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RESOURCE RECOVERY & REUSE SERIES 10

10

Testing the Implementation Potential of Resource Recovery and Reuse Business Models

FROM BASELINE SURVEYS TO FEASIBILITY STUDIES AND BUSINESS PLANS

Miriam Otoo, Pay Drechsel, George Danso, Solomie Gebrezgabher, Krishna Rao and Ganesha Madurangi

About the Resource Recovery and Reuse Series

Resource Recovery and Reuse (RRR) is a subprogram of the **CGIAR Research Program on Water, Land and Ecosystems (WLE)** dedicated to applied research on the safe recovery of water, nutrients and energy from domestic and agro-industrial waste streams. This subprogram aims to create impact through different lines of action research, including (i) developing and testing scalable RRR business models, (ii) assessing and mitigating risks from RRR for public health and the environment, (iii) supporting public and private entities with innovative approaches for the safe reuse of wastewater and organic waste, and (iv) improving rural-urban linkages and resource allocations while minimizing the negative urban footprint on the peri-urban environment. This sub-program works closely with the World Health Organization (WHO), Food and Agriculture Organization of the United Nations (FAO), United Nations Environment Programme (UNEP), United Nations University (UNU), and many national and international partners across the globe. The RRR series of documents present summaries and reviews of the sub-program's research and resulting application guidelines, targeting development experts and others in the research for development continuum.

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ACRONYMS AND ABBREVIATIONS

AgCLIR	Agribusiness Commercial Legal and Institutional Reform
BCR	Benefit-Cost Ratio
BM	Business Model
BOOT	Build-Own-Operate-Transfer
BOT	Build-Operate-Transfer
CBA	Cost-Benefit Analysis
CBO	Community-based Organization
EBIT	Earnings before Interest and Taxes
EIA	Environmental Impact Assessment
FAO	Food and Agriculture Organization of the United Nations
FS	Fecal Sludge
GCI	Global Competitiveness Index
GHG	Greenhouse Gas
IC	Investment Climate
IMF	International Monetary Fund
IRR	Internal Rate of Return
MCA	Multicriteria Analysis
MSW	Municipal Solid Waste
NGO	Nongovernmental Organization
NPV	Net Present Value
O&M	Operation and Maintenance
OECD	Organisation for Economic Co-operation and Development
PPP	Public-Private Partnership
QMRA	Quantitative Microbial Risk Assessment
RoI	Return on Investments
RRR	Resource Recovery and Reuse
SCP	Structure, Conduct and Performance
SWOT	Strengths, Weaknesses, Opportunities and Threats
TELOS	Technical, Economic, Legal, Operational, and Scheduling
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
VCA	Value Chain Approach
WEF	World Economic Forum
WHO	World Health Organization
WTP	Willingness-To-Pay

SUMMARY

In many developing countries, the sanitation sector is highly subsidized by public sector agencies which has resulted in inadequate and inequitable provision of waste management services. The historical reliance on public sector provision has partly prevented the development of markets in sanitation services, including resource recovery and reuse (RRR). A paradigm shift in the sanitation sector towards cost recovery is increasingly being supported by many donors pushing for private sector participation and waste-to-wealth programs. This development advocates for a shift from waste 'treatment for disposal' to 'treatment for reuse' as the latter offers options for business development and cost recovery for the sanitation sector.

Although the potential benefits from waste reuse are apparent, it is becoming increasingly important that potential investors are given sound information on its feasibility and positive return on investments (RoI) be they in monetary or nonmonetary (e.g., social or environmental) terms.

This guideline presents a detailed methodological framework that can be used for the feasibility assessment of RRR business models in the context of developing countries. Its purpose is to support public and private sectors as well as investors in determining the potential viability of RRR in a particular location and context. The guideline was developed in the context of four cities (Lima, Bangalore, Kampala and Hanoi) and later in other cities in Ghana and Sri Lanka, which can all be considered as relatively data-scarce environments; this influenced data gathering and the eventually suggested methodology.

The conceptual framework adopted a step-wise assessment of the implementation potential of RRR business models, consisting of three main phases: a) prefeasibility study (baseline survey), b) feasibility study and c) implementation planning.

The prefeasibility study aims to determine within a short time frame the general potential and limitations of different waste-to-resource options and related business models in one or more suggested locations. The RRR feasibility study serves the purpose of answering within a suggested location (e.g., a city) the question: "Is this a viable venture which meets sustainability criteria?" The study can support the analysis of several alternative business models with the aim of identifying the best one(s) using a multi-criteria assessment framework and identified performance indicators related to institutional, technical, policy and market environment, including the investment climate, but also perceptions, health and environmental aspects, cumulating in pro-poor business scenario modelling using financial and economic indicators.

The resulting outputs from the feasibility assessment phase are investment recommendations for donors, financial institutions and the public and private sectors; in particular they provide insights on constraints, if any, and the level of risk associated with their potential investments. The results from the feasibility assessment study can then form the basis for the development of implementation and business plans by the interested enterprise/investor.

Trials of safe, nutritious fertilizer pellets made from processed human waste at a trial site at Buet, Dhaka, Bangladesh. *Source:* Neil Palmer/IWMI

1 INTRODUCTION

Traditionally in low-income countries, sanitation and waste management have been highly subsidized by public sector agencies, with levels of service quality varying across locations and income levels. Until recently, private sector participation has been limited to the extraction, treatment or conveyance of solid waste or fecal sludge from on-site sanitation systems to disposal sites. The historical reliance on public sector provision has partly prevented the development of markets in sanitation services including resource recovery and reuse (RRR) that might be best provided by private companies.

A paradigm shift in the sanitation sector towards cost recovery is increasingly being supported by many donors pushing for private sector participation and waste-to-wealth programs. This development advocates for a shift from waste 'treatment for disposal' to 'treatment for reuse' as the latter offers options for a circular economy, business development and cost recovery for the sanitation sector (Murray and Buckley 2010). With many hopeful signs and success stories of viable RRR business models (BMs) emerging (Otoo and Drechsel 2016), the key questions are:

- Could a successful model which works in Hanoi, also work, for example, in Kampala, and if so, at what scale?
- How far could such a business break-even/make profit or how much public support would be needed?
- Could there be legal, institutional or technical limitations and could potential health or environmental risks be controlled?

This guideline presents a detailed methodological framework and outline that can be used for the feasibility assessment of RRR business models in the context of developing countries. Its purpose is to support the public and private sectors as well as investors in determining the potential viability of RRR in a particular location and context. The guideline was developed and initially tested in the context of four cities (Lima, Bangalore, Kampala and Hanoi) and later in other cities in Ghana and Sri Lanka, which can all be considered as relatively data-scarce environments; this influenced data gathering and the suggested methodology.

The guideline begins with a short description of the business model concept and its application to the RRR sector. Subsequently we present a section that defines what a feasibility assessment has to cover and provide a concept for performing the feasibility assessment of RRR business models, covering solid and liquid waste streams as well as water, nutrient, carbon and energy as recovered resources. Next, the methodological framework is applied to test the feasibility of various RRR business models – that is, the applicability, adaptability and comprehensiveness of the proposed business models in real-life settings; this results in strengthening of the methods proposed in view of scalability and viability. The report concludes with a check list of the characteristics of an effective feasibility report and business/investment plan. Given common limitations in time and resources to perform 'robust' feasibility assessments, the guideline will flag which steps and options might be best under such constraints.

