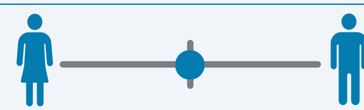
BUSINESS MODEL 19

Enabling private sector investment in large scale wastewater treatment

Katharina Felgenhauer

Key characteristics

Model name	Enabling private sector investment in large-scale wastewater treatment
Waste stream	Wastewater treatment for reuse
Value-Added Waste Products	Treated wastewater for irrigation and a healthy environment
Geography	Water-scarce regions
Scale of production	Medium- to very large-scale
Supporting cases in the book	As Samra, Jordan
Objective of entity	Cost-recovery [ ]; For profit [X]; Social/Environmental enterprise [X]
Investment cost range	USD 100–400 million
Organization type	Public-private
Socio-economic impact	High-technology setup and efficient, nearly energy neutral operation of waste-water treatment facility while maintaining affordable tariffs for water users
Gender equity	Socio-economic benefits for male and female population. All users benefit from affordable water tariffs 

Business value chain

Investments which are economically and socially desirable, like large-scale wastewater treatment for reuse, often lack financial viability. The upfront capital investment is too high for public or private sector to assume alone, and long gestation periods and the inability to increase user charges to commercial levels, decrease the likelihood of private sector buy-in. Especially larger plants with significant resource recovery potential often struggle with an appropriate finance plan. To share investment burden, investors are invited to cover the design and construction of the facility, coupled with a time-bound operation agreement, such as the Build-Operate-Transfer (BOT) model applied in the case of As Samra in Jordan. Private sector investment, however, can only be expected if the project is profitable and bankable.

Normally, revenue from such an investment is generated from user fees paid for wastewater treatment, public subsidies and to a minor degree, revenues from water reuse. In some cases, public sector services are configured with fixed or capped end-user fees. This may be useful to ensure broad and inclusive access to the service, such as in the framework of pro-poor policies. If fees are low and inflexible, the costs for infrastructure installation plus operation and maintenance is hardly recovered fully through user fees, let alone can a profit be made from the operation.

To address this common situation, the business concept applied in As Samra suggests ways to provide an attractive investment opportunity to private sector despite inflexible user fees and high capital costs. Government or donor funds can be used to cover up-front capital expenditure in infrastructure, thereby setting the stage for private investors. Such targeted investment of public sector funds can secure private sector resources in the forms of funding, material assets, technology and management expertise.

Public investment thereby achieves higher impact at a faster and more efficient rate compared to a solely public intervention. After a defined period of operation, the facility can be handed back to government, providing a return in kind on the initial public expenditure. Private sector management ensures a resource-efficient setup and running of the operation, giving the public sector opportunity to continue efficient service provision after the end of the public-private partnership (PPP) agreement. High degrees of energy recovery for system internal reuse is supporting the feasibility of the model.

To achieve this leverage, the upfront investment costs of the overall undertaking must be reduced to a level that makes the venture interesting and viable for private sector investors, including banks. A comprehensive risk management and reassurance scheme has to accompany and guide the partnership to ensure adherence to resource commitment by all parties throughout the duration of the PPP term.

Business model

This business model looks at blended finance options for the up-front investment of medium- to large-scale wastewater treatment plants. The model seeks to attract private sector co-funding and is applicable to situations in which the water user fees cannot fully recover investment, operating and maintenance costs. By reducing the up-front investment needs, the venture becomes financially interesting for private investors.

Public sector funds have to be available for this model to close the funding gap, either through domestic government budget or other sources, e.g. international development partners. Funds should be disbursed as grants to reduce financial liability. These funds are used to cover all or some initial infrastructure investment costs to reduce the up-front investment hurdle (Viability Gap Funding, see Box 10).

