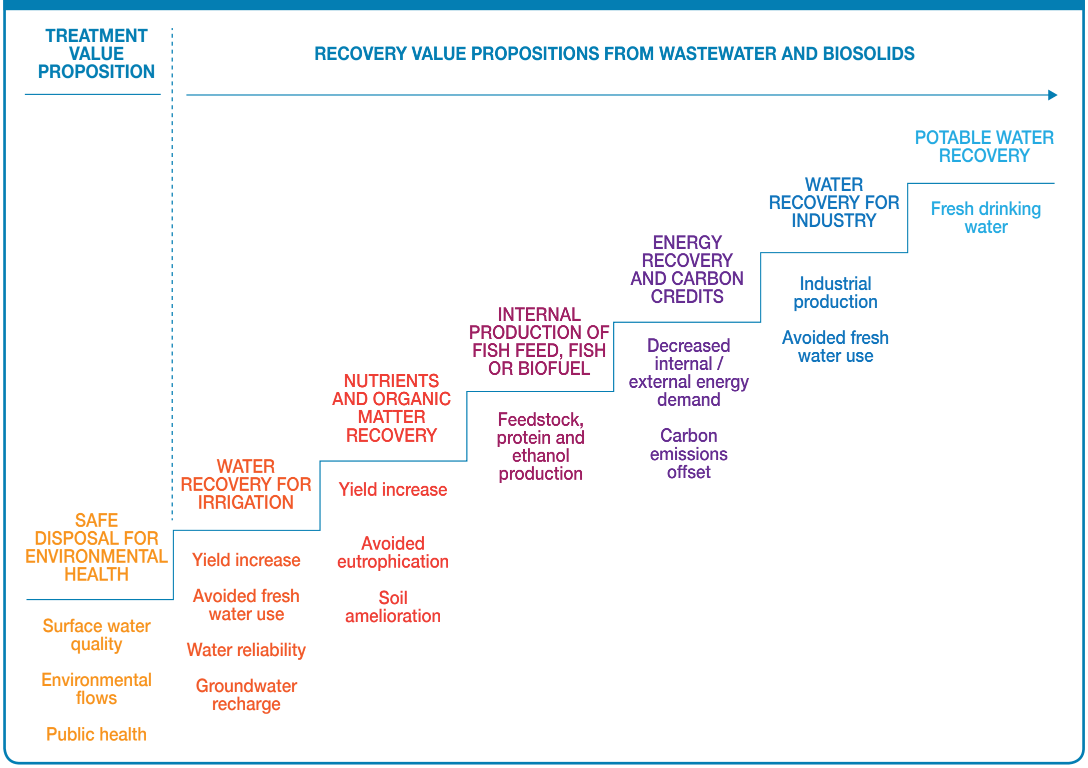
Wastewater for agriculture, forestry and aquaculture: An overview of presented business cases and models

Between now and 2030, the sourcing of water for human needs is expected to change, as the pressure on natural freshwater resources becomes more intense. This pressure is likely to come primarily from agriculture, as increasing demands for higher protein diets and biofuels will require a significant increase in agricultural output, which can only be met through greater water use. This will accelerate the over-exploitation of our freshwater resources, including a 66% increase in non-renewable groundwater withdrawals which is likely to affect millions of people by 2030, and billions by the end of the century (GWI, 2014). Under these circumstances, there will be limited alternatives to water reuse and desalination, especially where long-distance transfer is not cost-competitive. As public agencies seek economically and socially acceptable solutions to cope with increasing water demands, matching waters of different qualities with appropriate uses and implementing helpful reuse incentives will become essential for achieving the Sustainable Development Goals 6.3, 7.2 and 12.5, which directly address resource recycling, recovery and reuse. Unfortunately, the wastewater sector has long been a neglected utility, driven by regulation rather than economics or business thinking. But the situation is changing and water reuse is gaining significant momentum in discussions around green economies, urban resilience and enhancing urban food security. The awareness is growing that wastewater is in fact the only source of additional water that is increasing with population growth and higher water consumption, offering a range of opportunities for transforming wastewater and bio-solids into value propositions (Figure 206).

FIGURE 206. LADDER OF INCREASING VALUE PROPOSITIONS RELATED TO WASTEWATER TREATMENT BASED ON INCREASING INVESTMENTS IN WATER QUALITY AND/OR THE REUSE VALUE CHAIN



Source: Drechsel et al., 2015.

