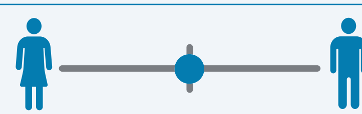
BUSINESS MODEL 17

Wastewater for greening the desert

Pay Drechsel and Munir A. Hanjra

Key characteristics

Model name	Wastewater for greening the desert
Waste stream	Domestic wastewater from decentralized sewer systems
Value-added waste products	Treated wastewater and sludge (biosolids); wood and other tree products
Geography	Arid and semi-arid regions (e.g. MENA)
Scale of production	Small to medium (300 to 30,000m^3/day reused)
Supporting cases in this book	Cairo, Egypt; Ouardanine, Tunisia; Drarga, Morocco
Objective of entity	Cost-recovery [X]; For profit [ ]; Social/environmental enterprise [X]
Investment cost range	Treatment plants: up to USD 50 million Agroforestry system: USD 300,000 to 1.6 million
Organization type	Public or public-private or for the reuse component also only private
Socio-economic impact	Green infrastructure like urban and peri-urban tree plantations have multiple financial and economic benefits from wood and fruit production to water retention, pollution combatement, job creation along the value chain and locally increasing property values
Gender equity	Gender specific advantages vary along the water reuse value chain 

Business value chain

The basic business concept is to recover in arid and semi-arid regions as much treated wastewater as possible for landscaping and productive reuse, like afforestation for timber, fuel or fruit production, while minimizing the unproductive or environmental harmful discharge of water and sludge. Given that treated wastewater of suitable quality for tree plantations will anyway be produced, or is already available, the additional value proposition for the creation of green infrastructure in a desert environment will have multiple social, environmental and economic benefits including improved overall living conditions while having the potential for recovering its own costs through the creation of opportunities for economic growth along the reuse value chain.

The treatment plant might be run by the public and/or private sector and has to be located at the border of a town or city with sufficiently available land for afforestation, recreation or agriculture in the vicinity. The high value for environment and society will help to sustain public subsidies, allowing the business to focus on the recovery of the additional reuse-related costs. For a high reuse rate and limited water conveyance (pumping), decentralized small to medium-sized wastewater treatment plants serving towns, peri-urban communities, suburbs and emerging cities would be most favourable. The institutional set-up across the sanitation-agriculture interface is important as all three case studies showed, and requires a high level of participatory planning and trust building for the recipients of the treated wastewater as well as their customers in its safety. The business model is most promising where no alternative water sources are available and the technology and safety standards permit the production of crops or produce in high demand. The model is at risk of limited impact where a) regulations are too weak; or b) do not match locally feasible technologies; and/or c) alternative water sources are available at a lower or even slightly higher cost.

Next to the sale of treated wastewater, also treated sludge (biosolids) can generate revenues as soils in dry areas are generally poor in organic matter and sludge could be an excellent soil ameliorant supporting soil fertility management and its water holding capacity. However, sewage sludge, even more than the treated water, requires a very reliable monitoring of potential contaminants. If these are too high, sludge can still be an asset but for other uses than food production. With the right institutional set up, market research, sales strategy and a pricing policy, net profits from the reuse scheme are possible.

The business concept involves a simple value chain schematic as shown in Figure 218. This treatment-reuse scheme can result in a public private partnership or remain in the public sector.

