BUSINESS MODEL 21

Cities as their own downstream user

(Towards managed aquifer recharge)

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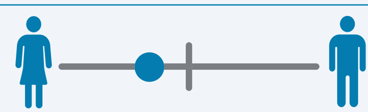
Key characteristics

Model name	Cities as their own downstream user
Waste stream	Treated and partially treated wastewater recharging local aquifers
Value-added waste product	Reclaimed groundwater for domestic and agricultural use
Geography	Water stressed urban areas with suitable peri-urban conditions for aquifer recharge
Scale of production	Medium to very large (depending on aquifer characteristics and urban demand)
Supporting cases in the book	Mexico City, Mexico; Bangalore, India
Objective of entity	Cost-recovery [ ]; For profit [ ]; Social enterprise [X]
Investment cost range	Depending on wastewater volume and scale from USD 500,000 to 700 million for wastewater treatment and conveyance (the water recovery from the aquifer will only be a fraction of this)
Organization type	Public, public-private, or mixed formal/informal sector arrangements
Socio-economic impact	Increased water security, reduced treatment costs, supported ecosystem services, but also health risks for farmers and urban consumers depending on final water quality
Gender equity	Beneficial to women and children due to increased water security and time savings for accessing water 

Business value chain

The model builds on the common trajectory of cities that are addressing growing water demand by first exploiting urban ground- and surface-water resources, and then start tapping into peri-urban and rural water resources while releasing all the time their wastewater into the urban periphery. Over time, surface and groundwater reservoirs in urban proximity become increasingly dependent on the urban return flow, making cities eventually their own downstream user. As there are multiple sources for water supply and possibilities for wastewater release, the city can turn this usually unplanned development into a development effort to a) target particularly suffering peri-urban areas for groundwater replenishment; and/or b) particular aquifers for underground storage serving the city itself.

The aquifer replenishing capacity can be remarkable as the two cases from India and Mexico showed. The two cases are, however, only examples of a diverse set of surface-groundwater interactions taking place in an increasing number of rural-urban corridors in low-income countries. Common characteristics are missing institutional responsibilities, limited water quality monitoring and wastewater treatment, and an increasing dependency of urban water supply on informal water markets. As mentioned in the model introduction, the presented cases are thus not success stories according to best practices and standards, as presented by Lazarova et al. (2013) but reflect situations and challenges on the trajectory to a more planned and managed aquifer recharge (Jiménez, 2014). To build on the positive potential of the cases, Model 21 has to emphasize risk management. The same applies to informal wastewater irrigation in the following Models 22 to 24.

The business concept is to turn the need for waste disposal, with its related costs and potential environmental hazards, into an opportunity to generate 'new' water in water scarce environments, which allows generating revenue from the value that water has to farmers and other users (Figure 259). The concept builds on the potential of managed aquifer recharge to maximize social and economic benefits including the protection of public health. The business concept can be implemented by public water/wastewater utilities, or in public-private partnership. The model acknowledges that conventional wastewater treatment in most low-income countries will in the short and medium term not be able to treat all urban wastewater to the standards needed for irrigation and/or domestic use. It builds therefore on the cost-saving additional treatment capacity of natural processes taking place during wastewater conveyance in open channels and infiltration in the soil for (deep) aquifer recharge. Part of the wastewater stored in aquifers can be retained for longer periods during wet years and used in drier years, to supply – depending on the achieved water quality – water to those users (domestic, farmers) who would otherwise face water scarcity challenges.

As the case studies showed, the urban return flow can with time constitute a major share in the local aquifer. Among several monitoring needs, a particular challenge for controlling water withdrawal and quality, concerns the informal water sector, which is usually accessing the aquifer for community water supply in a non-transparent manner. A related challenge is how far these commercial water traders could be charged for the volume of water they are abstracting as the water volumes are difficult to monitor. Moreover, the private sector would probably try to recover any abstraction fees from the served households, which would further disadvantage the poor depending on the informal sector.

Business model

The business model tries to support in dry climates peri-urban and rural areas with depleted aquifers by channelling the urban return flow to unlined reservoirs, forest plantations, etc. for targeted aquifer recharge. Depending on wastewater quality, the model provides a set of benefits:

- Costs for additional treatment or water disposal can be avoided.
- With restrictions, also farmland or forests can be used for aquifer recharge while providing water and nutrients, e.g. to fodder crops and ornamentals.
- Replenished aquifers can support local and urban water needs and economies, including small industries and irrigated crop production.
- Support of ecosystem services and biodiversity in dried-up reservoirs turned wetlands.