The highest market growth has been forecasted by Global Water Intelligence (GWI, 2010) for advanced water treatment supporting high value industrial and potable use. GWI is predicting that despite higher treatment costs the returns on investment will be rewarding. Already today we see many examples, also in developing countries, where up to 100 % of the operational and maintenance (O&M) requirements can be met from the sale of treated wastewater to local industries for uses such as cooling, power generation or air-conditioning (WSP, 2016). Cost recovery is usually less promising in view of agricultural reuse. Although the agricultural demand might be much higher than from particular industries, the sector's willingness and ability to pay are usually much lower, especially in low-income countries, while demand is often seasonally limited. Also in regions with highly subsidized freshwater tariffs or free groundwater access, cost recovery potential is low (Hanjra et al., 2015).

Thus, many wastewater business models are mainly **social models**, which are economically strong but fall short in view of financial sustainability unless the societal benefits are internalized. A survey conducted, for example, by the Water Environmental Research Foundation showed that only 12 out of 79 projects setting reclaimed water rates, aimed at full cost recovery (GWI, 2010). In these cases, motivating the use of reclaimed water takes precedence over cost recovery. In a report by the Tunisian Ministry of Agriculture, cost recovery rates in different irrigation projects with treated wastewater ranged between 13% and 76% of operational expenses for the agricultural supply component only (Chenini et al., 2003), not including the operational costs of the treatment facility. This is because financing water reuse projects can be challenging in that it is often expensive to build and operate an additional set of pipes and pumps to reach the final users, unless investors take over the responsibility. A more interesting point is why do some projects manage 76% while others only 13%? Such differences can derive from the choice of technology, institutional set-up, value proposition and targeted investment in cost reduction and recovery as our examples will show.

The first example of **Business Model 16** was presented in the previous section, and showed how wastewater treatment plants can reduce their operational costs of unwanted phosphorus (P) removal by investing in its recovery. The model by the company Ostara has therefore been presented in the Nutrient Recovery section. The model can be combined with energy recovery as shown recently in Amersfoort, the Netherlands where a 12,000-ton sludge treatment installation at the local wastewater treatment plant was commissioned in 2016, that will annually produce 900 ton (t) P-rich struvite and has an energy surplus of 2 million kilowatt hours (kWh) that will be delivered to the national grid.

This wastewater section of the Resource Recovery from Waste catalogue starts by describing three water reuse projects from **Egypt, Tunisia** and **Morocco** in Chapter 14**.** They represent different plant sizes, and institutional and regulatory challenges, and can therefore stimulate discussion on how to best maximize social and environmental benefits while targeting cost savings and recovery through closed loop processes and the sale of, for example, forest products. The three cases are located in a region where water is a scarce resource and reclaimed water can be of high importance for different sectors including farming and afforestation, therefore providing the basis for **Business Model 17: Wastewater for greening the desert (Institutional and regulatory pathways to cost recovery).** A fourth related case is Jordan's As Samra plant. However, due to its interesting financial set-up, the case is presented separately (see below).

The potential for cost recovery or even profit is multiplied when costs are minimized and returns maximized. This is possible where treatment systems are low in energy consumption and the resource recovery and reuse (RRR) value proposition goes beyond simply recovering water to incorporate the next steps of the value chain by selling products (e.g. fish fed with fodder) grown with the nutrients wastewater offers. In such cases, the likelihood of recovering both the fixed and variable costs of the (added) reuse component as well as the operational and maintenance costs of the treatment process can be substantial as the analyzed cases show. Technology choice is important, particularly in developing countries. Wastewater use in agriculture or aquaculture, can be supported through pond based treatment processes, with low investment costs and affordable operation and maintenance. Such processes are particularly suited to countries with warm climates where biological processes perform well. The investment costs for such locally 'appropriate' technologies are in the range of 20% to 50% of more conventional treatment plants, while the operation and maintenance costs are in the range of 5% to 25% of conventional (activated sludge) treatment plants (Libhaber and Orozco-Jaramillo, 2013). Chapter 15 presents two cases from **Bangladesh** and **Ghana** which show community based low-cost treatment systems in combination with the establishment of a fish-based value chain, taking advantage of the nutrient content of the wastewater. In the case of Bangladesh, the pond operator-cum-entrepreneur even recovered the construction costs of the treatment system. This is followed by an explanation of the overall model derived from the cases, which could potentially be applied to other settings – **Business Model 18: Leapfrogging the value chain**.

However, this business model does not imply that only smaller community-based pond systems can build on RRR to achieve high cost recovery. Many of the largest wastewater treatment plants in the world minimize their operational costs through highly efficient energy recovery mechanisms. As described in Chapter 16, **Jordan**'s extended As Samra wastewater treatment plant which was inaugurated in October 2015 is able to generate up to 95% of its energy needs, supported in part by a favorable topography. With minimized operational costs and an innovative overall cost sharing model, it contributes significantly to Jordan's entire renewable water resources, freeing up fresh water for more valuable uses. The main sources of finance for capital expenditure are public spending, external aid (loans, grants) and revenues from potable and industrial water use. The set-up of funding sources and guarantees can be of high complexity as shown in case of As Samra, but also much simpler as described for example by the Water and Sanitation Program (WSP) (2016) for Tamil Nadu. **Business Model 19: Enabling private sector investment in large-scale wastewater treatment** explains the institutional arrangements and overall characteristics for this type of model.

