sludge. The overall El Berka treatment plant including the plantation achieved according to FAO (2014) a 119% operational cost recovery despite the fact that only half of all connected households pay regularly the billed fees. USAID (2013) estimated for the operating GCSWC a more conservative 79% on O&M.

The business concept would gain momentum by revisiting the regulatory framework and institutions in charge, to avoid that whole harvests get lost, engagement in an annual planting/harvest cycle, increasing the cropped plantation area (and returns per paid staff), improving collection rates from households and the consideration of charging those 1,500 tenant farmers who are informally abstracting a large volume of treated wastewater from the El Berka drainage channels. The charges could be levied as part of the Governmental land rent while offering farmers extension services, e.g. on how to comply with the safety code 501/2005.

Other revenue streams, once available, could be carbon or biodiversity credits. Given the social dimension of this business model the level of governmental support could be supported based on an evaluation of the provided economic benefits in terms of ecosystem services.

Value chain and position

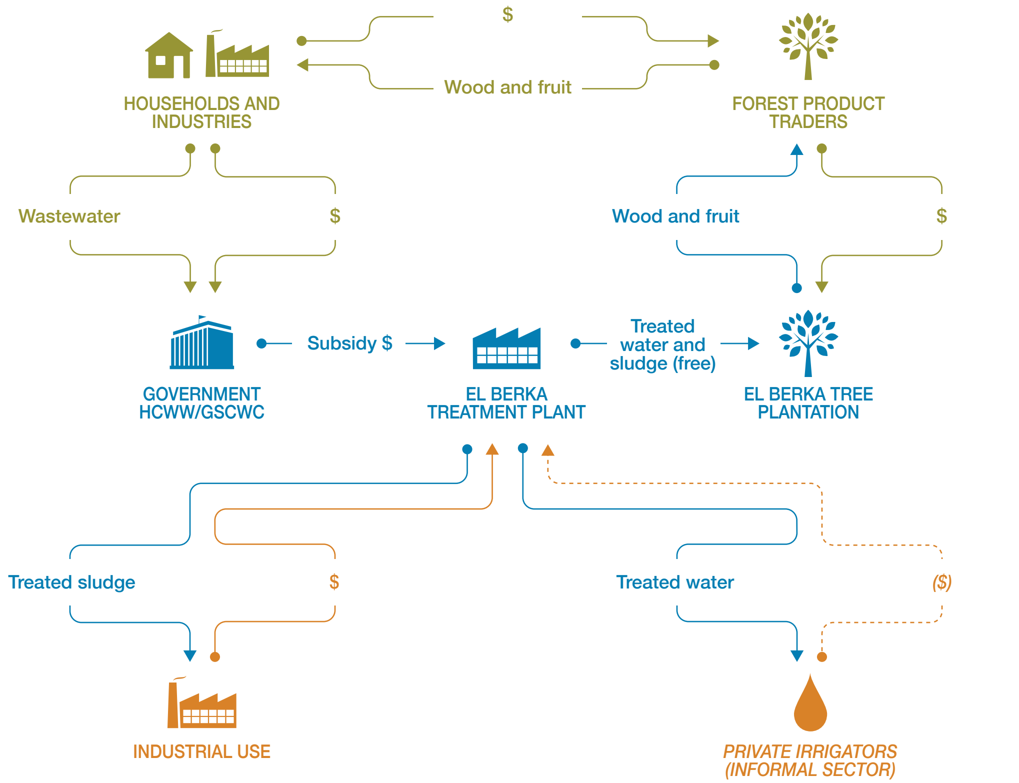
The main revenue streams are wastewater fees and additional governmental support (Figure 208). While the wood value chain in Egypt depends on import from Northern Europe and sub-Saharan Africa, this does not automatically make irrigated local forest plantations an attractive venture, especially not for private sector engagement due to the long growing time needed before the first harvest and returns on investments. A major initiative of HCWW is therefore to support the revision of the Egyptian Code for reuse to allow for the cultivation of industrial crops and some edible crops that are not eaten raw but have a significant market value, like cotton, industrial oil plants or biofuel and allow quick returns on investment (Abdel Wahaab, 2014). Growing such plants can reduce private sector risks, allows to diversify production and bridge till the first tree rotation after 13 years is on (FAO, 2014). The long initial waiting period is also risky for private sector investments considering the reform-friendly institutional landscape and related insecurities that policies might change over time to their disadvantage.