Business model

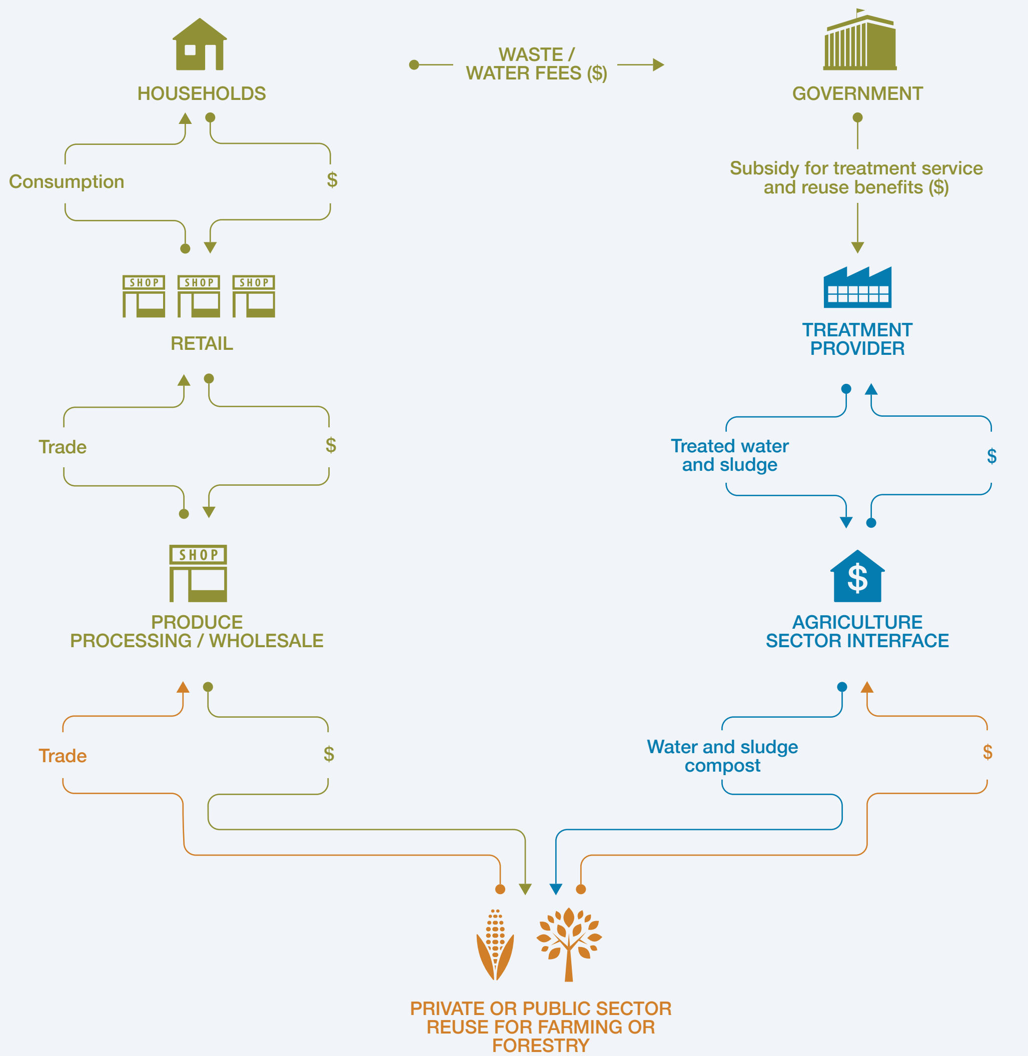
The basic value proposition of the model depends on the business goals and social objectives of the entity initiating the business model – government or private entity operating the wastewater treatment system, and government or farmers/ private enterprise operating the reuse system. Eventually the model will have several value propositions, but with different emphasis for cost recovery. **Next to the treatment of wastewater for safeguarding public health and other water resources, the second value proposition is to establish green infrastructure by offering water, crop nutrients and soil organic matter.** This will result in amenity values and other ecosystem services. Improved soil productivity can for example support tree or fruit plantations, wood and cotton production, biofuel, fodder or also vegetables as long as possible health risks can be minimized and controlled.

There are many institutional options for running the model. Two examples are:

a) Treatment plant and tree plantation are managed by the same public company. With free water and land allocation, cost recovery for the reuse component will largely depend on the efficiency of reducing operational (e.g. electricity) costs and possible overstaffing. Extending the privileges of free land and water to the private sector, would certainly constitute a strong incentive for its engagement assuming trees/crops with high market value and short turnover can be grown.
b) Alternatively, the responsibilities between treatment, water transport and reuse are shared between different stakeholders, which can be public or private like in the Tunisian case where water is sold along its pathway and each entity is using different strategies for cost recovery.