In case that also farms are used for aquifer recharge, farming and irrigation practices must follow appropriate safety guidelines and be such that they facilitate water infiltration (e.g. high irrigation rate in the area, storage and transport of wastewater in unlined dams and channels), and the underground suitable for water treatment (supportive soil texture and geo-hydrological conditions).

With most direct revenues deriving from the sale of 'reclaimed' waste/groundwater to urban and industrial users (Figure 260), a positive benefit-cost ratio could be expected if avoided costs are considered, like for wastewater treatment, storage or obtaining water from other sources (Perrone and Merri Rohde, 2016; Vanderzalm et al., 2015). As shown from those cases of managed aquifer recharge, any additional environmental and social benefits will help outweighing costs. A main incentive for this

FIGURE 259. SIMPLIFIED VALUE CHAIN WITH ONLY ONE URBAN AND RURAL UTILITY REPRESENTING POTENTIALLY MORE PUBLIC ENTITIES ENGAGED IN THE MANAGEMENT OF WATER AND (TREATED) WASTEWATER FOR GROUNDWATER RECHARGE FOR REUSE

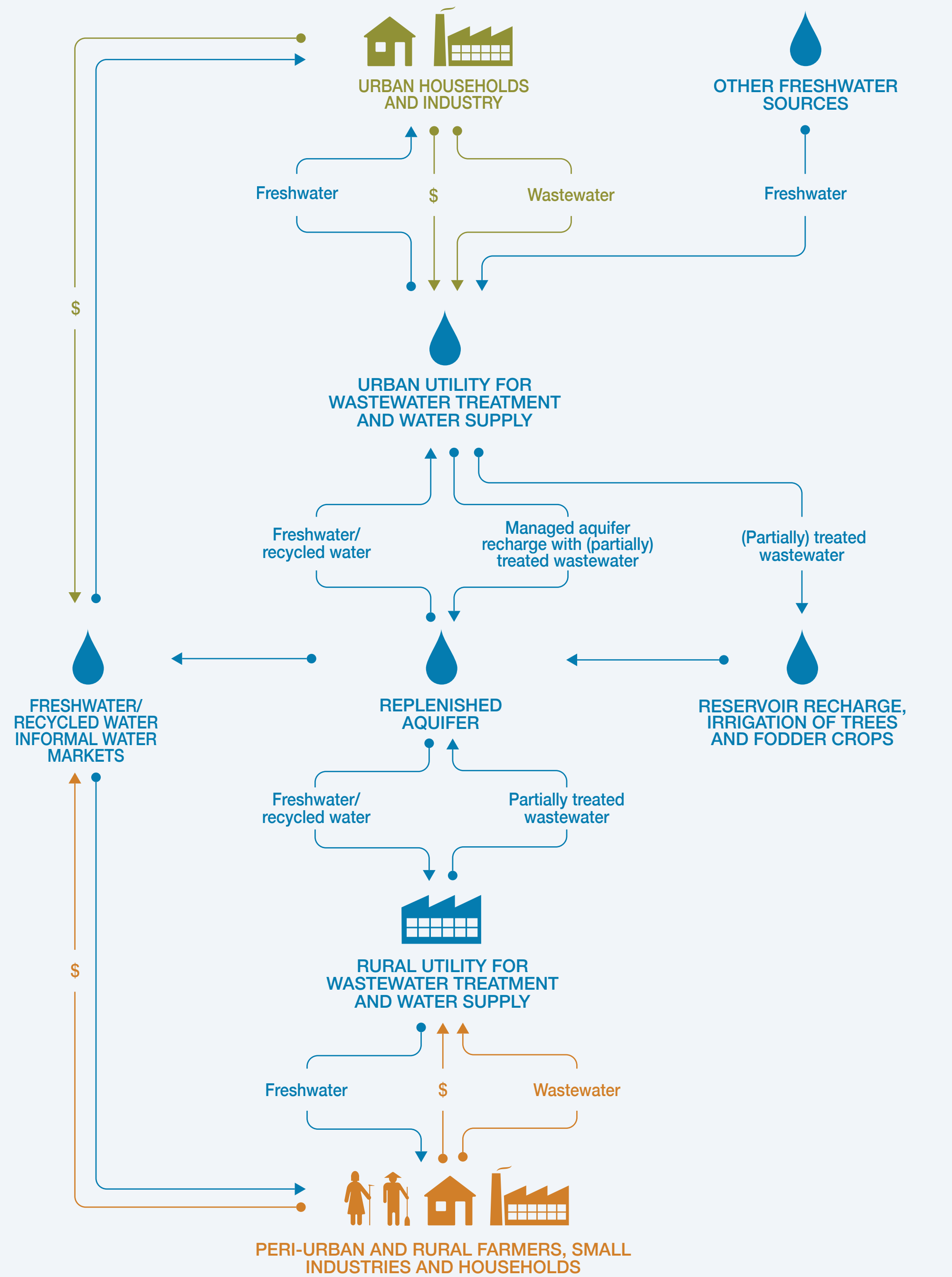


FIGURE 260. BUSINESS MODEL CANVAS FROM THE PERSPECTIVE OF THE MAIN PUBLIC UTILITY RESPONSIBLE FOR WASTEWATER MANAGEMENT IN THE CASE OF AQUIFER RECHARGE AND REUSE

KEY PARTNERS
- Community representatives from recharge area
- Other urban and rural water utilities and operators (health, agriculture, geology, . . .)
- Private (informal) water market

KEY ACTIVITIES
- Managing wastewater (treatment, conveyance)
- Selling treated wastewater and freshwater/ groundwater
- Aquifer management and water quality control

KEY RESOURCES
- Land with hydro-geological conditions suitable for water treatment and aquifer recharge
- Treatment plants and water conveyance infrastructure/ capital
- Aquifer management expertise

VALUE PROPOSITIONS
- Improving the cross-seasonal access to water for irrigation and domestic needs through underground storage and reuse of treated wastewater

CUSTOMER RELATIONSHIPS
- Formal water allocation contracts

CHANNELS
- Automatic billing
- Water transfer through pipes and canals
- Stakeholder platform

CUSTOMER SEGMENTS
- Households and farmers in rural, peri-urban and urban areas in need of water

COST STRUCTURE
- Wastewater treatment
