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# Business models for a circular economy: Linking waste management and sanitation with agriculture

Urbanization is the pre-eminent global phenomenon of our time. Currently, urban areas account for 75% of the world's natural resource consumption, while producing over 50% of the globe's waste on just 2–3% of the earth's land surface (UNEP, 2013). Without recycling, cities will continue to constitute vast sinks for food waste including valuable crop nutrients and organic matter, while millions of rural, peri-urban or urban farmers struggle with depleted soils to feed the growing urban population. Yet, it is not only the loss of valuable, and in part, finite resources, but also the costs of poor waste management, i.e. environmental pollution and the production of avoidable greenhouse gases (GHG) which threatens sustainable urban growth. Halving, for example, the current rate of food wastage would greatly support waste management while reducing GHG emissions by 22–28% (WEF, 2016). So far, the environmental costs of poor waste management are usually externalized and the market incentives to reduce waste are minimal.

While global demand projections for water, food and energy predict continuous and significant growth, the declining reserves of the non-renewable phosphorus, copper and zinc resources (Holmgren et al., 2015) reinforce the need for more investments in resource recovery and reuse across the food, waste and sanitation sectors (Ellen MacArthur Foundation, 2017; TBC, 2016).

While Europe continues setting an example with the implementation of a first action plan on the circular economy (EC, 2016), more attention should be given to natural resource loops in low- and middle-income countries, especially in the tropics where soils are poor and nutrient depletion is high and commercial fertilizer is basically unaffordable. Minimizing resource loss and returning resources into the food production process is essential in particular in drier climates where every drop of water counts and organic matter is needed for sustaining soil fertility as natural biomass production is low.

Aside from the reduction of food waste along the food chain, resource recovery allows to capture value even from apparently 'wasted' resources (FAO, 2011). In particular, domestic and agro-industrial waste is rich in water, nutrients, energy and organic compounds. Yet, in most parts of the world, this waste is not being managed in a way that permits us to derive value from its reuse, although resource recovery is nothing new. Closed loop systems linking food waste and food production have been practiced for generations in many rural societies. However, population growth and urbanization in particular have increased distances and polarized food flows towards urban centres where agricultural reuse opportunities for food waste are limited.

But cities are not only 'hungry'; they are also 'thirsty'. Van Rooijen et al. (2005) crafted the term 'Sponge City' to visualize the **urban metabolism** which is absorbing freshwater from its periphery while discharging wastewater which has a high potential to support ecosystem services and food production in water-scarce regions, if wastewater treatment and safe reuse can be achieved. If not, this water will be a threat to food safety and public health.

In fact, due to limited treatment capacities, the various domestic waste streams, solid as well as liquid, form a significant part of the unwanted urban footprint. The resulting pollution constitutes not only the paramount environmental and health challenges that today's exploding cities and their surroundings are facing, but also a significant economic challenge in countries where waste collection and treatment cannot be financed through taxes and fees (Kennedy et al., 2007; Le Courtois, 2012). This mismatch