The key revenue sources for the treatment plant are (i) households via sanitation fees, usually collected as part of the water bill; (ii) governmental subsidies reflecting the treatment service for society and nature; and (iii) direct or indirect income from the sales of forest/tree crop products (Figure 219). For the conveyance of the treated water to the plantations, both the treatment entity and the government (saving directly/indirectly water disposal costs), and the benefitting water user association should contribute. A target could be to align wastewater selling rates with the operational cost of the water transfer and the market value of the irrigated product. Another possible revenue stream could derive

FIGURE 218. VALUE CHAIN SCHEMATIC – WASTEWATER REUSE FOR AGRICULTURE AND FORESTRY



from carbon sequestration in forest plantations or orchards (Box 8). While investments in perennial plants, like trees for wood production or evergreen citrus trees can absorb water year-round, their payback period till the first harvest (for fruits at least three to five years, for wood production twice as long) does not support quick returns on investment. In such cases, such trees might best be combined with other crops allowing earlier revenues. Many farmers call in particular for advanced treatment to grow highly profitable cash crops like vegetables.

FIGURE 219. BUSINESS MODEL CANVAS – WASTEWATER REUSE FOR GREEN INFRASTRUCTURE IN (SEMI)ARID REGIONS

KEY PARTNERS

- Sector ministry
- Agroforestry systems (managed by public or private sector)
- Served households
- Authorities in charge of safety monitoring
- Larger public (trust building)
- Environmental ministry/authority

KEY ACTIVITIES

- Treatment and sale of wastewater and sludge
- Collection of household fees (sanitation tariff)
- Social marketing to support perceptions on reuse safety

KEY RESOURCES

- Treatment plant
- Wastewater with no or limited industrial contamination
- Land, labor and capital investment
- Partnerships with agricultural sector

VALUE PROPOSITIONS

- To build green infrastructure and value chains from treated wastewater and sludge (biosolids)

CUSTOMER RELATIONSHIPS

- Government to government
- Government to water user associations/ private sector
- Online household billing
- Direct sale of biosolids to traders (or farmers)

CHANNELS

- Direct dialog and contract (water/biosolids reuse)
- Wholesale contracts (if treatment plant operator also runs plantation)
- Online communication with served households

CUSTOMER SEGMENTS

- Water user associations
- Golf courses
- Forestry projects
- Cotton plantations
- Orchards
- Biofuel and energy market
- Soil input dealers

COST STRUCTURE

- Capital investment (treatment plant, water to farm conveyance)
- Operation and maintenance costs (incl. in-house quality monitoring and costs of risk prevention)
- Customer interface and social marketing/promotional costs

REVENUE STREAMS

- Sewage tax for connected households
- Government subsidy (environmental and social benefits)
- Sale of forest products, wastewater and sludge
- Energy savings (via internal (treatment plant) energy recovery)
- Carbon sequestration (potentially, see Box 8)

SOCIAL & ENVIRONMENTAL COSTS

- Limited costs if treatment plant can avoid receiving untreated industrial effluents, treatment level is appropriate and monitored, and compliance with safety protocols strictly enforced.

SOCIAL & ENVIRONMENTAL BENEFITS

- Green infrastructure benefits from ecosystem service support, like water and nutrient cycling, micro-climate improvement, amenity values, jobs along the value chain, and editable or non-editable (e.g. firewood) produce
- It reduces the disposal of treated but nutrient rich wastewater into natural water bodies
- Reduction in energy use (optional)

Alternate scenario

Greater cost recovery through better accounting, pricing and market extension

As seen in the example of the Drarga plant near Agadir in Morocco, an advantage of decentralized plant management can be that for each plant's service area, all sales revenues and revenues from the water or sewage tariff are deposited into a special account, independently of others accounts, to serve solely the cost-recovery and maintenance of each individual treatment plant. This system can prevent that community revenues are redirected to other needs, and could also provide incentives for benchmarking where management is centralized if transaction costs can be minimized.