Companies in charge of drinking water and sanitation (like HCWW) are not mandated to set the tariff structure for the services they provide. It is the State which approves rates according to socio-economic and political criteria. This results in low prices that do not cover the cost of the service or the operation of these organizations in the majority of cases. There are continuing efforts to work towards a tariff policy and reform package, in support of an improved financial performance of the sector.

Institutional environment

The water and sanitation sector of Egypt went over the last decades through a series of institutional reforms.[1] Given the common water scarcity and the fact that the agricultural sector is the highest freshwater consumer, utilizing about 86% of the available supplies, water reuse, especially in

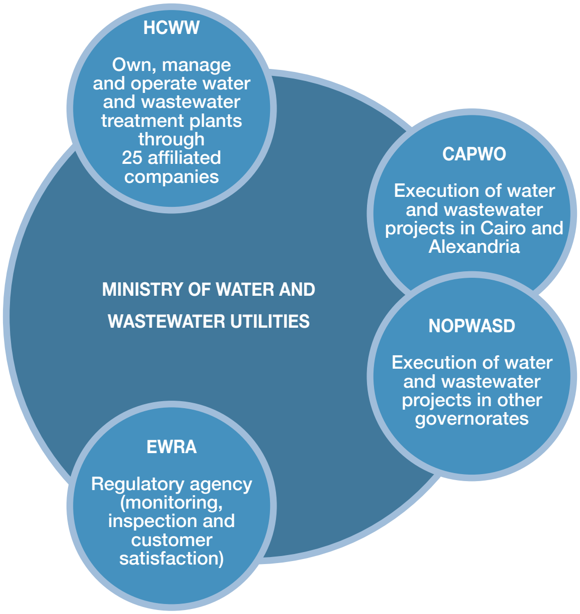
FIGURE 208. BUSINESS PROCESS FLOW OF THE EL BERKA WASTEWATER AND AGROFORESTRY SYSTEM UNDER COMMON OWNERSHIP



agriculture, was always part of the agenda. Laws and decrees have been issued including guidelines for mixing drainage water with fresh water, regulations for sewage and industrial effluents, wastewater reuse, cropping patterns, and health protection measures and standards specifications. The most important one is the Egyptian Code for the Reuse of Treated Wastewater in Agriculture (501/2005) by the Ministry of Housing Utilities and New Communities (Abdel Wahaab, 2014). There are at least five to six ministries with different roles involved in the wastewater management and reuse in Egypt. To streamline the institutional landscape the 2004 established HCWW owns, manages and operates all wastewater treatment plants across Egypt through its about 25 subsidiary companies. Other public companies under the 2012 created Ministry of Water and Wastewater Utilities (MWWU)[1] are the Cairo and Alexandria Potable Water Authority (CAPWO), which is responsible for the execution of water and wastewater projects in Cairo and Alexandria, the National Organization for Potable Water and Sanitary Drainage (NOPWASD) in charge of the execution of water and wastewater projects in other Governorates, and the Egyptian Water Regulatory Agency (EWRA) as an independent body of the others in charge of monitoring, inspection and customer satisfaction (Figure 209). However, due to overlapping responsibilities the regulatory agency remains so far relatively weak.

Besides the MWWU, several other ministries and institutes are involved in the wastewater activities. The Ministry of Agriculture and Land Reclamation (MALR) manages agricultural aspects, especially it operates forest plantations on reclaimed desert lands via the Undersecretariat of Afforestation and

FIGURE 209. INSTITUTIONAL ARRANGEMENTS UNDER THE MINISTRY OF WATER AND WASTEWATER UTILITIES



Source: Abdel Wahaab, 2013.

Environment (UAE) as its subsidiary body. MWWU took over function from the Ministry of Housing Utilities and Urban Communities (MHUUC), which was concerned with the planning and construction of municipal wastewater treatment plants.