Although this might be the first methodological guideline for the feasibility assessment of RRR business models for various waste streams and value propositions, the applied multidisciplinary approach has its roots in work by Harris et al. (2001) and Danso and Drechsel (2014) on organic waste composting.

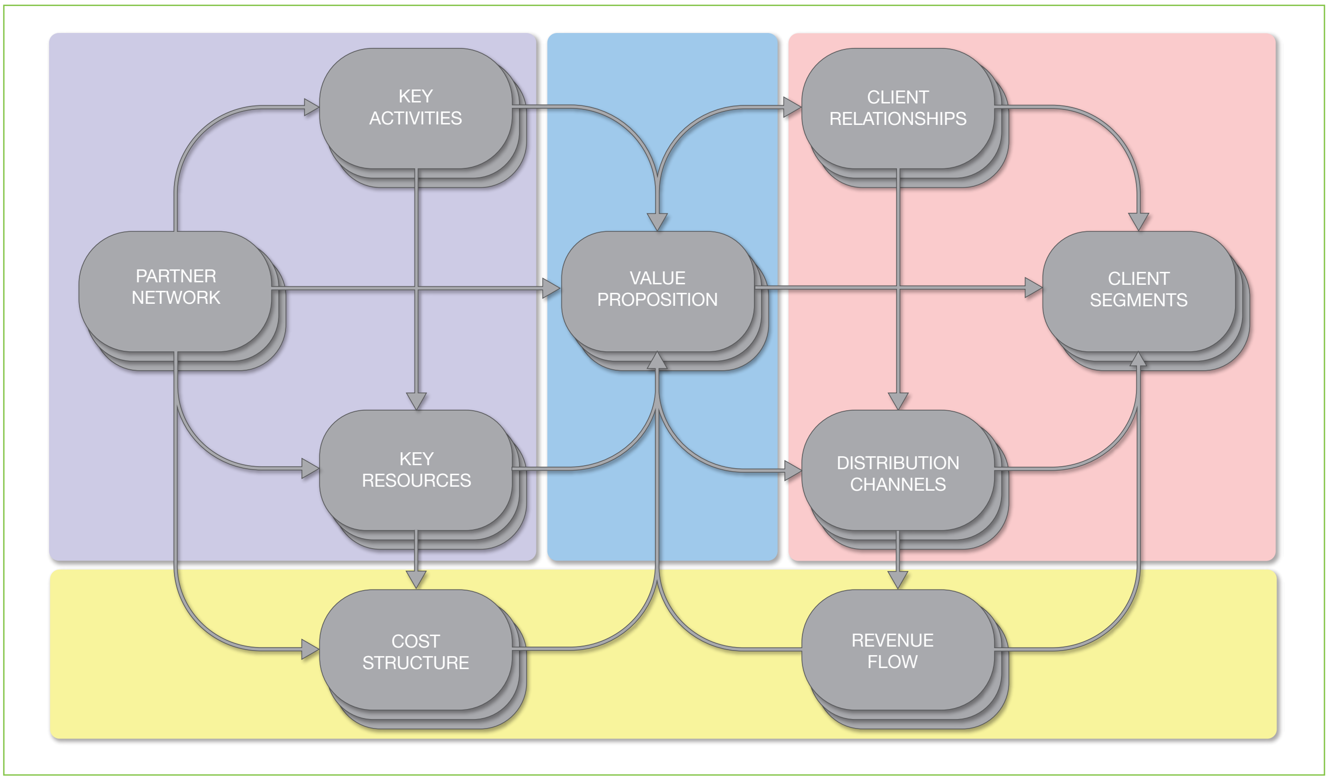
2 BUSINESS MODELS FOR RESOURCE RECOVERY AND REUSE

2.1 The Business Model Concept

Prior to the development of the methodological framework for testing the feasibility of RRR business models for implementation, it is imperative that the concept of business modelling and the content of a business model are clearly defined. In the past decade, starting from the mid-1990s (Box 1), the business model concept has become an increasingly pertinent notion in management theory and practice and has received substantial attention from academics and business practitioners (Magretta 2002; Osterwalder et al. 2005; Shafer et al. 2005; Zott et al. 2011). Numerous definitions of the concept have been proposed in the literature but in general a business model describes how a business creates, delivers and captures value (Osterwalder and Pigneur 2010). In the RRR context, no particular terminology has so far been proposed while the generic value proposition is the creation of a useful resource from material which would otherwise be wasted.

With value proposition at its core, Osterwalder and Pigneur (2010) described a business model canvas based on nine components as illustrated in Figure 1. This approach of dividing a business model into different components enables firms to explicitly visualize the processes underlying their business models and identify ways to boost their strengths, mitigate weaknesses and threats, and explore and capture the benefits from any opportunities that exist.

FIGURE 1. COMPONENTS OF THE BUSINESS MODEL CANVAS.



Source: Osterwalder et al. 2005.

BOX 1. BUSINESS MODELS IN THE RRR SECTOR.

It is important in this context to note that the term 'business' does not necessarily imply that the models are profit-oriented or able to achieve full cost recovery through their value proposition. First, the sanitation sector offers many opportunities for social business models that aim to improve living conditions, offer more employment, safeguard public health or reduce environmental pollution. Second, public subsidies are a key revenue stream. However, in a sector which usually depends fully on public financing, leveraging private capital and increasing cost recovery are important steps towards sustainability.

Reduced 'business' expectations apply in particular to water reuse in agriculture. In many situations, the direct revenues from selling treated wastewater are small, given that freshwater prices are often highly subsidized. However, further value proposition could be added to improve cost recovery. There are of course also empirical cases and models which allow partial or full recovery of operation and maintenance (O&M) costs, the recovery of capital costs or the generation of profit which could, with the right contractual model and incentives, be shared with the sanitation service provider. More common however are those cases where operational cost recovery varies between 10 and 90% and it is critical to analyze what prevents an enterprise from moving up the scale (Drechsel et al. 2015).

The business model canvas also provides many of the details needed to understand the model's requirements on markets and resources that have to be studied within a **feasibility assessment.**

2.2 Business Model Categorization

RRR business models can be described according to various parameters but there is no fixed framework regarding how business models should be classified. Models can be categorized according to the type of waste (waste stream), the recovered resource, the value proposition to progress from the waste to the resource, or based on the institutional partnership or finance mechanism. Some wastewater business models, for example, are best distinguished by the agricultural end-product produced, energy projects by the business approach they use, nutrient recovery cases by the technology employed and so forth, while institutional factors like the type of public-private partnerships (PPP) or technology hand-over (like BOT or BOOT[1]), the scale of operation, cost recovery potential or social benefits will allow further options.

The ideal taxonomy will vary between its users and objectives and can strongly influence the feasibility assessment depending on its emphasis, e.g., on the institutional set up or required technology. In the context of the feasibility studies carried out by the authors, approximately 20 RRR business models (Otoo and Drechsel 2016) were categorized (Table 1). In this example, the business model descriptive

[1] BOT: Build-Operate-Transfer; BOOT: Build-Own-Operate-Transfer.

TABLE 1. A SAMPLE CATEGORIZATION OF RRR BUSINESS MODELS.

