Nutrient and organic matter recovery: An overview of presented business cases and models

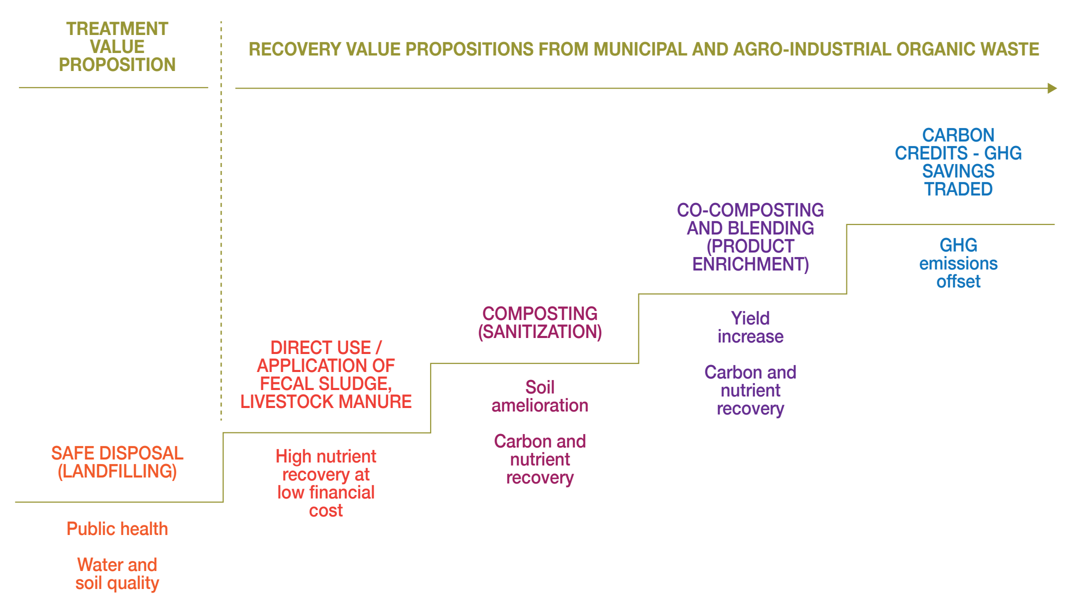
Nutrient recovery from organic waste streams such as municipal solid waste, agro-industrial waste, urine and fecal sludge, is high on the development agenda. The increased momentum around nutrient recovery is largely driven by the need to feed the global population with increasingly limited resources under progressing climate change, diminishing global nutrient reserves (peak phosphorus), increasing fertilizer prices and stricter regulations for safeguarding the environment from pollution. In this context, increasing amounts of plant nutrients will be needed to ensure the food security of an expanding global population. However, while a century ago, food waste was locally recycled, urbanization has created a polarizing effect on food flows, thus generating centres of consumption and waste generation. Nutrient recycling is therefore crucial in preventing cities from becoming vast nutrient sinks (Drechsel et al., 2015; Otoo et al., 2012; Otoo et al., 2015). Unfortunately, in most low- and middle-income countries, urban waste management continues to struggle with waste collection and safe disposal making e.g. nutrient recovery only a future target. However, simultaneous efforts are required and possible, also as the waste and sanitation sectors are under pressure to cut costs and show cost recovery. The waste volume reduction through composting and agricultural demand open related opportunities (Drechsel et al., 2015).

Nutrient recovery is additionally of great importance in view of diminishing non-renewable resources, such as phosphorus. As large portions of global phosphate rock deposits cannot be mined efficiently at competitive costs, there is a great debate on when the world will reach a state of 'peak phosphorus' and how far market prices will regulate phosphorus supply (Edixhoven et al., 2013). On the other hand, there is a consensus that the recovery of phosphorus is an increasingly important task, especially given that soils in many tropical developing countries are of very low fertility and fertilizers too expensive. The latter is evident in many African countries and attributed to ineffective policies, and limited and inefficient distribution network. This results in exorbitant market prices, and invariably leading to low fertilizer application rates and decreased agricultural productivity.