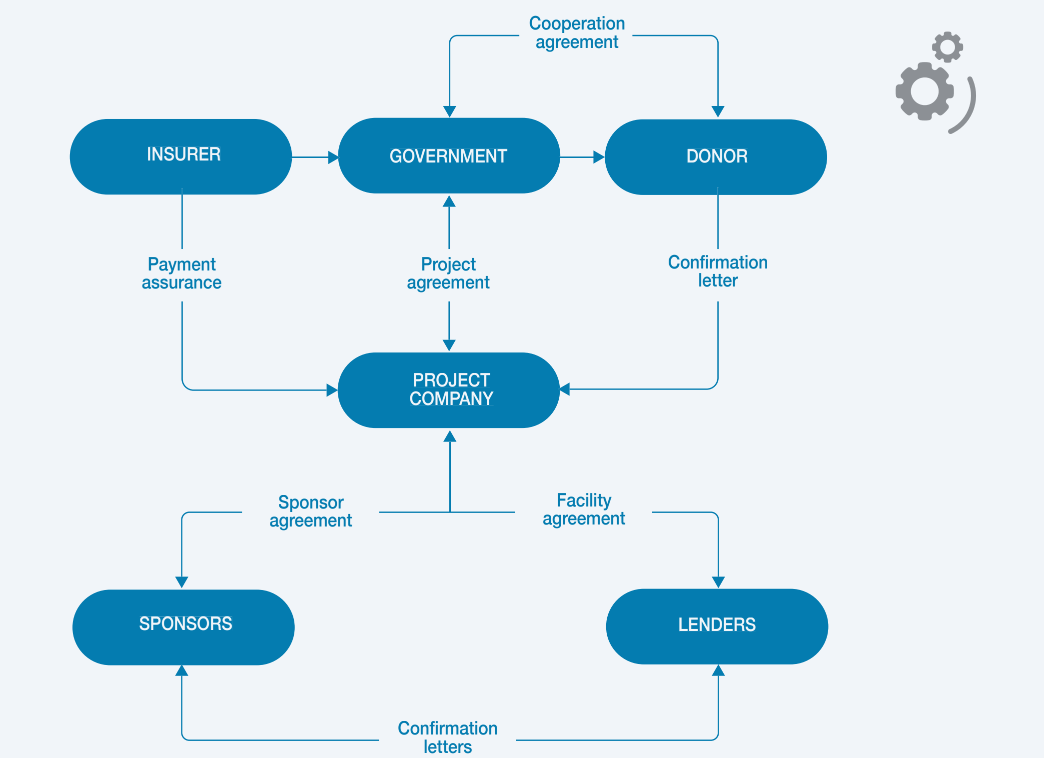
The funds should not subsidize the companies themselves nor their operations but the infrastructure development at hand; companies will earn a return only on their share of investment. Investors can create a project company, in which different sponsors can hold shares, to ease transaction management and tracking. Benefits can be combined with existing measures which attract foreign direct investment, such as tax breaks or reduction of duties and levies.

The private sector co-funding can only be secured if the viability gap funding has been fully committed to. Guarantee mechanisms have to be in place to back the commitments, e.g. through comprehensive contracts (see example in Figure 237) and guarantees from government or multilateral bodies. Backing by the Ministry of Finance (e.g. through a reserve fund) as well as international reinsurance and dispute resolution services help build trust among the partners and lower the investment risk. In the case of As Samra, Jordan, the Multilateral Investment Guarantee Agency (MIGA) provided guarantees against breach of contract for the expansion of the plant and its operation during the 20 year PPP term (MIGA, 2015). Failure to comply with any commitment should lead to strict and clearly spelled out penalties,

Box 10. Viability Gap Funding

Viability Gap Funding (VGF) refers to a grant, one-time or deferred, provided to support infrastructure projects that are **economically justified but fall short of financial viability**. The lack of financial viability usually arises from long gestation periods and the inability to increase user charges to commercial levels, making it unattractive for private sector investments. Viability Gap Funding (VGF) reduces the upfront capital costs of pro-poor private infrastructure investments by providing grant funding at the time of financial close, which can be used during construction. The VGF 'gap' is between the revenues needed to make a project commercially viable and the revenues likely to be generated by user fees paid mostly by poor customers. Although the economic benefits of a private investment project may be high, in situations where the incomes of end users are low, it may not be possible to collect sufficient user fees to cover costs. VGF is designed to make projects that are economically viable over the long term, commercially viable for investors. It helps mobilize private sector investment for development projects, while ensuring that the private sector accepts a share in the risks of infrastructure delivery and operation. Recognized by several international financial organizations the As Samra innovative financing has set up a new template for Viability Gap Financing. This new mechanism provides a significant leverage to the financial assistance of international donors and will allow new projects to materialize.

FIGURE 237. SAMPLE CONTRACTUAL LANDSCAPE BASED ON THE CASE OF THE AS SAMRA PLANT, JORDAN



Source: Adapted from SPC, 2014.

compensation or other rectification measures for all negligent parties. Banks are more likely to avail credit to private sector partners with a substantive risk-sharing mechanism in place.

For such a setup with multiple actors and a high level of interdependency to work, a number of framework conditions need to be fulfilled (OECD, 2014). Government requires strong and stable institutions with growing capacity to manage private sector partners. In Jordan, the Millennium Challenge Corporation (MCC, 2012) funded transaction advisors who would help broker the multi-party agreement system on behalf of the government. Unclear roles and responsibilities, ongoing reforms and policy gaps all contribute to a higher level of uncertainty, i.e. investment risk. The less flexible the water tariffs, the more reliable the government commitment to maintain minimum prices must be. Otherwise, cost recovery risks become difficult for the investor to hedge. Partners need to be aware that negotiations are likely to take considerable time before completion; project implementation will not commence before closure. These transaction costs add to the overall financial burden of the investment opportunity.