Greater cost recovery could come through improved pricing of the services, resources and products. For instance, household could be charged block rates prices for wastewater treatment based on actual water usage, instead of a flat sewage tax as it is common in some countries. Treated wastewater could be sold in bulk to the water user association at a price that reflects more on the costs of water treatment rather than just the additional cost of the water conveyance between treatment plant and irrigation system. The farmer body could then resell the water to its members charging them a markup to recover additional costs of operations including routine maintenance and repairs within the irrigation system. However, all this requires that farmers have limited access to other water sources.

Increasing the freshwater tariffs would make agricultural irrigation with freshwater unfeasible and might force farmers to shift to using reclaimed wastewater if its tariffs are maintained low and if its supply and quality are reliable. This incentive might be constrained by the fact that many farmers control their own facilities for meeting their needs from groundwater resources; thus, energy tariffs should also be considered to steer pumping costs.

For further income, new market segments are needed, like industrial demand for dried sludge as fuel. To reduce the industrial carbon footprint, especially in the cement industry, or where conventional fuel sources are in irregular supply or expensive, sewage sludge derived kiln fuels can be an alternative which the industry might favor as it will in addition qualify under the Clean Development Mechanism (CDM, Box 8).

Box 8. Forest carbon offset: An additional revenue stream?

Converting 'no forest' desert land into a 'forest' absorbs carbon in the growing wood which can be sold on the carbon offset market to carbon emitters, and add a revenue stream to the wastewater reuse project. The gain depends on the total carbon offset which is estimated in 'million tonnes equivalent' (mt CO_2-eq.) stored in living tree biomas. In 2012, a cumulative 134Mt CO_2e of offsets have globally been transacted from 26.5 million hectares of forests. Two out of every three offsets were sold to multinational corporations. Businesses were motivated by offset-inclusive corporate social responsibility (CSR) activities, or to "demonstrate climate leadership" in their industry or to send signals to regulators. Demand for offsets from afforestation or reforestation projects were in 2012 with 8.6 MtCO_2e at a similar level as demand based on *reduced emissions from deforestation and forest degradation* (REDD).

The issuing of carbon credits for afforestation activities has to meet a set of strict guidelines. The amount of carbon sequestered by forests has to be assessed and depends upon many factors including type of tree, tree age and local growth rate, which again depends on climate, irrigation and soil quality.

If a forest owner sells his forest then (s)he is committing to maintain the CO_2 stock. If wood gets lost, like to climate events, disease or unplanned instead of planned harvest, the owner would have to buy back offset credits to cover the loss. An 'ideal' carbon sequestration forest is one where the owner is able to sell carbon credits each year until tree growth and the carbon sequestration rate plateaus, at which time the forest could be harvested and the harvest revenue is higher than what is needed to pay for the lost (above ground) carbon stock. This requires close monitoring of the wood and carbon markets. An alternative target would be to establish a sustainable rotation with regular planting and harvesting, where the stock and growth rate of sold forest biomass could be maintained despite harvests.

Obviously, this type of management and certification has costs and the question is if the returns make them worthwhile. From a purely financial perspective, revenues from offsets in today's still-developing offset market are limited. The price per ton of CO_2e varies significantly but is commonly in the range of USD 4–10, although higher and lower prices can be found. Trees might bind five to ten metric tons of CO_2 per ha per year which translates on average into an annual gain of about USD 30–80 per ha. Thus a 50 ha irrigated wood plantation could generate a gross annual income from carbon sequestration of about USD 1,500–4,000 which has to be compared with the transaction costs of registration and alternative commercial options (timber, firewood, fruits, etc.). Orchards are in the carbon business less prominently as they are usually less densely planted and also pruned, i.e. their carbon accumulation rate will be lower than of many forest species. The plantation sizes as reported in our two case studies are rather small and as offset credits are often traded in units of 10,000t $C0_2e$ or more, which might only be achieved on about 1,000 ha, forest owners need to pay an Offset Aggregator who functions like a broker between woodland owners and the carbon market. A possible alternative for the future could be other offset markets, such as BioBanking where plantation owners can sell Bioversity credits to the market as seen e.g. in Australia (NSW 2007) or payments for watershed services (The Rockefeller Foundation 2015).