Furthermore, nutrient recovery from organic waste streams such as agricultural and agro-industrial waste, the biodegradable fraction of household and market waste, domestic urine and fecal sludge, extends beyond direct economic benefits to health and environmental benefits (ADB, 2011; Hernando-Sanchez et al., 2015; Otoo et al., 2015; Rao et al., 2016). With increasing population growth, nutrients accumulate in consumption centres and contribute to pollution wherever the coverage of waste collection and treatment is insufficient. With progressively limited public funds to support waste management infrastructure and services, particularly in large urban areas in developing countries, nutrient recovery enterprises will be essential for reducing waste quantities and generating revenues from recovered resources to bridge financial gaps (operational and maintenance [O&M] costs) and complement other supportive financing mechanisms for waste management.

There is great potential to close the nutrient recycling loop, support a 'circular economy' and attain cost recovery within the waste sector, and even to create viable businesses. While, many of these efforts have often been limited in size or duration partly because waste is not viewed as a resource and sanitation is a public service rather than a business; there are many interesting and successful examples of cases and business models emerging in developing countries. These cover a wide range of opportunities for waste valorization (Figure 117) and demonstrate significant potential for scalability and sustainability.

FIGURE 117. LADDER OF VALUE PROPOSITIONS FOR NUTRIENT AND CARBON RECOVERY FROM EXCRETA, AGRO-INDUSTRIAL/AGRO-WASTE AND MUNICIPAL SOLID WASTE STREAMS



Significant investments, mainly public funding, for the set-up and operation of compost facilities is observed throughout the developing world (Kaza et al., 2016). These compost plants are typically large-scale centralized facilities that are able to process huge volumes of waste at a time, but require substantial capital investments, and operational and maintenance costs given the advanced and mechanized equipments used, high-level skill and high energy requirements. Although geared towards full cost-recovery, many of these initiatives are unable to generate sufficient revenues to cover the O&M costs, talk less of recouping capital investments. Municipalities however continue to provide financial support in the form of government grants, subsidies, tax credits, waivers and rebates to bridge the financial gap and ensure sustainability of the compost plants (Kaza et al., 2016; Pandyaswargo and Premakumara, 2014). This is because the net environmental and socio-economic benefits from composting (typically municipal solid waste (MSW) and fecal sludge) outweigh the costs of financial support to the compost plants (**Business model 10: Partially subsidized composting at district level)**. In this nutrient recovery section of this Resource Recovery and Reuse (RRR) catalogue, we present three such cases from **Sri Lanka** and **Uganda**, representing different waste streams and options of public-private partnerships.

In view of increasingly shrinking budget allocations for waste management, a notable percentage of compost plants reach the end of their life cycle or in dire need of upgrade and maintenance, especially to improve their production efficiencies and revenues. Decentralized composting enterprises offer some advantages over centralized large-scale systems and are increasingly observed to be financially self-sustaining, particularly for secondary cities and small towns, and even large cities where the local government can allocate land (**Business model 11: Subsidy-free community-based composting**). In instances where technological processes adopted capitalize on abundant local resources (e.g. labor), and models that attribute ownership to communities are encouraged (e.g. cooperatives), high sustainability of the nutrient recovery enterprise has been observed. The presented case study from

Kenya in Chapter 8 shows that subsidy-free community based composting offers a sustainable solution for turning waste into wealth but requires investments in social capital to organize and mobilize the communities.

Looking beyond cost recovery and aiming for profit-making models is imperative if sustainable financial returns on investments are expected (**Business model 12: Large-scale composting for revenue generation**). While the composting concept is applicable across scale, larger composting operations offer greater opportunities for capturing economies of scale benefits, revenue generation and market proliferation. Multiple revenue generation streams beyond compost sales to include sale of energy (electricity) represent additional avenues for nutrient recovery enterprises to become financially viable. The ability for businesses to successfully implement the above value propositions and capture the greatest economic benefits will partly depend on scale and strategic partnerships. The scale element of the model offers access into markets that smaller-scale enterprises are often excluded from such as the energy and carbon credit markets. Although, it is important to note that there are cases where small-scale enterprises form conglomerates to increase accessibility into these markets. The need for strategic partnerships extends beyond those with NGOs for development of waste-based clean development mechanisms (CDM) projects, compost marketers and dealers for increased market share to include municipal authorities for exclusive rights/access to waste streams, research institutes for product and technology innovation, informal workers for increased access to slums and waste segregation efficiency and private sector entities for mitigating fiscal constraints. Mainstreaming private sector participation via public-private partnerships (PPP) can improve production efficiencies and business effectiveness and ensure value for money of public interventions as demonstrated by presented cases from **India** and **Bangladesh** in Chapter 9**.** Development of high value products (e.g. nutrient-fortified compost tailored for specific crops and soils) based on innovative technologies to enhance competitive advantage in product markets often allow enterprises to mitigate market distortions, for example, in the fertilizer market.