The Ministry of Health and Population (MHP) assumes responsibility for sampling and analysis of all wastewater effluents. It is also responsible for setting water and wastewater quality standards and regulations in addition to its central role as the custodian of public health. The Ministry of Water Resources and Irrigation (MWRI) allocates water for reclamation areas and is responsible for the Nile. The Ministry of State for Environmental Affairs (MSEA) and the Egyptian Environmental Affairs Agency (EEAA) cater to environmental aspects (FAO, 2014).[2] Other stakeholders are scientific institutions and universities conducting basic and applied research activities and international partners (USAID, AfDB, GIZ, EU, etc.) supporting the sector (Abdel Wahaab and Mohy El-Din, 2013).

However, lack of communication and coordination among the authorities, overstaffing and overlapping institutional responsibilities, strict regulations for reuse, but only enforced in formal, not informal, systems, are some of the recurrent issues challenging progress (Abdel Wahaab and Mohy El-Din, 2013). While the ongoing reforms addressed major issues, others remain unresolved. For example, sector fragmentation was not actually reduced. No organization was dissolved; instead several new organizations were created. Cost recovery is still very low; overstaffing has apparently even increased, and the institutional separation of responsibilities for investment and operation remains a challenge, also for foreign assistance.

Technology and processes

Water: The wastewater treatment plant at El Berka was realized in two steps. The primary treatment was constructed in the year 1990. Facilities for secondary treatment were established in 1998. The plant has a total area of 42 ha and receives the wastewater from the 5 million people (1 million households) in the northeast Cairo through a specific sewer system. The treatment is biological and activated sludge in the aerated basins. An additional chlorine treatment is used to limit microbial contamination and potential disease risks for people and animals. While chemical characteristics of the treated wastewater were reported within the acceptable range for reuse with beneficial crop nutrient levels, microbial and parasitic data indicate that chlorination levels might be too low and do not reduce viable nematode numbers (Abd El Lateef et al., 2006). Consequently, additional safety measures are recommended where the water is used informally for crops eaten unwashed or raw. Groundwater levels are between 15–17m in the study area and an impact from irrigation difficult to verify (Abd El Lateef et al., 2006).

The treated wastewater arrives at the plantation from the treatment plant by gravity and by electric pumps. The water is pumped to the parcels and a drip irrigation system is installed for the wood trees, whereas flood irrigation is used for lemon trees and for cactus. The lemon trees and the cactus plants are irrigated both with treated wastewater and fresh water, whereas the wood trees are irrigated only with treated wastewater.

The plantation size is very small given the treatment capacity and there is a strong call for better matched systems, where decentralized, smaller wastewater treatment facilities allow to reuse a larger proportion of the treated water for agro-forestry than in large-scale facilities where the majority is discharged into receiving water bodies.

A particular challenge is the lack of controls to monitor wastewater discharge. This situation is untenable to a public private partnership (PPP) investor/contractor who is subject to a significant risk due to the practices of upstream dischargers that could easily compromise with toxic effluents the ability of a treatment plant to satisfy contractual obligations related to the quality of the plant effluent (USAID, 2013). There is a need to treat industrial wastewater separately and/or before discharge onto public sewer networks.

Sludge from the activate sludge treatment is dewatered in a gravity thickener and then sun dried. While its chemical characteristics were found acceptable (Ghazy et al., 2009), pathogen levels are natural high. To destroy pathogens a mixture of the sludge and agricultural waste (e.g. rice straw) are air composted where the temperature reaches about 65°C. The composted product is then sold as organic fertilizer for landscaping or for construction (to be mixed with cement). A limitation of the project is the expensive cost of rice straw (Massoud, 2010). The untreated sludge is discharged in desert areas.

Energy: For the replication of the system lessons from the neighbouring El Gabal El Asfar treatment plant will be useful where methane from the anaerobic digestion of sludge allows to produce 37–68% of the total power consumption for the treatment plant (Ghazy et al., 2009; Massoud, 2010).