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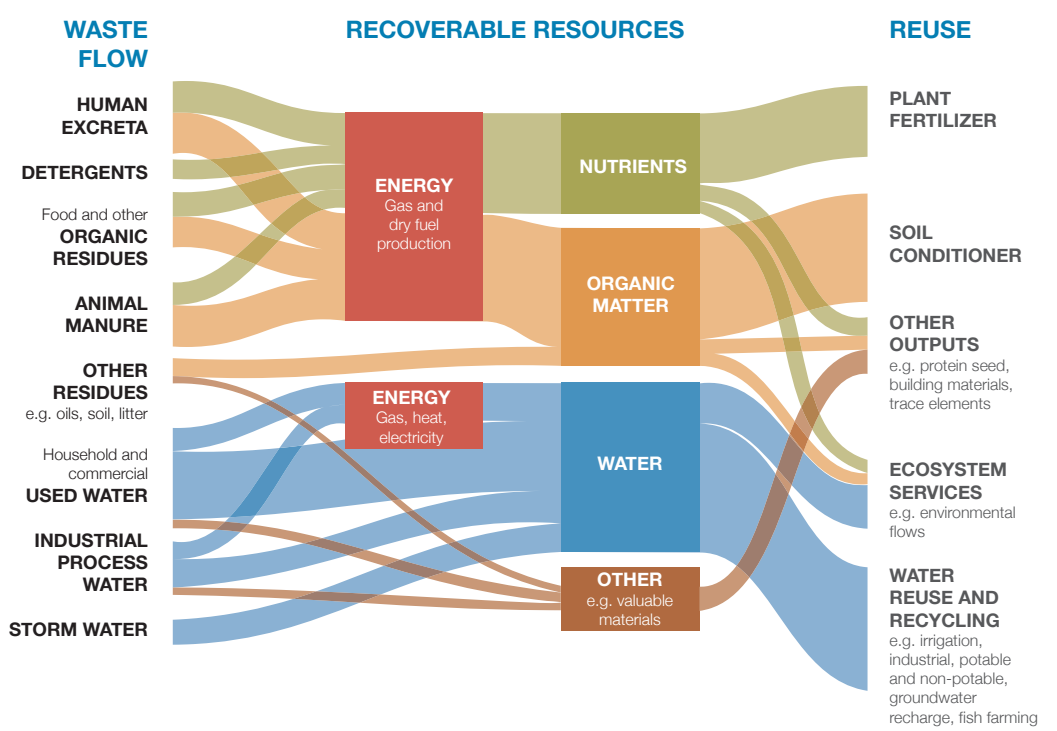
puts into question the sustainability of urban growth where it is the fastest unless alternative business models are put in place (Muradian et al., 2012; Villarroel Walker et al., 2012).

In the context of resource poor countries, it is more than opportune to argue for a circular metabolism, as increasingly promoted in many developed nations, where waste segregation and recycling contribute to overall system resilience (UNEP, 2017) and the values of *green growth*, i.e. an economy without degrading the environment. In this regard, the urban waste challenge – including fecal matter generation – can offer immense and scalable opportunities for entrepreneurs through transforming waste from domestic and agro-industrial sources into low-carbon assets for use in agriculture and other sectors (Figure 1). This is strongly supported by the Sustainable Development Goals (SDG) targeting for example water reuse (SDG 6), renewable energy (SDG 7) and waste recycling and reuse (SDG 12), which can help to restore degraded soils (SDG 15) for sustainable agriculture and food security (SDG 2) and resilient cities (SDG 11). Especially wastewater and the different organic fractions of municipal waste streams offer a significant potential for the support of a 'biocycle economy' (Ellen MacArthur Foundation, 2017).

These opportunities for value creation from resources that would otherwise be irretrievably lost also allow for cost savings and/or cost recovery in the sanitation sector; for example in the case of composting which, depending on scale, reduces municipal solid waste volumes and transport costs with the potential to enhance the lifetime of landfills with less GHG emissions. Furthermore, by moving increasing amounts of biological material through anaerobic digestion or composting back into the soil, a circular economy approach will reduce the need for chemical fertilizers and soil amendments (Box 1).

**FIGURE 1. OVERVIEW OF WASTE STREAMS AND RESOURCES WITH POTENTIAL FOR THE RECOVERY AND REUSE OF NUTRIENTS, ORGANIC MATTER, WATER AND ENERGY**




Source: Andersson et al., 2016, modified.

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## Box 1. The potential of organic waste for the circular economy

The World Economic Forum has estimated potential global revenues from the biomass value chain (production of agricultural inputs, biomass trading and biorefinery outputs) as high as USD 295 billion by 2020. Cities, as major concentrators of materials and nutrients, and the power of generating over 80% of the global Gross Domestic Product (GDP), will play a major role on the 'biocycle economy'.

**Return of food waste:** If 100% of consumption-related food waste and 50% of other food waste generated today were returned to the soil, it could replenish 5 million tonnes of nitrogen, phosphorus and potassium (N, P, K) reserves, substituting for 4% of current N, P, K consumption.