- Water pumping for transfer and withdrawal
- Water quality monitoring

REVENUE STREAMS
- Sale of freshwater including reclaimed water from the aquifer
- Savings in potable water access from alternative sources
- Savings in wastewater treatment

SOCIAL & ENVIRONMENTAL COSTS
- Possible health risks/costs from insufficiently treated wastewater
- Possible soil contamination through long term wastewater infiltration

SOCIAL & ENVIRONMENTAL BENEFITS
- Increased water and food security
- Economic stability also in dry seasons and under climate change
- Reduced impact of water stress levels on livelihoods
- Ecosystem service support

social business model, like in the water swap model (Chapter 17, Business Model 20), should however be the potential costs for the society at large under extended periods of droughts as well as the costs of possible epidemics in the business-as-usual situation vis-à-vis investments in quality monitoring.

Thus, to propose a sustainable model, possible health hazards have to be controlled. This requires clear institutional responsibilities and regulations across the rural-urban boundary, the common administrative freshwater – sanitation divide, and acknowledgement of informal water markets to start a dialog on 'best practices'. All of this constitutes in many low-income countries significant challenges in need of multi-stakeholder platforms (Londhe et al., 2004; Foster et al., 2010; Foster and Vairavamoorthy, 2013; Yuan et al., 2016).

Potential risks and mitigation

In designing any optimized business model based on case studies, it is assumed that generic business risks are known and will be taken care of. However, some risks might be more model specific and will be acknowledged in the following:

Market risks: The market risk is small as long as no other water sources are available cheaply for farmers or households and groundwater ownership is clearly defined, allowing the utility to charge for water use or sell water entitlements. Market risk may however arise due to risks associated with the use of unsafe water, and customers losing trust in the replenished groundwater. The informal water market is likely to take advantage of the replenished aquifer (even with farmers entering the water trade) and its water withdrawal requires regulations and innovative ways of monitoring.