Once operational, the treatment plant can generate revenue from government payment or user fees for both, wastewater treatment and reuse of treated wastewater (Figure 238). If government steps in, expenses can partly be recovered through water fees or taxes at household or entity level. Farmers and companies which use treated water can be charged, however, fees will likely remain below the level of fresh water. A differentiated assessment of the clients' willingness and capacity to pay will estimate the cost recovery potential of this revenue stream. Ideally, tariffs should be calculated to cover at least operation and maintenance of the wastewater treatment facility to ensure long-term viability even after the end of the PPP agreement. Flexible tariff structures reduce the economic risk of the investment.

In return, government investment leverages private co-funding for a timely setup and operation of wastewater treatment to benefit large portions of society. Making additional water resources available for use in agriculture and industry supports economic development while maintaining affordable water user tariffs. At the end of the PPP agreement, government will receive the wastewater treatment facility at no additional cost. Efficient management processes will be in place, spurred by private sector interest in efficiency gains during the PPP term.

Alternate scenario

Lower viability gap funding through tender

Difficulties might arise when calculating the dimension of viability gap funding needed to make the venture interesting to private investors. Cost recovery alone will be insufficient to entice investors who are looking to make maximum profit. Investors, for the same reason, are motivated to predict inflated cost estimates when asked for advice in calculating the appropriate viability gap funding.

One way to limit the risk of overspending at the onset is to include the viability gap funding as element in a public tender. Expressions of interest from private sector partners should include an assessment of the amount of grant funding needed. The tender can then be allocated to the best bidder in terms of service provision and viability gap funding necessary to ensure maximum return on the public sector grant. The competitive nature of the bidding process encourages minimum gap funding requests. Service delivery quality, however, should not be compromised.

FIGURE 238. BUSINESS MODEL CANVAS – ENABLING PRIVATE SECTOR INVESTMENT IN WASTEWATER TREATMENT

KEY PARTNERS

- Sector ministry
- Ministry of Finance
- Donor(s)
- Private investor(s) / operator(s)
- Commercial banks
- Risk mitigation broker / insurer

KEY ACTIVITIES

- Secure viability gap funding and revenue guarantee
- Negotiate effective risk management and insurance mechanisms
- Moderate multi-partner platform

KEY RESOURCES

- Grant funding (government or donor funds)
- Budget for payment to operators per m^3 of treated water
- Risk insurance

VALUE PROPOSITIONS

- To create attractive business opportunities for private sector investment in wastewater treatment infrastructure

CUSTOMER RELATIONSHIPS

- Public-private partnership agreement
- Price guarantee
- Risk management and mitigation system

CHANNELS

- Multilateral negotiations
- Mutual risk management guarantees
- Public-private partnership agreement

CUSTOMER SEGMENTS

Private sector with strong track record in wastewater treatment, incl.

- Infrastructure companies
- Operators
- Commercial banks / investors

COST STRUCTURE

- Capital investment (one-time grant)
- Payment to operators per m^3 of treated water (ongoing expenses during PPP term)

REVENUE STREAMS

- Water user fees for wastewater and water reuse
- Government budget allocation and/or donor funds
- High degree of energy recovery as cost saving measure
- P-recovery as cost saving measure and possible revenue

SOCIAL & ENVIRONMENTAL COSTS

- Large-scale treatment plant to occupy land and eco-system
- Sludge storage

SOCIAL & ENVIRONMENTAL BENEFITS

- Business-run operation will generate efficiency gains, i.e. save resources at high output, like low external energy requirements
- Private sector funds increase scope and impact of operation, i.e. more water is treated and available for reuse, reducing e.g. groundwater abstraction

Potential risks and mitigation

This business model has been derived from the successful and acclaimed example of the As Samra Plant in Jordan. In addition to general risks related to reuse projects involving wastewater, such as harm to human and environmental health, the following risk mitigation options are particularly relevant to the financing model at hand.

Market risks: The viability gap funding requires a careful analysis of the business case for wastewater treatment in the region. Without reliable calculations of cost recovery and attractive profit margins, public overspent is likely. The risk can be partly mitigated by including an assessment of necessary viability gap funding in tender selection criteria (see alternate scenario above).

The careful assessment of the business case for wastewater treatment will also help to ensure long-term sustainability of the operation, in particular upon handover of the facility back to government at the end of the PPP. Water users' fees, as sole income to refinance the service, must cover operation and maintenance costs of the facility to avoid continuous subsidy. A differentiated fee structure for users of treated water, e.g. in agriculture or industry, can expedite cost recovery.