VALUE-ADDED PRODUCT	SECTOR	OBJECTIVE	BUSINESS MODEL
Water reuse	Public sector	Cost recovery	On-cost savings and recovery
	Private sector	Welfare/profit maximization	Beyond cost recovery
			Hedging and matchmaking of futures contracts
			Intersectoral water exchange
	Informal sector	Welfare maximization	Informal to formal trajectory in wastewater irrigation
			Groundwater recharge
Nutrient and organic matter recovery	Public sector	Cost recovery	Subsidy-free community-based community
			Partially subsidized composting at district levels
	Private sector	Welfare/profit maximization	Large-scale composting for revenue generation
			High value fertilizer production for profit
			Compost production for sanitation service delivery
		Cost savings	Nutrient recovery from own agro-industrial waste
			Nitrogen and phosphorus recovery at scale
	Informal sector	Welfare maximization	Outsourcing fecal sludge treatment to the farm
Energy recovery	Private sector	Profit maximization	Dry fuel manufacturing
			Energy service companies at scale
		Cost savings	Energy generation from own agro-industrial waste
			Manure to power
			Emerging technology model
		Welfare maximization/ corporate social responsibility	Onsite energy generation by sanitation service providers
			Biogas from food waste

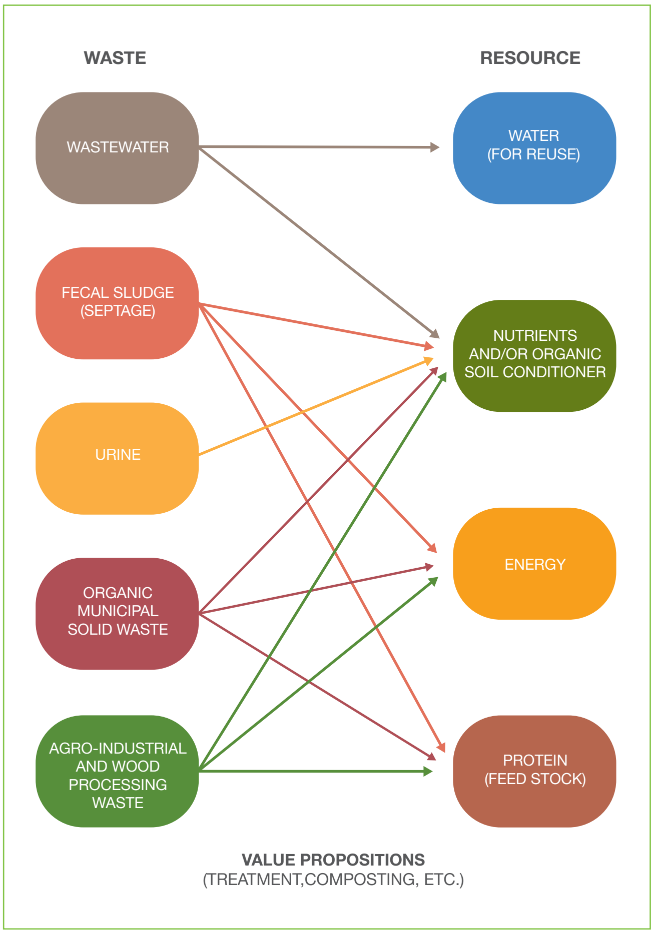
for wastewater use is defined by the market and financial dynamics driven by the objective of the firm. Alternatively, the business model descriptive for energy recovery is defined mainly by the waste stream and primary output.

The examples show that there is significant flexibility in how business models are classified and named. More importantly is the need to specify model requirements in terms of institutional and regulatory set up, expected customer segments, required resources in terms of quantity and quality, technological options and possible risks for the business as well as its environment to guide model implementation.

3 CONCEPTUAL FRAMEWORK FOR ANALYZING THE IMPLEMENTATION POTENTIAL OF RRR BUSINESS MODELS

As many waste streams offer a variety of options for turning their embedded resources into an asset (Figure 2), any study on the implementation potential of related value propositions and business models has first of all to set priorities in terms of the targeted area, type of waste and

FIGURE 2. SELECTED OPTIONS FOR RESOURCE RECOVERY AND REUSE FROM DOMESTIC AND AGRO-INDUSTRIAL WASTE STREAMS.



the recovered resources. This priority setting is essential to avoid very complex feasibility studies. To set priorities, the presented conceptual framework suggests a step-wise approach starting with a baseline survey combined with local stakeholder consultations, followed by more detailed feasibility studies for a smaller set of waste streams, resources and locations.

The conceptual framework for a step-wise assessment of the implementation potential of RRR business models (Figure 3) consists of three main phases: a) a prefeasibility study (baseline survey), b) feasibility study, and c) implementation.

The prefeasibility phase starts with conducting a **baseline survey** to determine the general potential and limitations of different waste-to-resource options and related business models in one or more suggested locations. In collaboration with local stakeholders, the objective is to zoom into a smaller set of waste streams/sources and more specific business models with high probability of success. As the business models we are targeting aim at closing the **rural-urban resource loop,** i.e., large-scale RRR, our spatial target areas are usually towns, suburbs or cities (Box 2) .

The baseline survey or prefeasibility study will be followed by the **feasibility study** which will seek to determine which business model for the selected waste stream will have the highest probability of success in the local context. Depending on the level of detail gathered, the feasibility study might include an implementation plan for the most promising business model. However, if the feasibility study ends with a choice of options, local stakeholders have to set priorities and choose, according to their objectives, the most preferred option and location. In this case the **implementation plan** would follow the feasibility study. Finally, the new entrepreneur will have to draft a **business plan** outlining the business strategy and targets. Whilst this report will touch on all phases, the main focus for this guideline is on the prefeasibility and feasibility studies.

3.1 Prefeasibility Phase – Baseline Survey

3.1.1 Objective

In general terms, the purpose of a baseline survey is to gather with basic effort (expert opinion, literature survey) mostly qualitative information for a specific geographical area on the enabling environment and likelihood of success for a planned RRR intervention. At its core, the prefeasibility study should help to understand past and ongoing RRR businesses, their scale of operation and type of challenges. The prefeasibility analysis will be of particular value in view of locations with significant constraints (e.g., missing type of waste, too much competition or regulatory challenges) which the planned intervention might not be able to address. In such a case, the intervention would have to target a different location or be replaced by an alternative model.

Conducting a prefeasibility study will serve multiple purposes for testing the potential feasibility and impact of RRR business models:

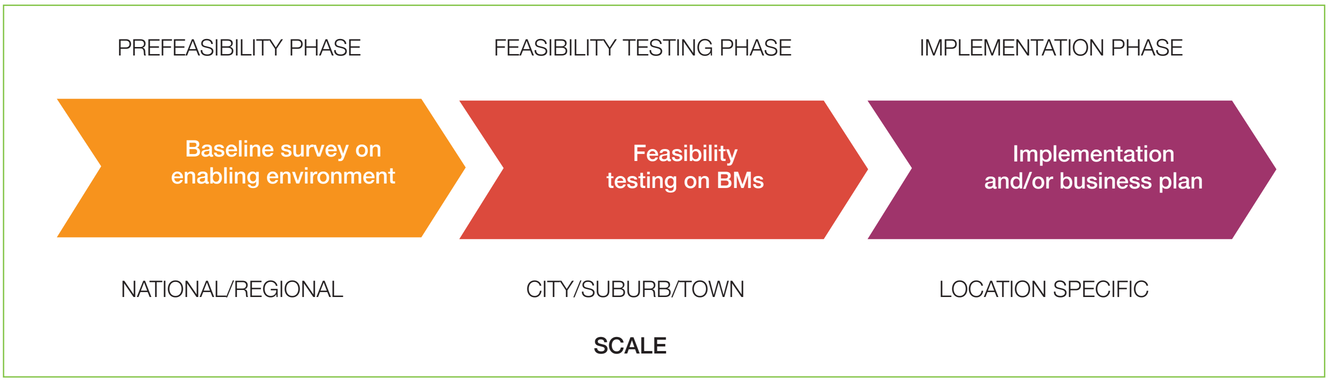
1. *It is a starting (or call-off) point for any implementation initiative:* It is essential to understand the local institutional landscape including private and public players in the sector and the type and scale of past, ongoing and

BOX 2. SETTING A SYSTEM BOUNDARY FOR THE FEASIBILITY ASSESSMENT OF RRR BUSINESS MODELS.