Additional sources: http://www.rogerdickie.co.nz/Forestry.aspx; www.forestcarbonportal.com/; www.ecofys.com/files/files/world-bank-ecofys-2014-state-trends-carbon-pricing.pdf.

Potential risks and mitigation

The business model presented here was designed based on the analysis of three case studies in Tunisia, Egypt and Morocco, and other cases and references. There can be a variety of business risks affecting the successful implementation of such a model, most of them being more generic than model specific. For example, as reuse projects involving wastewater are potentially harmful to human and environmental health, particular health risk (mitigation) options are obvious and have to be highlighted.

Market risks: There is no risk related to the need for treating the wastewater, which is a necessity for safeguarding public health. Market risks exists however for the reuse part of the system, which can derive e.g. from (i) competing water/fertilizer sources; (ii) competing final products; and (iii) lack of trust in product quality.

i) Lower costs for accessing alternative water sources (e.g. groundwater) or organic fertilizer can reduce demand for reclaimed water or sludge as fertilizer.
ii) If imported fruits or timber have an established local market, market penetration will require extra efforts or highly competitive pricing which reduces the likelihood of cost coverage.

iii) Different kinds of reuse like irrigating trees, orchards, fodder or vegetables will require different water quality standards. It is mandatory that treatment and post-treatment options will meet these standards to maintain trust in the reclaimed water. Monitoring compliance with safety measures and final water effluent are part of the risk management protocol, as outlined in the WHO *Sanitation Safety Planning Manual* (WHO, 2015). However, technical capacity alone might not be sufficient to address negative consumer perceptions. Any reuse project requires active stakeholder engagement, transparency and feedback from the start on. The role of social marketing and awareness raising can be critical in reducing opposition to water reuse especially in agriculture.

Technology performance risks: A large variety of treatment technology and irrigation systems are available. In low-income countries, common reasons for low or decreasing technical performance in wastewater treatment are poor maintenance practices often due to lack of incentives, lack of electricity, or e.g. lack of sufficient water to flush the sewers. Poor maintenance can result in non-compliance with set treatment standards, which can translate into health risks and loss of customers. Also irrigation technology can have shortcomings, especially where wastewater has to pass in small tubes, like in drip irrigation, where clogging is more common than with fresh water.

A mismatch between imported treatment technologies and local requirements, possibilities and capacities has also been described, for example by Nhapi and Gijzen (2004) from Zimbabwe and supports the call for low-cost applied technologies (Libhaber and Orozco-Jaramillo, 2013) with any additional treatment levels matching cost-effectively the intended reuse or disposal.

Political and regulatory risks: These risks vary from country to country and can be high where the regulatory frameworks, like reuse standards, are under discussion or managed by different authorities with overlapping responsibilities.

Social equity related risks: The model is considered in general as neutral in view of particular gender advantages or disadvantages from the operational or business perspective. As the percentage of women graduating in both, agriculture/forestry and engineering in MENA countries is comparable to or higher than in more developed countries, the foundation for women employment in treatment plants or forestry is increasing. However, women's increasing enrollment in engineering and the sciences is not (yet) reflected in a higher female labor force participation or lower female unemployment (World Bank 2009). There are significant variations between countries, and there can be more permanent employment opportunities for men in forestry and wood processing, while the forest might provide firewood as primary or secondary objective, which could be a significant social benefit in an environment where women struggle finding fuel. There is also evidence of seasonal employment opportunities for women (e.g. olive harvest in Tunisia), although in many countries female workers receive lower wages than male.

Safety, environmental and health risks: Wherever wastewater is used there can be a health risk for different stakeholders and the environment, including occupational risks for workers, discomfort (odor) affecting communities in plant vicinity, and depending on what is produced also risk for buyers/ consumers. Mitigation measures are ideally installed along the wastewater treatment to reuse value chain (WHO multiple barrier approach). To minimize safety and health risks to workers and other stakeholders, standard protection measures are required as elaborated below (Table 51). Among various reuse options, growing trees is considered one of the safest. However, where trees are harvested for editable products for the market (e.g. citrus, olives), care has to be taken that pathogens do not get in contact with the harvested product. A particular challenge derives from the use of wastewater and sludge (even if composted, i.e. sanitized) where the wastewater includes industrial effluent due to the possibility of heavy metal entering the food chain. As in all cases of industrial effluent, local pretreatment is required before the water enters the public sewer network and eventually the treatment plant. The risk would matter less for wood than fruit production where it requires monitoring. Although in the target areas aquifers are usually only found in considerable depth, regular groundwater monitoring is also required.