Funding and financial outlook

Both the reliable supply of **wastewater** of suitable quality as well as vast areas of land are freely available for reuse. Although soil quality is poor, there are large volumes of nutrient rich organic (sludge) compost in direct proximity. Several trees and agro-industrial crops species showed good performance under the given climatic conditions. Thus, there should not be any biophysical problem to establish agro-forestry plantations. That so far most agroforestry schemes in Egypt operate sub-optimally and current irrigated areas are far below the areas actually planned and/or equipped for irrigation has man-made reasons which can be addressed. So far only a small fraction of treated wastewater is reused, also in the El Berka agroforestry systems and the bulk is being discharged amid some informal reuse by crop farmers, yet no wastewater reuse charges are levied either on land rent or as reuse fees, which could offer additional revenues.

The main source of cost recovery are the household sanitation fees charged with the water bill. Given that only every second household pays as required, and the tariffs are far too low, adjusting the tariffs and increasing fee collection provide the largest opportunity for exceeding cost recovery while subsidizing any further expansion of the plantation (FAO, 2014). Higher freshwater tariffs could also stimulate demand for lower priced reclaimed water. On the other hand, if the plantation is supposed to be run by a third party, low wastewater tariffs will support investments. More important is in this case that the regulatory framework supports the commercialization of short-rotation crops with high market value, including export markets, allowing the operator to have diverse income sources and returns on investment before the first tree rotation is due. With such measures and annual planting/harvesting cycles the prospects of business viability are high.

The use of **sewage sludge** in landscaping and forestry should be part of the model as plants need organic matter and nutrients. According to the Egyptian Government future plan, there is the possibility that the El Berka composting project may be expanded to a full-scale project to produce a compost of 720 tons per day from the dried sewage sludge accumulated from El Berka, Shobera and Al Gabel Asfer WWTPs (Ghazy et al., 2009). Such a significant sludge production supports the Egyptian policy to reclaim land lost due to desertification. The extensive sunshine exposure, high temperature, and dry conditions provide aggressive and unfavorable conditions for the survival of microbial pathogens. Chemical risks can be limited by industrial source treatment and sludge reuse for non-edible crops. Moreover, the high pH of most soils limits crop uptake of heavy metals. Indeed, most soils in Egypt would benefit from sludge compost, as reclaimed land is usually poor in micro-nutrients, such as zinc and copper which are required for plant growth and present in sludge (Ghazy et al., 2009). The theoretical calculated monetary value of the dried sewage sludge in Egypt is about USD 53/ton (USD 28.5/m^3). This value probably indicates the maximum price of the dried sewage sludge that can be paid by farmers, including the transport costs in the Egyptian market (Ghazy et al., 2009). Where sludge quality does not match safety standards, other reuse options exist. The El Amria Cement Company in Alexandria has been granted EEAA approval for use of substitute fuel to natural gas in the cement kiln including hazardous waste. The proposed project is to use part of the dried and dewatered sludge produced from the wastewater treatment plants in Alexandria as substitute fuel in the cement kilns. This will reduce GHG emissions generated from the anaerobic conditions if sludge is disposed in the landfill. Moreover, incineration of this type of bio-fuel will produce less CO_2 emissions if compared to fossil fuel. Therefore, there is a possibility that this project can be considered as a potential clean development mechanism (CDM) project; which offers interesting perspectives for other plants in Egypt (Massoud, 2010).

Socio-economic, health and environmental impact

An environmental and social impact assessment carried out by the African Development Bank for the extension of the El-Gabal El-Asfar wastewater treatment plant with comparable treatment quality and draining into the same water resources as El Berka confirmed an overall positive impact of the plant on its social and ecological environment (AfDB, 2008). The wastewater and sludge reuse activities, if done at scale, are reducing in addition their unproductive discharge into the environment while creating employment opportunities. These like other benefits for land reclamation, the support of the local wood or cement industry, micro-climatic improvements and carbon sequestration will depend on the scale of the water reuse and afforestation activities. The largest socio-economic and environmental benefit of reuse is its contribution to addressing water scarcity of communities across Egypt in the face of rising demand and shrinking freshwater volumes. The strict reuse standards provide less flexibility than the current WHO guidelines and Sanitation Safety Plans and could be adjusted, especially in formal reuse schemes where compliance monitoring is feasible. Efforts have to be increased, however, to address informal wastewater reuse by farmers outside the plantations where crop restrictions are not enforced. There are signs of microbial soil and groundwater contamination and a need for monitoring if and how far the irrigation is affecting the 15m deep groundwater table (Abd El Lateef et al., 2006).