A system boundary has to be established to allow comparisons between RRR options, costs, benefits and scenarios of scale. The boundary will vary with the type of waste and customers and can be a combination of a **spatial** focus on a part of a city or a watershed (for wastewater use), a **business** boundary defined by the resource input acquisition and use of the recovered resource (i.e., the supply and reuse value chains) and an **impact** boundary (e.g., in view of benefits to the general public). The boundary will play a particular role in the assessment of the socio-economic impact and might vary from indicator to indicator, but should not vary within the same indicator.

Additionally, for budget reasons it may be important to define an assessment **boundary** for the field work, especially where primary data are needed.

FIGURE 3. CONCEPTUAL FRAMEWORK FOR SITING AND IMPLEMENTING AN RRR BUSINESS.



planned initiatives, projects and businesses. Expert interviews will help to assess the overall investment climate, policy and regulatory support, common challenges and risks, and where the planned intervention could add value to the overall priorities of the specific region. Past experiences and stakeholders' perceptions will be important components of the analysis.

2. *Establishing priority areas:* Results from the baseline survey will help in selecting the most suitable locations for more in-depth feasibility studies. It will also help in flagging priority components within the feasibility study, where either opportunities or implementation constraints can be expected, or where data availability/ access might be a challenge.
3. *Selecting the types and number of RRR options and business models:* As there are different technical options and business models even for one and the same waste stream, a key objective of the prefeasibility study is to narrow the spectrum of options down to those with highest probability of success and buy-in by the local stakeholders. Moving from, for example ten to three business models will be a useful initial 'filter' as it allows one to save time and research costs in the more detailed feasibility studies. Stakeholder participation in this process is imperative, to understand which RRR options resonate best with local stakeholders.
4. *Impact attribution:* A baseline survey can also help to establish a benchmark for the planned RRR interventions by collecting data prior to the change. These data, which can be of economic, environmental or social nature, will later serve as a benchmark for any impact assessment.

3.1.2 Methods

To achieve the objectives of selecting the most suitable locations for testing the feasibility of the business models and the types of business models to select, it is important that a general overview of the enabling environment as well as sector-specific data are gathered. Both primary and secondary data will be collected via interviews and data mining. There are, for example, different datasets for assessing countries' general investment climates. At this prefeasibility study phase, it is recommended that, as far as possible, secondary data should be collected and utilized, especially if working with significant time and resource constraints. Additional primary data collection can be done via one-on-one expert interviews, which can be locally arranged or done remotely. One-on-one meetings with key authorities (typically high-level officials) are recommended and will help to preselect the number and types of possible BMs that locally make sense and are of local interest; i.e., they will be key in aligning any future RRR interventions with the current priorities of the locality.

If resources permit, workshops with local experts and key stakeholders could help to better: a) introduce the background to the enquiry and intended outcomes of the baseline survey; b) any future proposed RRR interventions; c) develop an understanding of the urban waste and sanitation challenges faced by the city and understand different visions for its improvement from the perspective of key stakeholder groups; and d) initiate an engagement process with stakeholders so that the following feasibility study and outcomes of the overall research are fed into and support the development processes of the specific location (e.g., city level).

In testing the feasibility potential of RRR business models for implementation, multiple questions covering many aspects will be needed to assess and compare the suitability of a town or suburb (for the types of business models to select). The extent of what can be covered within the prefeasibility study will strongly depend on: (i) previous research and/ or data availability in the public domain, including lessons from business successes and/or failures; and (ii) resources and time available for data gathering (Box 3). Topics to be covered include: general information of the locality (i.e., city), institutional landscape and capacity, previous and ongoing RRR initiatives, projects and businesses, supporting policies, regulations and practices, possible and known risks, level of private sector engagement in RRR, the current collection, treatment and destination of the different waste streams (i.e., solid waste, fecal sludge, agrowaste, wastewater), amongst others. An important question pertains to possible partner institutions or consultants with the capacity to undertake the following feasibility studies which require a team with technical, economic, environmental and institutional expertise.

As the prefeasibility study is also the call-off point it has as a *minimum* number of basic questions about the pillars of the intended business to answer, such as:

- Is the required waste actually produced (and sufficiently available) in the location?
- Is there any indication of demand for the waste-derived resource?
- Are there any legislations/regulations which could prevent the business?
- Are there any institutions (public, private) which could qualify as business owners and partners and be interested?

Any non-supportive answers would in most cases mean that the intervention should better target a different location. However, some bottlenecks can also be addressed, e.g., low institutional capacity through training, a limited market through expansion to new market segments. In other words, in each case expert judgement is required and ideally more analysis if a certain finding is really a call-off point. This applies in particular to possible competition. It would certainly be interesting to explore in the baseline survey if similar RRR businesses of the same or larger size at the same location targeting the same waste supply and final

BOX 3. OPTIONS UNDER TIME AND/OR BUDGET CONSTRAINTS.

1. Focus on a set of minimum questions (see above).
2. Check relevant literature or local donor offices for subject matter experts and try to get introduced/ arrange phone or skype interviews.
3. Web search previous studies like sector overviews, donor reports, university studies, etc. and if related businesses already exist.
4. If the selected location has no track records, select a comparable location where more research has been done like a similarly-sized town or city in the same country and agro-climatic zone.

users already exist. To understand if this can be a call-off factor, a more detailed **competition analysis** has to be done which is a part of the feasibility study. Thus, the prefeasibility study also has the objective to flag which components of the following feasibility study should receive **priority attention.**

An example of a semi-detailed questionnaire designed for all waste streams to be filled by local experts is provided in Annex 1.

3.1.3 Anticipated Outputs

It is expected that a baseline survey will result in the following outputs:

1. If several locations (city/suburb/town/etc.) are to be compared, a recommendation for the one with the most promising enabling environment.
2. A decision on a narrow set of RRR options and business models.
3. An overview of present and planned RRR initiatives, related feasibility studies and information on challenges and successes.
4. A general overview about regulatory and financial support or constraints for RRR.
5. An overview about the local institutional landscape for RRR business model implementation and support.
6. A general demand statement for the proposed value proposition from local stakeholders and likely customers, including information on competition and possible market saturation.
7. A preliminary idea of comparable businesses and their locations suitable for studying risks and risk mitigation in the local context.
8. Baseline data on waste (reuse) to establish a reference point for future comparison or impact studies to assess if and how well any planned intervention will add value.
9. Suggestions for local partners with the capacity to carry out a multidisciplinary feasibility study.