While the first three business models largely centre on food waste and municipal solid waste stream, another set of interesting business models focuses on nutrient recovery from agro-industrial and agro-waste (vegetative and livestock) streams. To ensure business sustainability, largely for compliance with legislative mandates, many agro-processing enterprises are increasingly implementing an additional arm to their main business for converting their waste into organic fertilizers. Conversion of their waste into nutrients is imperative, particularly given that the implicit cost of non-compliance can be significant due to their large operational scale, resulting in potential losses of up to several million dollars in annual revenue (**Business model 13: Nutrient recovery from own agro-industrial waste**). Chapter 10 presents several variants of this model via empirical cases from **Kenya, India** and **Mexico.**

In addition to nutrient recovery from municipal solid waste and agro-industrial waste streams, another set of interesting business models considered in this section focus mainly on fecal sludge and urine reuse for agricultural production. Global mandates to improve access to sanitation (toilets facilities) at the household level in developing countries is notable although some groups such as migratory populations and slum inhabitants still only have marginal access to sanitation products and services. An increasing number of private businesses are setting up public toilet facilities to close this gap, however limited septage collection and treatment can undermine the sustainability of these services. Benefits from nutrient recovery from fecal sludge into value-added products (e.g. urine-enriched compost) for agricultural production are three-fold: a) it significantly reduces the burden for septage collection, treatment and disposal, ensuring a sustainable sanitation service chain; b) it provides sanitation businesses with an additional revenue stream; and c) it provides a sanitized and nutrient-rich compost product for farmers. The latter is an important driver for the business model as farmers have a great demand for the nutrient-rich fecal sludge-based compost (often a substitute for chemical fertilizer) compared to the often low-nutrient MSW-based compost. Chapter 11 describes a case from **Rwanda** where private entities are capturing the commercial value in fecal sludge via nutrient recovery to ensure sustainable delivery of sanitation services (**Business model 14: Compost production for sustainable sanitation service delivery**). It is important to note that while reuse can ensure a sustainable sanitation chain, public toilet fees remain the key driver for financial sustainability of this business model. The case presented here only shows a medium-scale operation and links to the agricultural sector; for a more extensive review on fecal sludge reuse cases and models at different scales and recovered resources, see Rao et al., 2016.

Beyond the formal avenues of septage treatment via nutrient recovery, an interesting model observed in developing countries, is where cesspit truck operators deliver nutrient–rich septage collected from households to farmers' fields instead of designated or unofficial dumping sites – with the latter being more common (**Business model 15: Outsourcing fecal sludge treatment to the farm**). This model is largely driven by farmers' high demand for nutrient-rich septage, therefore bypassing a more formal sanitation process in the form of composting for direct disposal of raw fecal sludge on their farm fields. This practice is increasingly observed in Sub-Saharan Africa and South Asia (Cofie et al., 2009; Drechsel et al., 2011; Evans et al., 2013). The business model presented in Chapter 12, supported by a case from **India**, essentially relegates septage treatment to the farm and importantly reverses the cash flow as farmers pay the cesspit drivers for farm–gate delivery, whereas normally the transporter would have to pay a tipping fee for desludging into a treatment system. Disposal to farmlands outside the city offers a partial waste management solution, however better oversight and occupational and consumer risk reduction measures are critically needed. There are emerging models and cases that aim to increase the safety and usability of fecal sludge via composting, pelletization and blending of fecal sludge-based compost with rock-phosphate, urea/struvite or NPK, among others (see Rao et al., 2016).

Finally, there is also the potential for phosphorus (P) recovery from human excreta (**Business model 16: Phosphorus recovery from wastewater at scale**). The model presented in Chapter 13 demonstrates an opportunity for increased accessibility to phosphorus (in view of diminishing global P resources) for agricultural production and significant prospects for cost recovery if savings in treatment and sludge disposal costs are considered, as until recently phosphate recovery costs still result in prices higher than those of phosphate rock, unless niche markets are targeted. Although different technologies and approaches are possible for P recovery from human excreta, this chapter presents two cases representing the two ends of the opportunity spectrum. One is where urine is collected from unsewered households in **Burkina Faso** and sanitized in storage units for processing into liquid fertilizer (typically occurring at community-scale); and the other is based on phosphorus extraction from sewage treatment using the approach of Ostara in **Canada** as an example. The latter approach is applicable both at a community and large-scale level.