Energy recovery has also in smaller treatment plants the most significant potential for cost savings. While water and nutrient recovery can provide a certain contribution to offset the costs of sanitation and wastewater management systems, it is mostly the recovery of bioenergy that supports more substantial O&M savings. A survey carried out by WSP in India, for example, showed that energy recovery rates of 80–95% allowed to cut O&M cost of the studied wastewater treatment plants by half. The addition of a biogas plant, which costs about 15% of the wastewater treatment plants own capital cost, showed a pay-back period of only two to three years with an Internal Rate of Return of 33%. To support on-site electricity generation, contracts with private plant operators can be designed so that twice the amount for the power is charged whenever power is drawn from the grid to meet the plant's energy need and this is deducted from the payment made to the contractor (WSP, 2016). According to a 50-country analysis by Wang et al. (2015) bioenergy recovery has a high potential to realize environmental sustainability in developing countries where approaches should be customized, rather than attempting to replicate the successful models of developed countries.

Another set of interesting business models are emerging in the rural–urban interface. Growing urban water demands are placing substantial pressure on urban and peri-urban areas, leading to increasing calls for water reuse and integrated inter-sectoral water management and transfers. Chapter 17 covers four cases in this important interface: the rural-urban water-wastewater swaps in **Spain** and **Iran** (**Business Model 20: Inter-sectoral water exchange)**, and the cases of **India** and **Mexico** where urban wastewater refills peri-urban and rural aquifers. In these cases, peri-urban areas function increasingly as 'kidneys' for the urban metabolism (**Business Model 21: Cities as their own downstream user**), which can be a promising model as long as possible environmental and human health risks are controlled, a statement which of course applies to all waste-based RRR models.

The last set of 'business models' differ from the others and are intended to stimulate further discussion. This is needed as wastewater reuse in agriculture is actually much more common than any official statistics so far have shown. The latest estimates indicate 36 million hectares of irrigated cropland depend on untreated or partially treated wastewater, used directly or indirectly after dilution (Thebo et al., 2017), in areas where urban treatment capacities are not keeping pace with population growth. The widespread use of unsafe water in these areas has prompted the World Health Organization (WHO) to test and recommend alternative on- and off-farm options for safeguarding farmers and public health, such as the multi-barrier approach (Drechsel et al., 2010). However, the adoption – or more precisely the provision of incentives for the adoption – of such safety measures remains a major challenge, and is urgently needed where regulations are not able to enforce measures such as crop restrictions in the informal irrigation sector. In support of WHO's sanitation safety planning concept (WHO, 2015) this catalogue presents three "business models" based on empirical cases from **Pakistan, India** and **Ghana**, supported by similar observations from other countries. The models are not mutually exclusive and show entry points and opportunities for increasing the safety of informal wastewater irrigation (**Business Model 22–24**) based on corporate social responsibility, the marketing of wastewater as a commodity and farmers' own investments in infrastructure, respectively. A model related to No. 23 and 24 with focus on improving the safety of informal (sludge) reuse was presented in the Nutrient Recovery section (Business Model 15).

In summary, most examples presented in the wastewater section of the *Resource Recovery from Waste* catalogue address the more common, but still complex and financially challenging situation of water reuse for agriculture, forestry and aquaculture, covering cases from Latin America, Africa, Asia and the Middle East and North African region. Several of the examples recover more than one resource and/or support more than the agricultural market. Further wastewater reuse examples from other sectors than agriculture have been covered elsewhere (e.g. 2030 WRG, 2013; Lazarova et al., 2013; USEPA, 2012).

A significant **weakness** throughout large parts of the wastewater section of the catalogue is the lack of reliable data on infrastructure financing or financial performance, as well as economic benefits. Extracting financial data from authorities or their publications posed a significant challenge, while economic impact assessments are generally rare. This is unfortunate, as internalizing the social and environmental benefits of wastewater treatment would probably well justify any public investments.

The presented cases and models – although by far not exhaustive – show a tremendous potential for RRR and private sector participation, where the enabling environment is in place (Chapter 19). If the well-known health and environmental risks can be controlled appropriately, there are many options to go beyond the social benefits of wastewater treatment and monetize the reuse value in ways that enable public and private sectors to achieve higher degrees of savings as well as cost recovery or even to generate profit. This 'double value proposition' will hopefully pave the way for a better delivery of wastewater services, and a more 'circular economy' for overall system sustainability (Andersson et al., 2016; Drechsel et al., 2015).

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