3.2 Feasibility Studies for Business Model Implementation

Having selected the most appropriate locations (country, cities, districts, zones, etc.), number and types of RRR business models for feasibility testing, we move on to the actual feasibility testing phase as depicted in Figure 3. This section will present the detailed conceptual framework for the methodology for the feasibility assessment of RRR business models. The section will start by defining what the feasibility testing phase entails and subsequently outline the suggested methodological framework. Subsequently, this framework is applied in an example to test the feasibility of a specific business model.

3.2.1 Objective

In order to incentivize increased investments in RRR interventions, it is becoming increasingly important that potential investors are given the appropriate information to value the potential of a proposed RRR initiative. This is because future investors/stakeholders will expect a positive return on investments (RoI) be it in monetary or nonmonetary (like social or environmental) terms (Box 4). Essentially, the two main criteria thus used to judge the feasibility of any intervention are the ‘cost’ and ‘benefits’ from financial and economic perspectives and the viability and sustainability of the intervention over time.

BOX 4. FEASIBILITY TESTING FOR RRR BUSINESS MODELS.

A **feasibility study** in our context serves the purpose of answering the question: “Is this a viable venture which meets the sustainability criteria?” The study can end with an **implementation plan**, or be followed by one, after local stakeholders have expressed their approval and choice for a particular model and location. The **business plan** can be written at the end when operations start and allows the entrepreneur or operator to outline his/her targets and ways to achieve them in the future.

The feasibility study analyzes several alternatives/best business scenarios to identify the best one(s) which will achieve the highest success.[2] The results from the feasibility assessment phase then form the basis for the development of the implementation and business plans. The feasibility assessment phase, in the context of the RRR sector, is thus conducted with an objective and an unbiased approach to providing information upon which potential stakeholders (donors, financial institutions and the public and private sectors) can base their investment decisions on.

A feasibility study (or assessment) is thus essentially:

a. Analyzing the returns-on-investment, as well as the strengths, weaknesses, opportunities and threats (SWOT) of the proposed intervention.

[2] Success is defined here as having the highest potential for sustainability and impact at scale.

b. Paying due attention to sustainability over time. Sustainability is defined in this context as financially viable, socially acceptable, environmentally sound and with controlled internal and external production risks, which should give particular attention to the mitigation of potential health risks given the materials RRR businesses deal with.
c. Indicating the potential to work at different scales and locations (scalability and replicability).

The resulting outputs from the feasibility assessment phase are investment recommendations for donors, financial institutions and the public and private sectors; in particular, provision of insights on constraints, if any, possibly related to key resource factors, and the level of risk associated with their potential investments.

3.2.2 Methods

The methodology builds on an adapted multicriteria assessment framework and identified performance indicators related among others to institutional, technical, policy and market environments, perception studies and pro-poor business scenario modelling. This requires an in-depth understanding of the functioning of both input and output markets, enabling institutional environment and supportive economic, regulatory and financial conditions (investment climate), which are essential in assessing the sustainability, replication and scaling-up potential of RRR business models. For this purpose, different qualitative and quantitative approaches and related methodologies can be used, and interlinked with stakeholder processes.

Multicriteria Assessment Conceptual Framework

To capture the different dimensions of the task, a multicriteria analysis (MCA) offers an appropriate framework to provide decision-makers with a full range of social, environmental, technical, economic and financial information (DTLR 2001) as well as sufficient flexibility to choose the best option(s) among several alternatives, without compromising their set objective. The MCA also has limitations, and many relate to the comparison *across* chosen criteria, related decisions on 'weights' and so forth. However, there are different options to address them and hereunder we will focus first of all on the key criteria which have to be covered.

There are many MCA-based approaches used in feasibility assessments of future interventions. The Technical, Economic, Legal, Operational, and Scheduling (TELOS) is a well-known approach in business management used to define the five key areas of feasibility that determine whether an intervention or project should be implemented or not (Amanor-Boadu 2003; Bentley and Whitten 2007; O'Brien and Marakas 2011). The TELOS framework has been extended into other frameworks such as the value chain approach (VCA) used in business management (Heathcote 2005; Amanor-Boadu 2003; Hall 2010); essentially they conduct a feasibility assessment at each stage between input procurement and product and/or service provision. Whilst the TELOS and VCA frameworks have been widely applied across many sectors, their applications can be limiting especially for sectors where health and environmental risks and mitigation measures need to be accounted for – a clear example being the RRR sector which cuts across waste management, sanitation, public health and agriculture. The MCA approach considered here for the feasibility assessment of RRR business models extends beyond the TELOS framework to include additional criteria that take into account the entire environment (micro and macro, physical, social and economic) and system within which a future RRR intervention will operate (Harris et al. 2001; Danso and Drechsel 2014). Beyond the consideration of potential health and environmental risks and impacts, there are a number of risk factors that require attention in the feasibility assessment of RRR business models which will influence the final set of criteria defining the MCA framework.

An optimal RRR business model will seek to minimize all related business risks; these will include, but are not limited to: a) market risk, b) competition risk in both input and output markets, c) technology performance risk, d) political and regulatory risks, e) health and environmental risks, and f) social acceptance risk. Whilst business-related risks are typically context-specific, the above-mentioned risk factors can translate across different sectors, the specific objectives of entities implementing the RRR intervention and so forth. For this purpose, market-related risks (typically competition risks, often with seasonal and spatial components) that assess the likely sources of competition and ease of entry into both the input and output markets will be considered within the composition of the MCA framework. Another important risk factor is technological performance risk, which is related to whether the technology is commercially proven, can cope with variations in input and output markets and if there are anticipated challenges with repair and maintenance from a developing country perspective. As business sustainability is largely influenced by the macro-economic environment, political and regulatory risks that could be addressed by policies to rectify market failures (e.g., price subsidies) should also be taken into account. Externalities (positive and negative) are very important because the waste and sanitation sector is prone to environmental and human health risks. An important requirement for any type of waste management system, including resource recovery, is the need to safeguard workers and public health. Risk management and mitigation will thus be essential components of the sustainability and regulatory acceptance of any RRR business model especially where the waste might contain fecal matter. Finally, the potential success of an RRR business can not only depend significantly on its economic benefit for the general public, but also on public opinion, risk perceptions and cultural tradition. Social acceptability has shown to be a powerful risk factor for any RRR business, far beyond what conventional businesses will experience. Well-known cases are those trying to introduce water reuse for potable purposes where, despite demand, the initiatives did not take off (Drechsel et al. 2015).