Private sector investors will only buy into the venture if viability gap funding is fully committed. A comprehensive risk-sharing and mitigation mechanism has to be negotiated for all parties to agree. This, in return, also provides security to government that public funds will effectively leverage additional investment and result in efficient wastewater service delivery. Sufficient time and resources need to be spent on the partnership negotiations and the establishment of a reliable contractual framework.

Technology performance risks: Leveraging private sector investment supports high-end technology because companies will operate at competitive levels to sustain their own business and generate profit, e.g. through efficiency gains. At the end of the PPP agreement, public sector is likely to receive state-of-the-art facilities. However, private sector partners must be selected competitively, considering track records of service delivery, to avoid technology and funding pitfalls. Quality of service should be guaranteed in unambiguous commitments (contracts) with clear remedy processes in case of non-compliance.

Political and regulatory risks: The model's dependency on reliable funding commitments and risk-sharing entails heightened relevance of political and regulatory stability. Reinsurance guarantees have to be given by stable, legitimate partners that are very likely to remain unchanged throughout the duration of the PPP agreement. A multi-layer support system which includes, for example, national and international partners alike, can be beneficial.

Social equity related risks: The model enables social benefits independent from gender differentiation, such as increased water resources for agricultural and industrial production. Additional jobs will be created at the plant (likely to favour male over female employees) as well as in irrigated agriculture benefitting both gender. The model facilitates the preservation of low water user fees, thus supporting broad and inclusive access to wastewater treatment services across social layers and income groups.

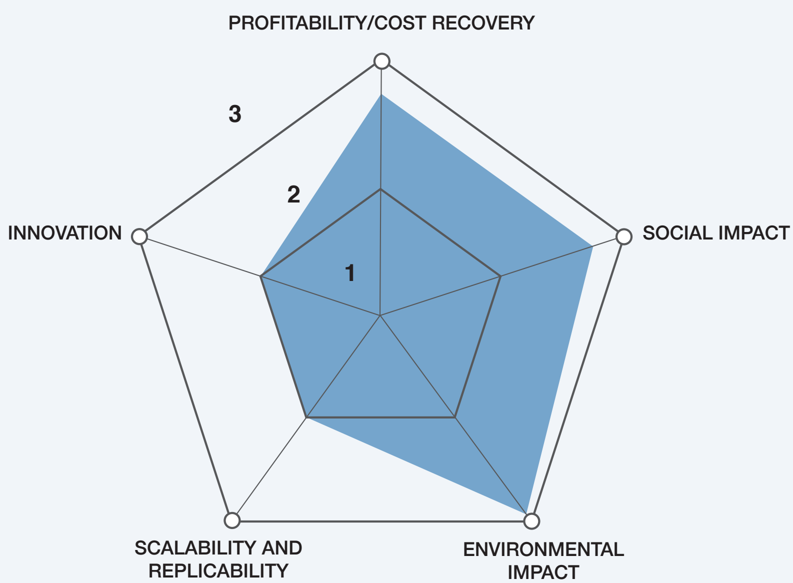
Safety, environmental and health risks: The model is about balancing financial risks for large-scale investments and as such not associated with any technology or particular environmental and health risks. In fact the financial volume is so high that it allows advanced treatment and risk mitigation. Naturally, the construction of a large-scale wastewater treatment plant will impact the site itself and its immediate surroundings, including eco-systems and communities. However, the downstream environmental benefits are significant in terms of preventing pollution, and providing large amounts of reclaimed water. The involvement of private companies in setup and operation of the wastewater treatment plant will support resource-efficient technology and management practices, e.g. covering the energy needs of production from own operation, and phosphorus recovery for reuse. In case of non-compliance with safety measures, potential health hazards will remain possible and demand risk mitigation measures as shown in Table 51 of Business Model 17. However, as this model is about the institutional–financial set-up, independently of the technology, **a separate table on potential risks and risk mitigation has been omitted.**

Business performance

Targeted viability gap funding by public sector helps leap ahead in wastewater treatment and water service delivery. Government and donor grants can leverage funding from private investors while tapping into business technology and expertise in wastewater treatment and management. Overall efficiency gains in water treatment (e.g. via energy recovery) coupled with the provision of additional water resources for agricultural or industrial consumption make the investment model attractive to government. While private sector partners exploit a profitable business opportunity, returns in economic development and environmental protection benefit society at large. Figure 239 shows the ranking of the model with its considerable strength to secure the anticipated positive environmental and social impacts as well as long-term viability.