In summary, most of the examples presented in this section demonstrate the potential range of cost recovery to full profitability business models for entities considering nutrient recovery as an avenue for ensuring sustainable delivery of waste management services. Although not exhaustive, the presented cases and models show a tremendous potential for resource recovery and reuse, and private sector participation where the enabling environment is in place. Supportive institutional settings and regulations are important to support the businesses and control the well-known health and environmental risks appropriately, although these may not necessarily be sufficient in guaranteeing the viability of the enterprise (see Chapter 19). Particularly for nutrient recovery enterprises, access to finance, technology and consumers' acceptance will play an important role in facilitating or hindering their sustainability and scalability.

References and further readings

Asian Development Bank (ADB). 2011. Toward sustainable municipal organic waste management in South Asia: A guidebook for policy makers and practitioners. Mandaluyong City, Philippines: Asian Development Bank.

Benson, T., Lubega, P., Bayite-Kasule, S., Mogues, T. and Nyachwo, J. 2012. The supply of inorganic fertilizers to smallholder farmers in Uganda: Evidence for Fertilizer Policy Development. IFPRI Discussion Paper 1228. Washington, D.C.: International Food Policy Research Institute (IFPRI).

Cofie, O.O., Drechsel, P., Agbottah, S. and van Veenhuizen, R. 2009. Resource recovery from urban waste: Options and challenges for community based composting in Sub-Saharan Africa. Desalination 248 (2009): 256–261.

Drechsel, P., Cofie, O.O., Keraita, B., Amoah, P., Evans, A. and Amerasinghe, P. 2011. Recovery and reuse of resources: Enhancing urban resilience in low-income countries. Urban Agriculture Magazine 25 (September 2011): 66–69.

Drechsel, P., Qadir, M. and D. Wichelns (eds). 2015. Wastewater: An economic asset in an urbanizing world. Springer. 282p.

Evans, A., Otoo, M. and Drechsel, P. 2013. Developing business model typologies for resource recovery and reuse-based businesses. Urban Agriculture Magazine 26: 24–30.

Edixhoven, J.D., Gupta, J. and Savenije, H.H.G. 2013. Recent revisions of phosphate rock reserves and resources: Reassuring or misleading? An in-depth literature review of global estimates of phosphate rock reserves and resources. Earth System Dynamics Discussions 4 (2): 1005–1034.

Hernandez-Sancho, F., Lamizana-Diallo, B. and Mateo-Sagasta, J. 2015. Economic valuation of wastewater: The cost of action and the cost of no action. Nairobi, Kenya: United Nations Environment Programme (UNEP). 72p.

Kaza, S., Yao, L. and Stowell, A. 2016. Sustainable financing and policy: Models for municipal composting. Urban development series Knowledge Papers 24. Washington, D.C.: World Bank Group.

Kinobe, J.R., Niwagaba, C.B., Gebresenbet, G., Komakech, A.J. and Vinnerås, B. 2015. Mapping out the solid waste generation and collection models: The case of Kampala City. J. Air Waste Manage. Assoc. 65 (2): 197–205.

Pandyaswargo, A.H. and Premakumara, D.G.J. 2014. Financial sustainability of modern composting: The economically optimal scale for municipal waste composting plant in developing Asia. International Journal of Recycling Organic Waste in Agriculture 2014 (3): 66.

Otoo, M., Drechsel, P. and Hanjra, M.A. 2015. Business models and economic approaches for nutrient recovery from wastewater and fecal sludge. In: Drechsel, P., Qadir, M., Wichelns, D. (eds) Wastewater: Economic asset in an urbanizing world. Springer, Chapter 13, pp. 247–270.

Otoo, M., Ryan J. and Drechsel, P. 2012. Where there is muck, there is money. Handshake – IFC Quarterly journal publication on public private partnerships, World Bank. 1, May 2012.

Rao, K.C., Kvarnström, E., Di Mario, L. and Drechsel, P. 2016. Business models for fecal sludge management. Colombo, Sri Lanka: International Water Management Institute (IWMI). CGIAR Research Program on Water, Land and Ecosystems (WLE). 80p.