Multicriteria Assessment Approach

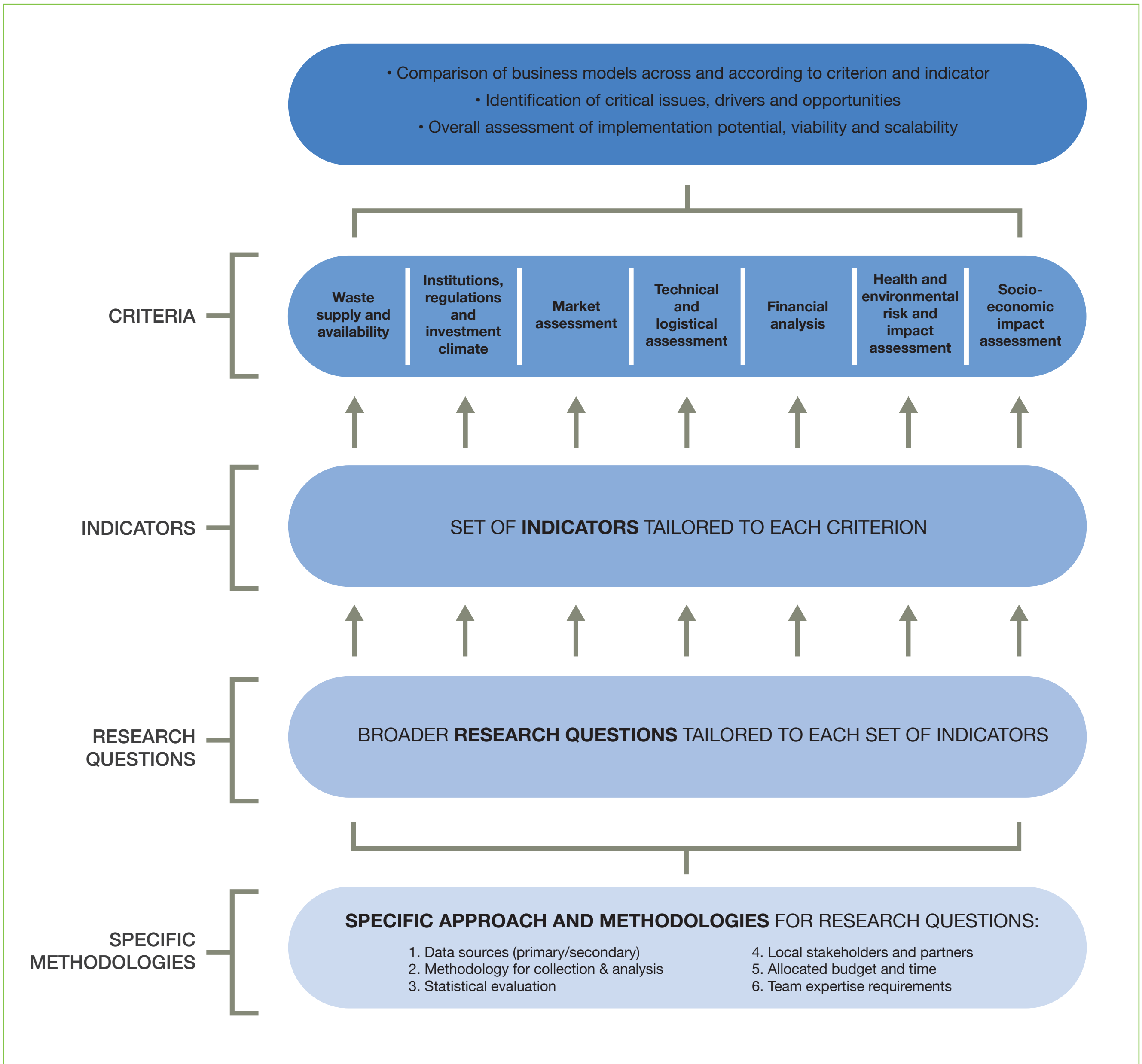
Taking the limitations of the TELOS and VCA approaches and potential risks that RRR interventions are likely to face into consideration, we recommend the following seven criteria for the MCA framework in the feasibility assessment of RRR business models:

i. Waste supply and availability
ii. Institutions, regulations and investment climate
iii. Market assessment
iv. Technical and logistical assessment
v. Financial analysis
vi. Health and environmental risk and impact assessment
vii. Socio-economic impact assessment

While it might be impossible to identify a complete list of factors that will determine the sustainability, scalability and replication potential of any RRR business model without knowing the specific context, the goal here is to present an extensive range of different criteria that will cover what is usually important in different contexts for assessing the feasibility of different RRR business models. It is also important to note that this list of criteria can still be adapted depending on the context, or the type of business model being considered, among other factors, especially if some criteria have already been studied. The framework presented here thus sets its emphasis on a set of criteria, related indicators and research questions, and detailed methodology, under the overarching umbrella of a multicriteria analysis (Figure 4).

Each criterion has its own set of indicators, with these indicators having a set of research questions and to address these research questions, a specific approach/methodology will be applied. As noted in a United Nations Framework Convention on Climate Change (UNFCCC) report, *the actual measurement of indicators need not be in monetary terms, but are often based on the quantitative analysis (through scoring, ranking and weighting) of a wide*

FIGURE 4. FRAMEWORK FOR FEASIBILITY STUDIES.



range of qualitative impact categories and criteria (UNFCCC 2015). The selected indicators for each criterion will allow for comparisons between RRR business model options to assess their viability, scalability and sustainability per indicator and criterion. Most indicators will be criterion-specific although a few may apply to several criteria, addressing, for example, opportunities and constraints for going at scale.

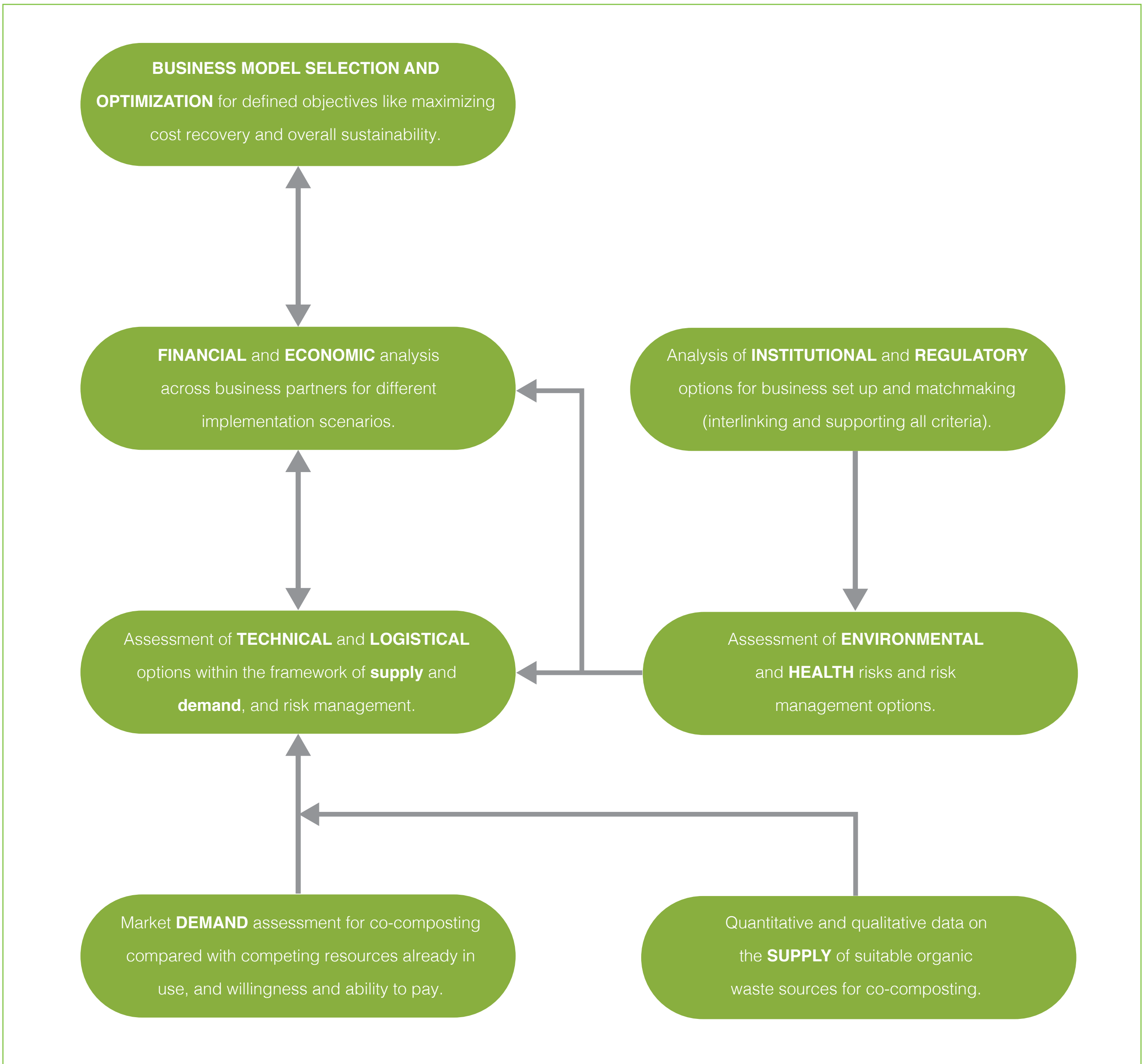
There will be overarching research questions and sub-questions. All research questions will be formulated to serve either: a) determination of the indicators, b) providing background information on the business model, and c) assessing the suitability of the indicators and functionality in any given biophysical or socio-economic setting (institutional capacity, infrastructure and technology).