That being said, the model can be challenging to set up with high transaction costs before operations can begin. Commitments need to be reliably secured through contracts and effective remedy mechanisms. Risk management and mitigation are of great importance, especially in large-scale and long-term ventures, as the model is vulnerable to economic, political and regulatory instability. If the capacity to effectively broker powerful public-private partnerships is further developed, substantial gains can be achieved in public service delivery.

FIGURE 239 RANKING RESULTS FOR BUSINESS MODEL 19



References and further readings

Keenan, R. and Norman, M. 2012. As-Samra sets expansion template. Project Finance International October 17: 48–51.

MCC. 2012. MCC completes first major build-operate-transfer project financing in Jordan. 11 September, 2012. MCC. https://assets.mcc.gov/content/uploads/2017/05/action-2012-002-1136-01-first-major-build-operate-transfer-project.pdf (or https://goo.gl/LyRoH8; accessed 6 Nov. 2017).

MIGA. 2015. Guaranteeing investments in water and sanitation projects. MIGABrief Water July 2015.

OECD. 2014. Jordan: Overcoming the governance challenges to private sector participation in the water sector. 10th meeting of the Regulatory Policy Committee, 14–15 April 2014, GOV/RPC/NER(2014)5.

SPC. 2014. Samra: Wastewater treatment plant – A major asset for Jordan. Presentation 21 Oct, 2014. https://www.unece.org/fileadmin/DAM/ceci/documents/2014/water_and_sanitation_October/Jordan_the_Amman_wastewater_treatment_plant.pdf (or https://goo.gl/mi3VNY; accessed 6 Nov. 2017).

Wichelns, D., Drechsel, P. and Qadir, M. 2015. Wastewater: Economic asset in an urbanizing world. In: Drechsel, P., Qadir, M. and Wichelns, D. (eds. Wastewater: Economic asset in an urbanizing world. Dordrecht, Netherlands: Springer, pp. 3–14.

17. BUSINESS MODELS ON RURAL–URBAN WATER TRADING

Introduction

To sustain increasing urban water demands different strategies are common, such as a combination of long-distance water transfer and advanced wastewater treatment for reuse. Where possible also seawater desalination is being considered. Commonly referenced examples of technical excellence are the production of potable water from wastewater in Singapore and Namibia, based on a business model that is largely depending on reliable technology and positive public perceptions (Lazarova et al., 2013).

In this section, two business models (20 and 21) are presented which use a different approach of exchanging wastewater and freshwater, based on rural-urban water trading. Compared with inter-basin water transfers[1], the here presented models target **inter-sectoral transfers of water** to uses of higher economic value:

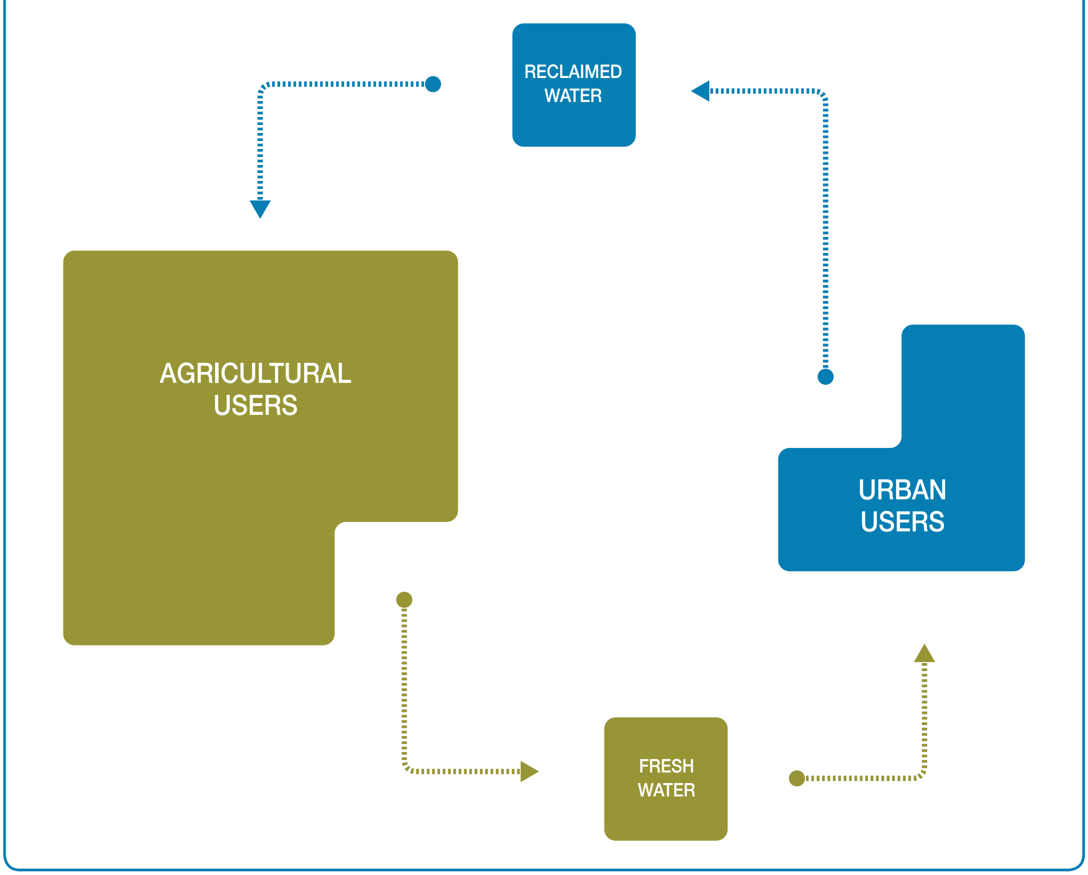
i) Water relocation takes place within the same basin or even the same watershed, moving water originally allocated to agriculture to domestic use, in particular drinking water.
ii) The models involve a two-way flow, i.e. freshwater release and transfer are based on the availability of a return flow of (treated) wastewater able to replace the created water gap and support if needed also other ecosystem service functions.
iii) Aquifer recharge is a common element complementing the available treatment capacity to produce water suitable for agricultural and/or domestic reuse also where treatment capacities are limited.