**Return of animal manure:** If all the nutrients from the current stocks of cattle, chicken, pig and sheep manure were captured, they would yield an astounding 345 million tonnes of N, P, K annually – more than twice the world's current consumption. Using animal manure also improves soil structure and organic content and reduces commercial fertilizer loss.

**Return of human waste:** Human waste also contains significant amounts of N, P, K. If nutrients contained in the waste of the world's population were captured, they would amount to 41 million tonnes, representing 28% of the current N, P, K consumption.

In theory, the organic sources of N, P, K fertilizer recovered from food, animal and human waste streams could on a global scale contribute up to 2.7 times the nutrients contained within the volumes of chemical fertilizer currently used.

Further analysis is needed to assess what share of organic fertilizers could be returned to the soil in a cost-effective way. In OECD countries, for example, an estimated 177 million tonnes of municipal organic waste are produced annually, of which 66 million tonnes are so far valorized in composting or anaerobic digestion. The market value of N, P, K in this fraction is estimated at USD 121 million per year, and adds an estimated 5 million tonnes of stable carbon (and 10 million tonnes of carbon in total) to OECD soils every year in the form of compost/digestate. ISWA (2015) estimate that around 58 million tonnes additionally could feasibly be collected and valorized.

Source: Ellen MacArthur Foundation, 2013, 2017; ISWA 2015.

As farm soils need organic material, especially on highly weathered tropical soils, closed loop processes appear to be a win-win situation (Drechsel and Kunze, 2001). It is estimated that halving the current rate of food wastage could meet over a fifth of caloric needs by 2050, reducing required cropland by 14% (WEF, 2016). The reality is however, that resource recovery and reuse (RRR) has been until now more theory than practice. RRR remains challenged where awareness for 'green' values and opportunities is less developed, public perceptions do not favour reuse or municipal capacities are too constrained to make the required investment. Developing countries spend around USD 46 billion annually on waste management, and it is estimated that they should spend another USD 40 billion to cover the current service delivery gap (Le Courtois, 2012). The total costs are expected to surpass USD 150 billion by 2025. The additional capital investments required for safe fecal waste management in support of the SDGs target 6.2 amount to about USD 49 billion per year (Hutton and Varughese, 2016).

In their daily struggle with the service delivery gap, many municipalities consider RRR a task for the future, once their current challenges are under control. What Onibokun (1999) called 'Managing the

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Monster' is in fact often absorbing as much as half of the municipal budget in many low-income countries (Le Courtois, 2012).

Accepting the limitations of the public sector, an opportunity is to leverage private capital based on the value of the recovered resources (Otoo et al., 2012; Le Courtois, 2012). This could also support a conceptual transition from 'treatment for safe disposal' to 'design for reuse' (Murray and Buckley, 2010; Huibers et al., 2010). In such a postmodern sanitation system (Ushijimaa et al., 2015), incentives for financing sanitation could be shared between 'front-end users' and 'back-end users' building on demand for the products of sanitation and waste management to motivate a combined finance model and more robust operation and maintenance of complete sanitation systems (Murray and Ray, 2010). This would require a supportive regulatory and finance environment and well-designed partnerships agreements.

However, the lessons learned so far have also shown that closed loop processes do not manifest themselves through the promotion of composting, water reuse or – for example – *ecological sanitation*. What is often described as an engineering challenge (*'Reinvent the Toilet'*) and in fact is often driven by technology development, like for the removal of unwanted struvite in wastewater treatment plants ('phosphorus recovery'), is increasingly understood as an institutional, social and economic challenge. There is significant need for investments in market research, bankable business models for cost recovery, stakeholder buy-in and innovative partnerships, especially if scalability and sustainability are targeted (Guest et al., 2009; Le Courtois, 2012; Beltramello et al., 2013; Hanjra et al., 2015; Verstraete and Cornel, 2014). Countless failed composting projects began with significant amounts of grant funding but eventually collapsed due to their inability to support their operational costs (World Bank, 2016).