Scalability and replicability considerations

The key drivers for the success of the reuse model are:

- Government's financial support for water, land and sludge use.
- Vast amounts of available resources, including a reliable water supply.
- Political will to further transform the sector.

The key obstacles are of institutional and regulatory nature:

- Limited private sector interest due to a too firm wastewater reuse code especially in terms of crop restriction.
- Overlapping responsibilities and limited cooperation among ministries and agencies in view of reuse and crop commercialization.
- Operational risk due to continuing sector reforms and reorganization with changing mandates and responsibilities.

Once the obstacles have been addressed, the El Berka model has significant potential for replication at decentralized level where land is available and forest plantations have a notable economic and social value for the local communities. Governmental support for initial capital cost will remain instrumental, both for the treatment systems and agroforestry system. However, cost recovery for the plantation is feasible. It can be run by the treatment facility or a third party. Product diversity with different payback intervals will be crucial while tapping into the emerging CDM market could be an additional option (Becker et al., 2013).

To support investments in reuse, HCWW embarked on an initiative to revise the Egyptian code for reuse to allow use of treated wastewater for cultivation of industrial crops and some edible crops that are not eaten raw, taking into consideration the required health protection measures. Ideally, a National Plan of Wastewater Reuse has to be established making freshwater use an exception where reclaimed wastewater is available, and where no reclaimed water is available, the freshwater tariffs have to be increased to stimulate wastewater (treatment for) reuse. However, since the Arab Spring residential tariff increases have become even more difficult to approve.

Summary assessment – SWOT analysis

Figure 210 presents the SWOT analysis of this business case from the reuse in agroforestry perspective. The case shows a high potential where resource supply and demand are in place but the institutional and regulatory environment prevents public and private sectors to make optimal use of the given opportunity.

FIGURE 210. SWOT ANALYSIS FOR EL BERKA WASTEWATER AND AGROFORESTRY SYSTEM

	HELPFUL TO ACHIEVING THE OBJECTIVES	**HARMFUL** TO ACHIEVING THE OBJECTIVES
INTERNAL ORIGIN ATTRIBUTES OF THE ENTERPRISE	**STRENGTHS** ▪ Vast land and wastewater resources at low cost or free ▪ Strong vision of HCWW to support reforms for private sector engagement and increased cost recovery ▪ Wastewater quality matching reuse for forestry and species mix ▪ Location with limited risk of negative trade-offs ▪ Highly trained staff in place	**WEAKNESSES** ▪ Severe overstaffing due to scaling back of production ▪ Unclear and complex decision making regarding what can be planted and commercialized ▪ Unclear standards for laboratory analyses to comply with water and sludge standards ▪ Treatment quality can vary and monitoring is weak ▪ Also groundwater quality needs monitoring
EXTERNAL ORIGIN ATTRIBUTES OF THE ENVIRONMENT	**OPPORTUNITIES** ▪ Revised regulatory framework allowing more non-edible products for commercialization ▪ Up-scaling of El Berka to design capacity and replication of similar plantations via decentralized smaller treatment plants ▪ WHO 2015 Sanitation Safety Planning concept facilitating compliance monitoring ▪ Export market ▪ Large national and export demand for wood which will support cost recovery	**THREATS** ▪ Mixed messages from authorities due to overlapping competencies ▪ Too restrictive regulations for cash crops which allow fast returns on investment ▪ Delay of reforms of regulatory framework and standards ▪ Negative public attitude and concerns related to product safety ▪ Fear of second Arab Spring preventing water tariff increase

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Case descriptions are based on primary and secondary data provided by case operators, insiders or other stakeholders, and reflect our best knowledge at the time of the assessments 2014/15. As business operations and institutional environments are dynamic data can be subject to change.

Notes

1 Also called Ministry of Water Supply and Sanitation Facilities.

2 The names of institutions and ministries and their responsibilities changed frequently in the past and can change again.