Given the young age of the presented cases and complexity of their setup, financial performance indicators as well as estimates of the social and/or environmental benefits or costs are largely missing, except for managed aquifer recharge, e.g. in USA or Australia (Maliva, 2014; Megdal et al., 2014; Gao et al., 2014).

Model 20: Inter-sectoral water exchange

Water exchange is driven by social and economic values. Not all uses of water are equally valued. Water for drinking has much high **social value** than for agriculture, yet the quantities involved are smaller. Water for irrigation has a lower **economic value** but the quantities involved are vast; on a global average about 70% of all the world's freshwater withdrawals go towards irrigation. Further, the quality requirements for drinking and agriculture are quite distinct. Therefore, taking a small volume of good quality water away from agriculture could make a sterling contribution to urban drinking water needs, while the resulting reduction to agriculture could be offset by substituting the lost amount with reclaimed water of lower but still appropriate quality, and this independent of seasons, i.e. throughout the year (Figure 240). In instances where farmers can get volumetrically more reclaimed water for irrigation than they release freshwater, and where a water-short municipality gets in a cost-competitive way a reliable supply of quality water for drinking, all partners benefit. Although such water exchange is in theory optimizing the value of the available water within a system, in support of greater environmental sustainability and climate change adaptation, it requires incentive systems and well-formulated contracts to secure the buy-in of a sufficiently large number of farmers who release freshwater for a mutually beneficial and thus sustainable business model. This is no easy endeavour with a range of possible gains but also conflicts (Molle and Berkoff, 2006; GWI, 2010), and might not recover its costs as long as swapped water volumes are low, but will greatly pay off in comparison with the direct and indirect costs of any extended drought period (Martin-Ortega et al., 2012).

FIGURE 240. BASIC IDEA OF AN INTER-SECTORAL WATER EXCHANGE



Source: GWI, 2010, modified

The two case studies, which informed Business Model 20, are from **Iran** and **Spain** and based on the most recent experience with inter-sectoral water exchange. In the case of the Llobregat delta in Spain, a severe drought in 2007–2008 catalyzed significant investments into infrastructure able to produce high-quality reclaimed water to secure farmers' acceptance of a water swap in prolonged periods of drought. For this, the water swap contract remained flexible to allow transfers as needed. In Iran, on the other hand, the urban water deficit of the city of Mashhad is common reality and farmers received incentives to transfer their (entire) freshwater rights to the city in exchange of treated wastewater. Both cases face challenges which provide valuable lessons.

The model offers **several related value propositions**:

- Mitigating drought and related economic costs through reallocating freshwater from agriculture to urban use in exchange for reclaimed water allowing to realign water supply and demand from various sectors based on sector specific water quality requirements.
- Improved crop production and food security across seasons, the support of ecosystem services, aquifer recharge and increased resilience against drought and climate variability.
- Opportunities to raise revenue from sale of freshwater for high-value use and enhancing cost-effectiveness of the overall rural-urban water systems.

Although a water exchange could be approached from the perspective of both main parties, the reality is that in most cases the urban end is the driver of the business. In the case of Iran, for example, an initial survey showed that all city dwellers supported the planned exchange while about 97% of water right holding farmers opposed the plan (Yazdi, 2011). While in this case the political power of the urban sector determined the negotiations, the opposite could be possible, like in the case of Faisalabad, Pakistan (Business Model 23) where farmers strongly prefer (untreated) wastewater instead of (the only temporarily available and nutrient-poor) freshwater.