Given the common situation of the waste and sanitation sectors, especially in Africa and Asia, the term 'business models' might appear to be out of place. However, exactly where every step towards cost recovery counts, the thinking has to change (Koné, 2010). While for example wastewater treatment was and is first of all a 'social business model' with a strong economic justification and returns on investments through safeguarding public health and the environment, a second (reuse-based) value proposition can offer incentives for private sector engagement, that leverage private capital to help realize commercial or social value. However, what sounds in theory promising often faces fundamental structural barriers. In fact, 88% of developing country governments have no cost recovery efforts at all for water and sanitation (Muspratt, 2016a).

There are multiple bottlenecks faced by both the public sector and/or the emerging private sector across most low- and middle-income countries. These include financing challenges, unsupportive regulations and slow approval processes, but also missing the capacity to present viable business plans for penetrating the reuse market. In particular, organic waste composting is often more driven by cost savings than revenue generation (Box 2) which can potentially undermine those SDG targets, which will count actual 'reuse'. Thus, private sector participation in waste management is not a panacea for success in promoting Resource Recovery *and Reuse* unless the companies understand how to approach the reuse market (e.g. Rouse et al., 2008) and can count on an enabling environment (see Chapter 19). In particular in Africa, smaller start-ups struggle with bureaucracies and financing (Muspratt, 2016ab), while larger companies, that can accommodate delays, succeed. In India, for example, several firms have emerged that treat today the waste collected by municipalities without any charge, while revenue is generated exclusively by recycling the waste collected (Furniturwala, 2012). In this regard, urbanization is not only posing challenges but also opportunities compared with rural areas, such as market proximity, shorter transport distances, higher purchasing power, export hubs and economies of scale that can attract private capital, if the enabling policy environment is in place and *de facto* functional.

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### Box 2. Cost savings as a driver for resource recovery (and reuse)

Where land prices go up in urban vicinity, communities do not accept hosting a landfill. This is resulting in increasing transport costs for municipal waste disposal to remote areas where land is still abundant. As transport can be their major cost factor, many waste managers show a strong interest in composting as a means to reduce waste volumes and transport costs (Drechsel et al., 2010). If the compost is eventually 'burned', distributed for free, or becomes a revenue stream, from the waste management perspective this is often of lower relevance, especially where (i) contracts are based on the processed waste volume, but not on the sale or reuse of the recovered resource, or (ii) the gains from volume reduction outweigh any expected returns from compost marketing.

The same applies to those waste-to-energy projects, which are designed (and financed) for absorbing municipal solid waste (MSW) in order to reduce municipal service costs as a whole. Energy production is in these cases often only a secondary revenue stream, while MSW sorting cost and its low calorific value constrain the business. Another example are enterprises engaged in the collection of human excreta from non-sewered sanitation systems, which might engage in composting, primarily to reduce the costs of waste disposal, and not because of expected compost revenues.

In addition, energy or phosphorus recovery within wastewater treatment processes is largely driven by cost reduction. The recovery of phosphorus, for example, prevents damage of pipes and valves through unwanted precipitation. The resulting savings in chemicals otherwise needed to remove the crystals can more or less finance enterprises specialized in P recovery while the generated P-fertilizer is a side product which is often struggling to find more than a niche market (Otoo et al., 2015; see also Business Model 16).

A second prominent RRR bottleneck is the understanding of the impact and related value of planned interventions compared with the counterfactual 'business as usual'. Internalizing any possible externalities especially on human and environmental health is important to attract public subsidy as a well-justified revenue stream. When the environmental and societal benefits of investments in sanitation and waste management are accounted for, most RRR projects will be viable (ADB, 2011; Andersson et al., 2016). However, while benefits can be easily and fully internalized by governments and citizens, they are very difficult for a private company to monetize (Muspratt, 2016a). On the other hand, the private sector is under increasing pressure to accept corporate social responsibility (CSR), account for its own externalities, and engage in mitigation measures.