Competition risks: A risk could arise if the water receiving households or farmers get in seasons of high water demands access to a cheaper alternative water source. This is however unlikely as any additional water would also be sold by the same utility and the informal market sells at higher prices than the utility. There could be competition between sectors within the same community if for whatever reason the wastewater transfer is interrupted and so the aquifer supply. In this case, municipalities might compete against farmers to acquire their groundwater abstraction rights to harness the economic benefits and revenue gains that the business model offers to domestic and industrial users.

Technological risk: There seems to be limited risk due to the low-technology status as long as land is available, and the recharge is based on hydro-geological feasibility and environmental impact assessments.

Political and regulatory risks: The business requires a) well defined groundwater and wastewater related water rights or entitlements; b) reuse guidelines based on water quality; and c) monitoring mechanisms related to both requirements. Building on the currently available global water reuse regulations and guidelines for MAR with reclaimed water, a standardized approach should be developed and can be used by regulatory agencies, municipalities, and other water providers if their own regulatory framework is inadequate, as suggested e.g. by Yuan et al. (2016).

Social equity related risks: Like the other rural–urban water exchange model, the model links different interest groups in need of water, and this across administrative boundaries and sectors and thus needs an inclusive process of planning and implementation where all parties can express their interests during fair contract negotiations.

The additional availability of water is considered a particular advantage for women in charge of water acquisition with multiple social and health benefits.

Safety, environmental and health risks: The health risks connected to this business model depend strongly on the treatment in place, before and after aquifer recharge. Given the interaction of wastewater and drinking water, the WHO *Water Safety Planning* and *Sanitation Safety Planning* manuals could be applied, but also guidelines particularly developed for aquifer recharge (Yuan et al., 2016). The latter also applies to environmental protection and long-term accumulation of contaminants in the soil. When sound regulations are in place, managed aquifer recharge can be safe and offer simple, low-tech and cost-effective treatment systems for developing countries.

The address possible safety and health risks, standard safety precautions should be applied to water withdrawn from the recharged aquifer (Table 60).

TABLE 60. POTENTIAL HEALTH AND ENVIRONMENTAL RISK AND SUGGESTED MITIGATION MEASURES FOR BUSINESS MODEL 21

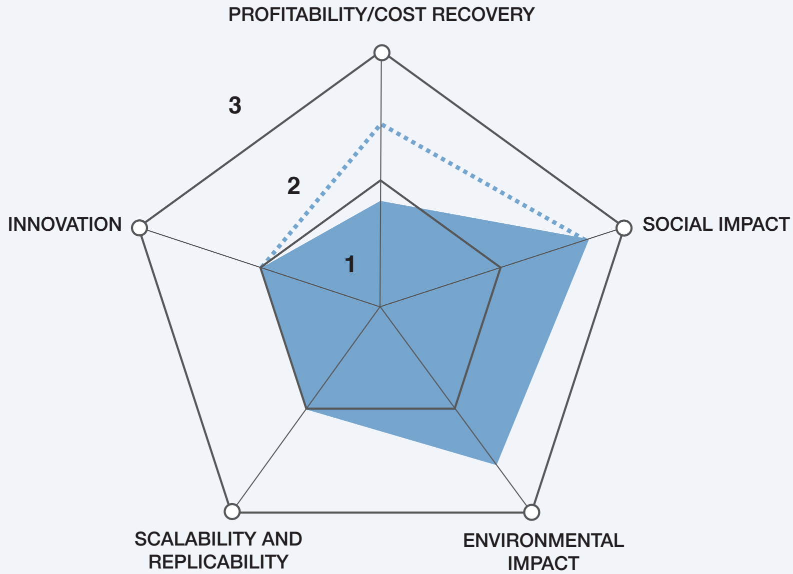
RISK GROUP	EXPOSURE					REMARKS
	DIRECT CONTACT	AIR/ ODOR	INSECTS	AQUIFER/ SOIL	RECLAIMED WATER	
Community	MEDIUM RISK	MEDIUM RISK	MEDIUM RISK	HIGH RISK	NOT APPLICABLE	Multi-barrier approach recommended and application of WHO's *Water and Sanitation Safety Planning* manuals (WHO 2009, 2015)
Farmer	LOW RISK	LOW RISK	MEDIUM RISK	HIGH RISK	NOT APPLICABLE	
Consumer	NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE	MEDIUM RISK	
Mitigation measures				Pb Hg Cd	Pb Hg Cd	

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

Business performance

This model ranks highest on **social impacts** as the reuse of wastewater for domestic supply and crop production offers significant benefits to urban consumers and agricultural communities as long as safety requirements are met. While in water scarce regions the model will probably be profitable compared to alternative options, its larger benefits are the prevention of drought related costs for the society at large, which can exceed the investment costs multiple times. While there are several plans for replicating the Indian **case** at other locations around Bangalore, it will require clear institutional mandates and regulations to implement the required safety monitoring system for human and environmental health. Assuming these are in place, also possible ecosystem benefits can become substantial (Figure 261).