Model 21: Cities as their own downstream user

The rapid growth in urban population in countries like India is putting immense pressure on urban water supply and wastewater management. This has led to large-scale water transaction between urban and peri-urban areas. On one hand, urban water authorities and informal water traders are increasingly importing water from the urban periphery to meet the urban water need, while on other hand, farmers in the hinterland are using wastewater disposed by urban centers for irrigation (Londhe et al., 2004; Van Rooijen et al., 2005; Jampani et al., 2015; Hanjra et al., 2018). This rural-urban water exchange is a common situation today, and becomes more 'interesting' in water scarce areas, where the imported freshwater is actually the exported wastewater. Model 21 thus brings a developing country perspective to what is commonly referred to as managed aquifer recharge (MAR), looking at the increasingly common phenomenon of a closed water loop where the city is tapping into its own return flow. Aquifer recharge happens in this context on a trajectory from unplanned to planned, with limited wastewater treatment and differently developed formal and informal water markets closing the loop (Foster et al., 2010; Londhe et al., 2004; Jiménez, 2014). This makes the models rather complex and unsafe in contrast to the more commonly described experiences from Australia or USA (Dillon, 2009; Megdal et al., 2014) where in part dedicated agencies manage the underground water banking program under well-defined regulations and monitoring.

The chosen examples in this book are thus not success stories per se (Lazarova et al., 2013) with already documented, positive benefit cost ratio (e.g. Vanderzalm et al., 2015; Perrone and Merri Rohde, 2016), but reflecting situations and challenges observed on the trajectory to a more planned and managed RRR program, which have a significant potential for upscaling, if appropriately addressed.

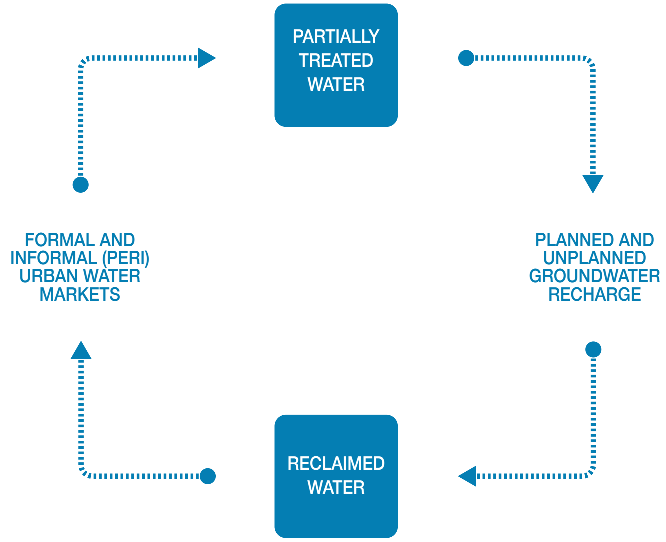
Common related challenges in developing countries are weak institutional linkages for integrated surface and groundwater management across rural-urban borders, as well as missing regulations and monitoring of water quality (Bahri, 2012; Foster and Vairavamoorthy, 2013; Yuan et al., 2016). Without enabling environment, related business models struggle although the economic benefits appear worth the investment. The two cases, which informed Model 21, are from **Mexico** and **India**. In the example from Bangalore, India, largely untreated wastewater is transferred out of town to replenish peri-urban water tanks (reservoirs) and aquifers with multiple benefits for society, farming and ecosystem services. Some of the water returns through informal water markets back to the city, often at prices unaffordable for poorer households. Such rural–urban water transactions are increasingly common around Bangalore and many other cities in India, and need much stronger official acknowledgement to address likely externalities (Londhe et al., 2004).

The second case is the Mezquital Valley of Mexico, which is well-known for its enormous scale of wastewater reuse (Jiménez, 2009). With the recent inauguration of the Atotonilco treatment plant, the recovery of 'freshwater' from the replenished aquifer can become for Mexico City an increasingly important business model with lower pumping costs than any alternative option. The two business cases offer:

- Turning wastewater into a commodity for all-year irrigation and potable reuse through tank revival and/or groundwater recharge.
- Savings in land, disposal and treatment costs while supporting the delivery of ecosystem services.

The resulting water loop from both cases appears to reflect an increasing reality of the circular economy between urban and rural areas, where the urban hinterland functions as a **'kidney'** for urban water reuse (Figure 241).