## Corporate social and environmental responsibility

The call for corporate responsibility is echoed in SDG 12.6 (Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle). While CSR has a high potential to support a circular economy, its success at national level will not only depend on the private sector but also how governments, which carry the responsibility for achieving the SDGs, will 'encourage' firms to take part (Fogelberg, 2015). For example, section 135 of India's Companies Act 2013 requires (on a "comply-or-explain" basis) that firms satisfying specific size or profit thresholds spend a minimum of 2% of their average (pre-tax) net profit on CSR; moving a voluntary CSR contribution into a law. The risk is that this transforms CSR more into an offset tax than social or environmental consciousness, as a company can choose

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to contribute, e.g. to funds of the Central Government or the State Governments for socio-economic development (Grant Thornton India LLP, 2013), independently of the company's own practices and challenges, e.g. in view of responsible resources management.

A closer monitoring is provided by independent CSR assessment agencies, as for instance by the Newsweek Green Rankings. The ranking is based on eight key performance indicators, including waste generation/recovery/reuse, GHG emissions, energy and water demands and so forth. Companies failing to disclose data for the rigorous analysis by Newsweek and partners would receive a score of '0', thus negatively affecting their overall performance and public image. The rise of the social media is in this regard an important factor. When catering to global markets, big companies sell millions of products every day. However, any negative press can set off within the shortest period a series of consequences via social media that may be detrimental to a product or brand's image. These days this puts much higher pressure on companies to maintain their image compared to a decade ago and a number of rating agencies support these efforts (Novethic, 2013).

Corporate social and environmental responsibility can thus directly and indirectly trigger and support RRR. The key words are "responsible and sustainable sourcing of raw materials", including direct commitments to the circular economy (Box 3).

**Sustainable sourcing** is increasingly receiving attention as consumers and other stakeholders want to know where their food comes from and how it was produced. Supply chain audits can have a far reach and catalyze environmental consciousness at an unexpected pace and far from the company's home. In one of the reported cases in this catalogue (Chapter 18), local private textile suppliers offered their own government to co-finance wastewater treatment plants to be able to comply with the responsible sourcing criteria of their European buyers as otherwise they would no longer be accepted, resulting in financial crisis.

### Box 3. Towards a circular economy in the food sector

Based on CSR principles global companies such as Cargill, Nestlé, Starbucks, Unilever etc. support in many low-income countries extension services, traders and farmers, e.g. in view of access to inputs and markets along the companies' value chains. Social and environmental commitments include responsible sourcing of raw materials and a high commitment to personal and product safety, resource recovery and zero waste schemes, or for example the provision of fortified but affordable food. In larger companies, these commitments are part of the corporate value proposition and monitored through audits and certifications by independent accredited bodies issuing sustainability rankings and indices. The same applies to agricultural input suppliers like BASF and its resource use efficiency optimizing 'Verbund' principle. Global food company, Danone, to give another example, has announced in 2016 a new partnership with the global waste-management company, Veolia, to embed circular economy principles inside the company and to promote them widely. Danone aims for systemic change to preserve natural resources and to move to a more circular value chain. Danone was recently awarded the Environment Top Performance prize by the Environmental and Social Governance (ESG) ratings agency Vigeo, among 1,300 companies assessed. The company has circular economy projects like recycling by-products from yoghurt production for animal feeds, fertilizer and energy.

See also: www.mckinsey.com/business-functions/sustainability-and-resource-productivity/our-insights/toward-a-circular-economy-in-food?cid=eml-web (accessed November 7, 2017)

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The next step of corporate responsibility is the monetary valuation of the ecosystem services that are positively or negatively affected, and to integrate these financial values into corporate accounting. Negative balances could be offset through carbon or ecosystem credits (NSW, 2007; The Rockefeller Foundation, 2015). Internal carbon pricing, which is of particular interest for RRR, is now becoming a widely used tool helping companies shift to lower-carbon business models. Over 1,200 companies reported to CDP, formerly the Carbon Disclosure Project, in 2016 that they are currently using an internal price on carbon or plan to do so within the next two years (CDP, 2016).