FIGURE 261. RANKING RESULTS FOR GROUNDWATER RECHARGE MODEL USING UNTREATED WASTEWATER WITH LIKELY VARIATIONS IN COST RECOVERY (DOTTED LINE)



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18. BUSINESS MODELS FOR INCREASING SAFETY IN INFORMAL WASTEWATER IRRIGATION

Introduction

The challenge in view of wastewater reuse is not only to increase the reuse of **treated** wastewater as targeted for example in SDG 6.3, but to make the already ongoing informal irrigation which is on millions of hectares directly or indirectly using **untreated** wastewater safer. Untreated wastewater is released in large volumes across the developing world into rivers, used for irrigation purposes. The indirect reuse of this water for crop production, like any direct wastewater use, allows water-borne diseases which affect farmers in the field to turn into food-borne diseases affecting consumers, with a potentially significant economic impact. This informal wastewater reuse sector which support millions of livelihoods in and around four of five cities in the developing world occupies about 30 times the area than the one in our records where treated wastewater is used (Scott et al., 2010; Thebo et al., 2017). There is a significant need for business models to move from informal to formal reuse, despite inability of most developing countries to progress as fast as needed with wastewater collection, treatment capacity, or ability to enforce regulations.

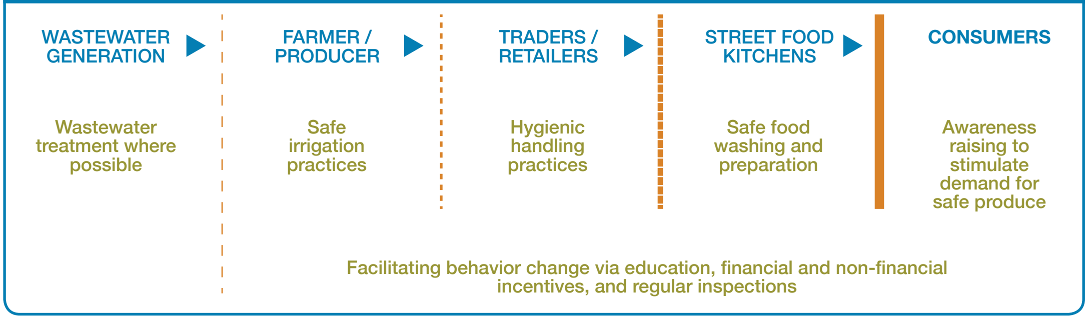
Informal reuse of wastewater is a booming economic activity that benefits farmers and irrigators privately and also the local economies and food supply, but also entails significant health costs, mostly borne by the public. The **social** nature of these costs justifies public investments in incentives to promote safe reuse of wastewater and minimize risk along the entire value chain to turn this **unsafe** informal activity into a **safe** and formal one with shared rewards for all the stakeholders. But how to finance such investments where public budgets cannot keep pace with population growth and wastewater generation?

Examples of answers are provided in a set of different business models which are (like all models in this catalogue) based on empirical cases. The variety represents regionally different drivers and pathways to catalyze individual or institutional behavior change from informal to formal reuse (Saldias, 2016). The change can be based on direct or indirect incentives, increased risk awareness or on a dialog between key stakeholders on their needs, the analysis of costs and benefits and business contract. Another pathway is to seek technical synergies between private and public interests, and where the public sector has limited capacity or resources to engage, also the private sector can offer the incentives needed for behavior change. In all these cases, the value proposition is increased food and occupational safety. Investments in these business models can save USD 5 in consumer health care for every dollar spent on risk reduction from 'farm to fork' (Drechsel and Seidu, 2011; Keraita et al., 2015).