It is important to note that the constituting components of the proposed MCA framework do not function in isolation but rather operate as an interlinked system – where the results/ findings of one criterion provide information for the assessment of another criterion as illustrated in Figure 5. The interlinkages between the different components are explained in the descriptions of the different criteria in the subsequent sections.

CRITERION 1: Waste Supply and Availability

There is a perception that waste is abundant in cities and thus supply is unlikely to be a critical issue. The likelihood for this situation is increasing with city size but different business models will need different waste streams, preferably not mixed with other waste, and preferably accessible at just one or a few locations to avoid transportation costs. Analyzing urban solid waste management 'transport' is the most significant cost factor, which should be kept in mind in the feasibility study. Additionally, different waste streams are 'owned' by different private or public sector entities which will have contractual arrangements for the collection and management of the waste which has implications for its accessibility and actual availability. This links to the institutional analysis.

FIGURE 5. INTERDEPENDENCE OF CRITERIA FOR DECISION-MAKING WITHIN AN MCA FEASIBILITY STUDY.



The technical dimension of the analysis will encompass the availability of the required resource in terms of the appropriate levels of quality and quantity, although ultimately the technology can be adjusted to transform sufficient waste into an asset as the market demands.

The assessment of waste availability has in addition to its strong spatial facet a temporal dimension as certain waste streams differ also between seasons. Additionally, within the same waste stream, its quality can differ spatially and temporally within a city, like fecal sludge from households versus public toilets. As mentioned above, the physical movement of the resource inputs from their origination points to the processing points is of utmost interest. Different sources and means of supply should be evaluated for their quality and quantity as well as cycles and trends in these characteristics. If specific human resources and technologies are required to facilitate the effectiveness of the input sourcing and procurement stage, their availability should be assessed within the domain of the feasibility study. Likewise, the sustainability of the source and its supply and infrastructural support for effectively procuring and moving inputs from origination points to the processing facility also need to be assessed. The prevailing range of market prices of inputs (especially under competing use) as well as costs associated with the procurement should also be assessed. The key research questions to be answered under this criterion have to be tailored to the targeted waste streams and include but are not limited to:

1. What and where are the types, quality and quantity of waste available and at what cost?
2. Is the supply of the specifically needed waste as a resource input legal?
3. Are there supply limitations of the resource input? Will there be adequate supply of the correct type of waste, in a usable form (or a form that can be relatively easily and inexpensively separated), in a suitable location?
4. What is the periodicity/seasonality of availability and does this change resource quality?
5. Who are the actors along the sanitation service chain that provide/need the resource?
6. What is the structure and ownership/institutional set up of the waste supply chain and how will this affect access and availability of the waste resource input in the required quantity?
7. What are the existing contractual/institutional agreements between firms and local governments/ or specific 'owners' for the acquisition of waste?
8. What is the current use of the waste input and its economic value? Which competing alternative destinations are available?
9. Will the potentially supplied product be safe (laboratory data)?
10. Are there preference sources with enough waste of high quality (limited mixing) to keep collection and transport most cost-efficient?

Based on these research questions, specific indicators should be selected to allow for comparisons between the different RRR business model options – to better help assess the opportunities and constraints in implementing and/or upscaling of a specific RRR business model (Table 2). Details of the methods to be implemented for the assessment of each indicator are presented in detail in Annex 2.

TABLE 2. INDICATORS FOR WASTE SUPPLY AND AVAILABILITY ANALYSIS.

A1	Sources, quantity and quality of generated and available waste
A2	Reliability of resource supply (spatial, temporal)
A3	Competitors' index for waste resource
A4	Status of legal, institutional and regulatory environments

If time permits, a material flow analysis can be used for the quantification of the waste fluxes in the system and the identification of processes through which the fluxes are changed. Subsequently, a supply chain framework from the context of a resource input market, can be used to examine the system of organizations, people, activities, information and resources involved in 'moving' the waste from the point of generation to the point of 'reuse' looking for the most feasible and cost-effective access options. Aside from the physical waste fluxes, a stakeholder analysis consisting of stakeholder relation and responsibility analyses is important to understand their roles, ownership rights, attitudes, interest and influence, and existing formal and informal agreements and contractual structures in the waste stream under consideration.

Data sources and work load will depend on the waste stream. For most waste streams secondary data might cover most of the information needed. For some waste streams, however, like fecal sludge, primary data collection might also be needed. But even where secondary data are used, it is important that these are recent and accurately extrapolated to account for urban growth factors, amongst others. Primary data collected via interviews with relevant institutional stakeholders will be useful to get cost data (waste access) and buttress other findings. If there are no secondary data (like in smaller towns), primary data can also be collected via survey questionnaires from the targeted waste generators (households, institutions, agro-industry), government entities (communal and municipal authorities, etc.), agricultural producers/users (livestock and crop farmers), nongovernmental organizations (NGOs)/projects, waste collection agencies/informal waste collectors, resource brokers, processing and storage agents, and so forth (Box 5). The sampling methodology will vary depending on the size of the target groups, and can include random stratified sampling, as well as purposive sampling via key experts.

BOX 5. OPTIONS UNDER TIME AND BUDGET CONSTRAINTS.

Assessment of options under time and budget constraints will require a significant amount of data which might already be available in local waste management departments or in the local agribusiness sector. There can however be significant differences between waste streams. A cost-effective entry point would be expert interviews in the waste sector or related academia. This also concerns queries about data sources related to particular waste streams, like wood shavings, slaughterhouse waste or particular food waste. Industrial sources can also be found in the 'yellow pages' where available. Where secondary data are used, it is important that these are as recent as possible, and, if not, accurately extrapolated to account for, *inter alia*, population growth and an increase in competing use (Ghauri 2005).