To avoid that offsetting becomes the main investment and a license for 'business as usual', green accounting requires shared definitions, indicators and methodologies for measuring and monitoring impacts to allow public sector investment ideally in the same area of concern, e.g. in wastewater treatment (DeLonge, 2012; Meyers and Waage, 2014).

## From business cases and opportunities to business models

With three SDG supporting directly RRR, and an increasing attention to the synergies between CSR and the circular economy, the objectives of this book are:

> To show scalable options for RRR as a value proposition to stimulate business thinking in the interface of sanitation, waste and agriculture.
>
> To build capacity for a more integrated and inclusive approach to the recovery of water, carbon, nutrients and energy from domestic and agro-industrial waste for reuse.
>
> To provide opportunities for local business model adaptation across low-income countries, where the public sector struggles to finance closed loop processes through household taxes and fees, and start-ups struggle with an only slowly emerging enabling environment.

Chosen from about 150 public and private RRR projects and enterprises, of which over 60 were analysed in detail, this catalogue presents a selection of 47 empirical business cases (Figure 2), from which 24 business models were extracted. Chapter 2 provides some background into the methodology and definitions used for the selection and analysis of the cases and models. A separate catalogue looking at 18 institutional business models for managing the 'ultimate' food waste, i.e. fecal sludge, including resource recovery and reuse as fertilizer and energy source, has been published separately (Rao et al., 2016).

Our understanding of the term 'business model' follows Osterwalder and Pigneur (2010), i.e. a business model describes the rationale of how a firm or organization creates, delivers and captures value in economic, social, cultural or other contexts. In our case, the common value proposition is the creation of a useful resource from material which otherwise would be wasted. Given the multitude of domestic and industrial RRR options, **in this publication we are looking mostly at those options where either the waste derives from the food chain and/or the recovered resources support the food chain**. In other words, most presented cases and models are limited to the recovery of (i) water, (ii) crop nutrients and carbon (organic matter) and (iii) energy, derived from domestic and agro-industrial waste, including food waste, wastewater and excreta. By limiting the scope to the food chain, other recyclable resources like glass, plastic or metal are not addressed.

In order to increase the probability of replication in low- and middle-income countries we tried to focus mostly on cases and experiences in Asia, Africa and Latin America, operating at community or city scale, i.e. we exclude individual household- or farm-based efforts for resource recovery and reuse. A few cases from high income countries, with potential for replication in other parts of the world,

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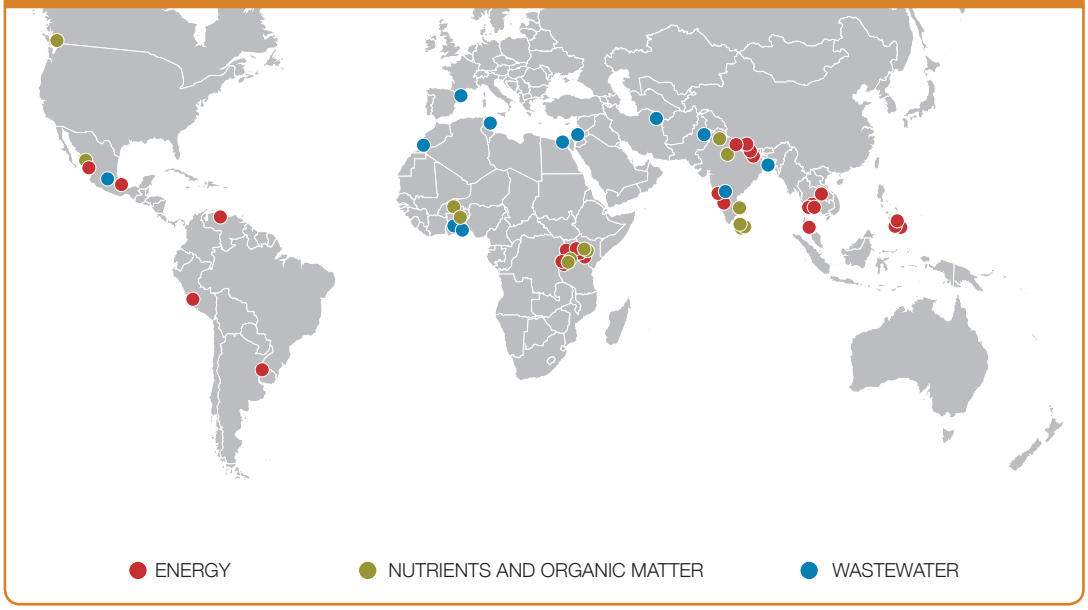
FIGURE 2. LOCATIONS OF BUSINESS CASES DESCRIBED IN THE BOOK