While the benefits outweigh the costs, risk awareness and the incidence of costs and benefits do not fall evenly across stakeholders along the value chain and this creates difficulty for incentive design and financing the investment. In other words, not all who could change the game might directly benefit from this, or understand the need for change. In this context it is for example important to distinguish between the direct reuse of raw, undiluted wastewater and the much more common indirect reuse. Direct reuse is usually a planned activity where farmers lack alternative water sources and/or seek the nutrient value of the water. In contrast, the indirect use of wastewater after it got mixed with other water sources is usually not driven by farmers' interest in wastewater, but simply in water. How far farmers experience and realize water pollution depends on the degree of wastewater dilution. As a result, many farmers would not consider themselves as wastewater users and also do not see anything wrong in their professional activities, in contrast to scientific risk assessments (Keraita et al., 2010).

The limited risk awareness is an important factor for the implementation of risk mitigation strategies, and calls for a mix of approaches with financial, regulatory as well as social incentives and awareness creation to support behavior change (Drechsel and Karg, 2013). From a technical perspective, there are many low-cost options available which can on their own or better in combination significantly reduce the risks on- and off-farm especially from pathogens. Such a multi-barrier approach is fully supported by the WHO (Figure 262). However, given the missing direct incentives and risk awareness of those who should implement these safety measures, they have to be easily adoptable, low-cost but highly cost-effective (Drechsel and Seidu, 2011).

FIGURE 262. THE WHO PROMOTED MULTI-BARRIER APPROACH TO REDUCE HEALTH RISKS WITH AND WITHOUT WASTEWATER TREATMENT



Source: Amoah et al., 2011. The approach is based on the Hazard Analysis and Critical Control Point (HACCP) concept.

The informal irrigation sector where the use of wastewater or polluted water is common in and around four of five cities in the global South, shows a mosaic of situation and business model and multiple pathways towards formally recognized and supported wastewater use (Raschid-Sally and Jayakody, 2008).

Variations exist in terms of water quality, i.e. level of treatment or dilution, scale of use, water access, related costs/fees, market penetration, risk awareness along the value chain, enforcement of safety measures, etc. In most cases of indirect use, i.e. where wastewater and freshwater are mixed, the water is perceived as a natural and allocated to framers according to freshwater rules. Where farmers use raw wastewater they might pay a fee for the water, which is usually lower than the one they would pay for freshwater, or their rent for land with access to wastewater is higher than of land without water access, or the wastewater user rights might be auctioned to farmer groups.

Among the multitude of cases and situations in the informal reuse sector, three types were selected where different drivers support change towards a higher degree of safety. The three cases/models are each presented as **hybrids** (case-cum-model) as there would be too much overlap if presented separately. The three show options how the informal use of wastewater (be it polluted fresh water or diluted or raw wastewater) could become safer even under the common circumstances of missing treatment capacities and unenforced or absent water reuse regulations and standards:

a) **Business Model 22** is based mostly on examples from Ghana and shows how private sector driven corporate social responsibility (CSR) initiatives can be a driver of change, in particular in the informal food supply sector.
b) **Business Model 23** is based on examples from Pakistan and India. It shows how contractual agreements allow turning informal reuse into formal reuse, with the potential to introduce safety measures. In this example, wastewater is auctioned to farmer associations.

c) **Business Model 24** is based on a case from Southern Ghana. It shows options on how farmers' investments in low-cost infrastructure to access and store water can be combined with the WHO promoted multi-barrier approach, i.e. using farmers' innovation capacity to support reuse safety. Farmers' innovation capacity is well known (Reij and Waters-Bayer, 2001) and has been reported also from other countries where wastewater irrigation is common (Buechler and Mekala, 2005).

A model with focus on improving the safety of informal (sludge) reuse which combines elements from Models 23 and 24 was presented in the Nutrient Recovery section (Business Model 15).

Many variations of these models are possible and can be supported through various incentives such as land security, training, certification schemes for safe farming, access to loans or subsidies etc. Assistance is also needed in view of compliance monitoring as farmers will not be able to finance water or produce analysis for comparison with safety standards. The WHO supported *Sanitation Safety Planning* manual (WHO, 2015) will be a useful guidance document in this situation.

Our three examples are not exhaustive. There are other options, especially where with increased wastewater treatment and enforced regulations wastewater use became a business sector on its own. For an analysis of possible trajectories from informal to formal water reuse, see Saldias (2016) and for success stories from the formal reuse sector, for example, Lazarova et al. (2013).

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