TABLE 51. POTENTIAL HEALTH AND ENVIRONMENTAL RISKS AND SUGGESTED MITIGATION MEASURES FOR BUSINESS MODEL 17

RISK GROUP	EXPOSURE						REMARKS
	DIRECT CONTACT	AIR/ DUST	INSECTS	WATER & SOIL	FRUIT	WOOD	
Workers							Sanitation Safety Planning (WHO 2015) recommended for entire value chain. Elevated risk if business opts for sewage sludge composting/sale.
Farmers							
Community							
Consumer							
Mitigation measures				Pb Hg Cd	Pb Hg Cd		

Key: NOT APPLICABLE; LOW RISK; MEDIUM RISK; HIGH RISK

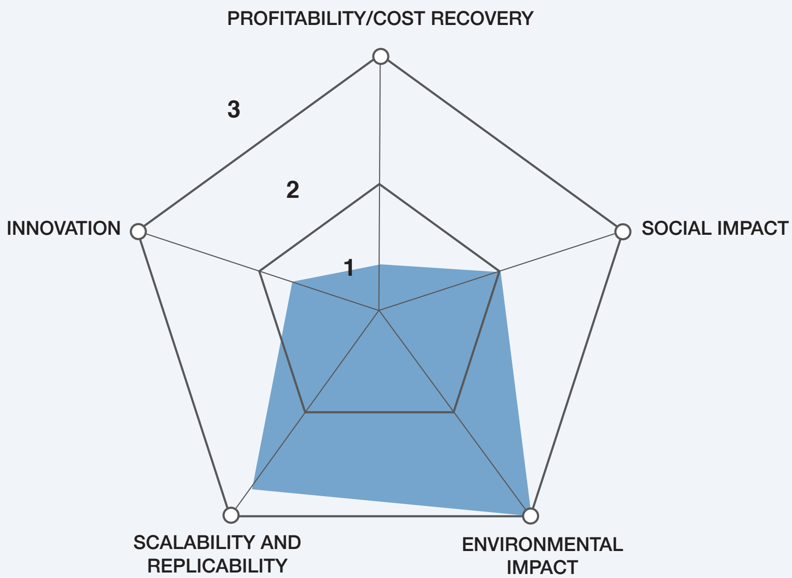
Business performance

Wastewater reuse to produce green infrastructure in human vicinity like tree plantations, parks or orchards can have significant social and ecosystem benefits in MENA region (Figure 220), although the overall social impact varies to some extend with the generated employment opportunities.

Using wastewater for wood production is one of the safest and financially promising reuse options. Thus from an investment perspective, stigma might be less an issue, and the main challenges of the model are more related to the time span between investment and payback, not the water itself. However, there are various options from fast growing trees to agro-forestry which can allow faster returns if supported by treatment quality and regulations.

Different ownership models are possible with cost recovery for the treatment plant largely depending on the freshwater and wastewater tariffs and prices. As long as freshwater is sold under value, the business model ranks low in view of recovering treatment costs although it reduces the water bill of the plantation, and can create significant financial value in form of wood and other forest products. The model ranks high in its adaptability to various bio-physical conditions and in terms of scalability and replicability wherever land is available and freshwater sufficiently scarce that farmers have no alternative. The model can work with plants of any size providing secondary treatment although the cost recovery share might be highest at the scale of smaller towns or suburbs. The right institutional setup to balance financial and economic benefits to the satisfaction of all involved parties is the challenge.

FIGURE 220. RANKING RESULTS FOR WASTEWATER REUSE IN AGROFORESTRY SYSTEMS



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