are also included. The description of cases and models followed defined templates (see Chapter 2) bridging between the needs of students in business schools looking for detailed case studies and those of investors in need of a compact information, which was not easy to combine.

In the literature, the term 'business model' is commonly used for a broad range of informal and formal business processes, structures and purposes resulting in very diverse interpretations and definitions. Similarly, many options exist to name or cluster business cases and models in categories, especially in the young domain of sustainable development and green economy where existing examples are fragmented (George and Bock 2011; Beltramello et al., 2013). It is important in this context to stress that the term '**business**' should not imply that 'business models' have to be profit-oriented or able to achieve through their value proposition full cost recovery. **In sectors, like waste and sanitation, which usually rely on public financing, any scalable efforts towards cost recovery or cost savings are already a paradigm shift and should be seen as a step in the right direction, next to the creation of social and environmental value**. Reduced expectations are in particular required in view of water reuse in agriculture. In many situations, the direct revenues from selling treated wastewater to farmers are small, given that fresh water prices are often subsidized or groundwater freely accessible. However, the situation can change if further value propositions are added, such as the use of the water for fish feed and fish production, energy recovery or treatment for industrial or potable reuse (Rao et al., 2015). In those cases, the full recovery of operational and maintenance costs, or even the recovery of capital costs, can be possible as the examples in the book show. But more common and equally important are those cases where operational cost recovery varies between 10 and 90% and it is critical to analyse what prevents a waste-based venture from moving up the scale.

In cooperation with different business schools, the catalogue adopted the **extended Business Model Canvas** (Osterwalder and Pigneur, 2010) to visualize the different business models, including their externalities. Externalities are very important as the waste and sanitation sectors not only benefit society but also are prone to environmental and human health risks. Hence, an important requirement

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for any type of waste management scheme, including resource recovery, is the need to safeguard public health. Risk management and mitigation for safe waste handling and reuse are thus essential components of the sustainability and acceptance of any RRR business model, especially where the waste might contain fecal matter or other chemical contaminants. This was emphasized through collaboration with the World Health Organization (WHO) and development of the *Sanitation Safety Planning* (SSP) concept, which supports the operationalization of the safe use of wastewater, excreta and greywater in agriculture and aquaculture (WHO, 2015; Andersson et al., 2016).

This catalogue with its cases and models targets a community more interested in business opportunities than technical solutions. The description of technologies as far as they relate to the value proposition or particular safety measures remains throughout brief except where business models are technology driven. With its focus on low- and middle-income countries, the catalogue does not include those high-tech solutions for RRR, which first have to show their replicability and sustainability in the context of these regions as stressed, e.g. by Wang et al. (2015), Nhapi and Gijzen (2004), Murray and Drechsel (2011) or Libhaber and Orozco-Jaramillo (2013).

Although neither the presented cases nor models cover the whole spectrum of agriculture related RRR value propositions, this catalogue is the most profound analysis and comprehensive compilation made so far to show the business side of RRR in the interface of sanitation, waste management and agriculture in low-income countries. While in some cases it was not possible to obtain from the private or public sector the requested financial information, or only under a non-disclosure agreement, the models should provide enough information to be an excellent starting point for business schools and investors to approach this so far uncharted sector.

An analysis, which is cutting across several of the presented cases and models was presented by Rao et al. (2015) for water reuse, Gebrezgabher et al. (2015) for energy recovery and Otoo et al. (2015) for nutrient and organic matter recovery and reuse.

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