FIGURE 241. THE EMERGING PICTURE OF URBAN-RURAL-URBAN WATER TRANSFERS



References and further readings

Bahri, A. 2012. Integrated urban water management. GWP (Global Water Partnership). TEC Background Paper 16.

Dillon, P. 2009. Water recycling via managed aquifer recharge in Australia. Boletín Geológico y Minero 120 (2): 121–130. ISSN: 0366-0176.

Foster, S., Hirata, R., Misra, S. and Garduno, H. 2010. Urban groundwater use policy – Balancing the benefits and risks in developing nations. GW•MATE Strategic Overview Series 3. Washington DC, USA: World Bank.

Foster, S. and Vairavamoorthy, K. 2013. Urban groundwater. Policies and institutions for integrated management. Global Water Partnership Perspectives Paper. 20pp.

Gao, L., Connor, J.D. and Dillon, P. 2014. The economics of groundwater replenishment for reliable urban water supply. Water 6: 1662–1670.

GWI. 2010. Municipal water reuse markets 2010. Oxford: Global Water Intelligence.

Hanjra, M. A., Wichelns, D. and Drechsel, P. 2018. Investing in water management in rural and urban landscapes to achieve and sustain global food security. In: Zeunert, J. and Waterman, T. (eds.) The Routledge Handbook of Landscape and Food. Routledge: London, UK.

Jampani, M., Amerasinghe, P. and Pavelic, P. 2015. An integrated approach to assess the dynamics of a peri-urban watershed influenced by wastewater irrigation. Journal of Hydrology 523: 427–440.

Jiménez, B. 2009. Water and wastewater management in Mexico City. In: Larry Mays (ed) Integrated urban water management: Arid and semi-arid regions. UNESCO-IHP, CRC Press, p. 81–112.

Jiménez, B. 2014. The unintentional and intentional recharge of aquifers in the Tula and the Mexico Valleys: The megalopolis needs mega solutions. In: Garrido, A. and Shechter, M. (eds) Water for the Americas: Challenges and opportunities. London and New York: Routledge, p. 156–174.

Lazarova, V., Asano, T., Bahri, A. and Anderson, J. 2013. Milestones in water reuse: The best success stories. IWA, 408pp.

Londhe, A., Talati, J., Singh, L.K., Vilayasseril, M., Dhaunta, S., Rawlley, B., Ganapathy, K.K. and Mathew, R.P. 2004. Urban-hinterland water transactions: A scoping study of six class I Indian cities. Draft paper of the IWMI-Tata Water Policy Program Annual Partner's Meet 2004. 21pp.

Maliva, R.G. 2014. Economics of managed aquifer recharge. Water 6: 1257–1279.

Martin-Ortega J., González-Eguino, M. and Markandya, A. 2012. The costs of drought: The 2007/2008 case of Barcelona. Water Policy 14: 539–560.

Megdal, S.B., Dillon, P. and Seasholes, K. 2014. Water banks: Using managed aquifer recharge to meet water policy objectives. Water 6: 1500–1514.

Molle, F. and Berkoff, J. 2006. Cities versus agriculture: Revisiting intersectoral water transfers, potential gains and conflicts. Comprehensive Assessment of Water Management in Agriculture Research Report 10. Colombo, Sri Lanka: International Water Management Institute (IWMI), Comprehensive Assessment, 70pp.

Perrone, D. and Merri Rohde, M. 2016. Benefits and economic costs of managed aquifer recharge in California. San Francisco Estuary and Watershed Science 14 (2): Article 4.

Vanderzalm, J.L., Dillon, P.J., Tapsuwan, S., Pickering, P., Arold, N., Bekele, E.B., Barry, K.E., Donn, M.J. and McFarlane, D. 2015, Economics and experiences of managed aquifer recharge (MAR) with recycled water in Australia. Australian Water Recycling Centre of Excellence.

Van Rooijen, D.J., Turral, H. and Biggs, T.W. 2005. Sponge city: Water balance of mega-city water use and wastewater use in Hyderabad, India. Irrig Drain 54: 81–91.

Yazdi, P. 2011. A survey on social issues in replacing effluent with agricultural water rights (Case study: replacing Mashhad effluent with water rights from Karder River). International Congress on Irrigation and Drainage, 15–23 October, Tehran, Iran.

Yuan, J., Van Dyke, M.I. and Huck, P.M. 2016. Water reuse through managed aquifer recharge (MAR): Assessment of regulations/guidelines and case studies. Water Quality Research Journal of Canada 51 (4): 357–376.

Note

1 Inter-basin water transfer schemes attempt to reduce regional imbalance in the availability of water, in particular for agricultural or domestic use, by constructing elaborate canals and pipelines over long distances to convey surplus water from one river basin to another which shows a water deficit.