CRITERION 2: Institutions, Regulations and Investment Climate

A technically and financially feasible RRR business or initiative can succeed or fail when confronted with certain government policies and/or regulations (Amanor-Boadu 2003). Any RRR initiative will function within an institutional and legal environment in which there are existing formal and informal rules of operations. The feasibility assessment of any RRR business model for implementation thus needs to assess the existing and planned regulatory initiatives and institutional organizational structures that may support and impinge on the planned initiative. As all parts of a business depend on the involved actors and regulations from supply to marketing, **this criterion cuts across all the other criteria and some of the key questions from an institutional and regulatory point of view are listed under the other criteria.**

Overall, three study areas should be flagged:

1. Understanding the **institutional landscape** and the strengths and weaknesses of individual players to understand if there are sufficient incentives for mutually beneficial partnerships that can sustain business and reduce the different dimensions of business risks, i.e., the organizational and institutional arrangements[3] that exist or have potential within the intervention location in relation to specified waste streams and reuse activities.
2. Understanding the **regulatory and administrative context**, in particular related to existing environmental and health regulations and their implications for technology, location and reuse, and the potential viability of future RRR initiatives. An important component of the regulatory analysis is to look beyond what concerns directly the waste-to-resource transformation. Thus even where RRR is encouraged, industrial fertilizers might be so strongly subsidized, or freshwater tariffs so low, that a waste-derived fertilizer business or sales of recycled water cannot compete from a financial perspective alone.
3. Assessing the enabling environment of an RRR intervention also necessitates analyzing the status of the **investment climate** to support the probability of private sector engagement, which is particularly important in developing countries with less experience in this matter. Public acceptance beyond market demand is an important component of this analysis especially where the public sector has to be part of the business proposition and reuse projects could become a political argument (Drechsel et al. 2015).

The key research questions to be answered under this criterion include but are not limited to:

1. What kind of constraints or supporting factors related to official plans, programs, regulations, by-laws or policies exist for RRR initiatives?
2. What organizations and stakeholders control or influence RRR in the locality under consideration? What are the structure and processes of these organizations? What supportive incentives are in place for existing and future RRR interventions?
3. What are the governance structures of ongoing RRR initiatives and businesses, the matchmaking incentives and at which scale does the business operate?
4. What are the strengths, weaknesses, opportunities and threats of likely or potential partner institutions in view of their engagement in the planned RRR?
5. What are the official attitudes and recommendations, e.g., at institutional/municipal/communal levels for the planned business model/waste valorization?
6. Could inter/intrasectoral cooperation be improved (platform building)?
7. What are the determinants of a supportive investment climate and implications for new business development in the RRR sector, including bottlenecks that have been experienced?
8. What is the degree of public (community) acceptance of the proposed RRR intervention(s)?
9. Are there private investors in the city who are interested in (co)funding RRR businesses?
10. What is the status of the capital market as related to the willingness of financial institutions to support RRR initiatives, probable terms of financing available from banks and other investors, and the nature of financing mechanisms?

Based on these research questions, specific indicators should be selected to allow for comparisons between the different RRR business model options – to better help

[3] Organizational refers to both formal organizations and groups of people or stakeholders; institutional refers to their formal or informal rules of operation, e.g., mandates or customary practices.

assess the opportunities and constraints in implementing and/or upscaling a specific RRR business model (Table 3). An important indicator relates to institutional capacity as many public-private partnerships (PPPs) within the waste sector (where revenue streams are mainly based on treated waste volumes, not sold recovered resources) have an underdeveloped marketing capacity. Alternatively, other sectors (like fertilizer sales) have to be suggested for effectively closing the loop. The methods to be implemented for the assessment of each indicator are presented in detail in Annex 2.

TABLE 3. INDICATORS FOR INSTITUTIONAL, LEGAL AND INVESTMENT CLIMATE ANALYSIS.

B1	Structure and capacity of institutions
B2	Policy and legal framework support
B3	Level of budgetary and other incentives for engagement
B4	Community support
B5	Status of the investment climate for RRR operations

As institutions and regulations are interlinked, the institutional and legal environment analysis can be combined. Key methodologies are stakeholder mapping and analysis of sector governance.

- **Stakeholder analysis** – to identify and understand all the players in waste production, management and reuse of recovered resources, and their roles, responsibilities, power, interest, organizational autonomy, level of collaboration with other stakeholders, performance targets and institutional capacities (might include a SWOT analysis).
- **Governance analysis** – to identify the rules, regulations, strategies and interinstitutional hierarchies in decision-making as well as alliances (business arrangements) that govern the sector and RRR in particular. This includes formal and informal institutions and covers policies and legislation, as well as social perceptions and practices.

A schematic presentation of the stakeholders—along the waste stream from supply to reuse—could be useful. Stakeholders could be clustered by roles and activities (regulators, organizers/management, users, and support). Although the analysis assumes that we are assessing the existing institutional environment to see whether RRR businesses could be established in the chosen locality, the analysis can/should also point at bottlenecks to make recommendations about areas in which organizational, regulatory or institutional change may benefit the establishment and sustainability of RRR. While literature reviews and 'expert consultations' will be particularly helpful for understanding overall sector governance and organization and the SWOT of individual institutions, round tables are recommended to verify the results with the concerned players.

The findings from the literature review and expert consultations can be interpreted, e.g., via the 'power and interest' analysis and 'triangle analysis'. Power and Interest Analysis (Moncrieffe and Luttrell 2005) is often used to map out the relative ability of key stakeholders to have an effect on a particular issue, for example, by influencing the agenda or by directly instigating change. It also identifies stakeholders that may be passive but who ultimately feel the costs or benefits of changes. The power and interest analysis will help identify whether changes are likely to take place under current institutional conditions – for example, is there any group with sufficient interest and power to make the change or to block a change? It will also highlight which stakeholders need to be persuaded of the need to address issues related to resource recovery and reuse of waste.

The 'Triangle Analysis' (see Start and Hovland 2004) is a technique for problem identification and solving that breaks the situation down into consideration of content, structure and culture. **Content** refers to the written laws, policies and budgets relevant to a specific issue. **Structure** refers to mechanisms for implementing a law or policy. This would include, for example, institutions and programs run by the government, or local business groups. **Culture** refers to the values and behavior that shape how communities of people value, deal with and understand an issue, as influenced by religion, custom, class, gender, ethnicity and age.

Investment climate (IC): The target is an IC analysis for the intended RRR options. Based on Stern (2002), in general the IC components of relevance include three broad categories: (1) macro-economic factors (fiscal, monetary, exchange rate policies and political stability), (2) governance and institutions, including bureaucratic harassment, and (3) financial and legal systems and infrastructure necessary for productive investment, including transportation, electricity and communications. Several international organizations and research institutions have developed IC assessment frameworks like the World Bank's *Doing Business* framework, the World Economic Forum (WEF) Global Competitiveness Index (GCI), the Organisation for Economic Co-operation and Development's (OECD) entrepreneurship measurement framework, which can provide a good analytical start although they differ in their assumptions, analytical scope and data demands (UNIDO and GTZ 2008). In addition to aggregate indices and ranking methods, econometric tools can also be used to assess the investment climate looking at the relationship between key investment climate indicators and productivity (Escribano and Guasch 2008).

Whatever approach is used, it is important to understand the underlying assumptions, data needs and indicators used for the computation of different indices in order to remain relevant for the RRR sector. While some factors and conditions are certainly cross-cutting for any economic sector, others might be more relevant to specific sectors. This is important especially for RRR as it is a nascent sector (green economy, circular economy) which might warrant in many locations a more specific sector-based business environment assessment. This could be achieved, for example, by adapting a national-level assessment framework to a sector-level assessment; the United States Agency for International Development (USAID) Agribusiness Commercial Legal and Institutional Reform (AgCLIR) provides a toolkit for analyzing agribusiness-enabling environments based on the World Bank's *Doing Business* framework by adapting the ten key *Doing Business* areas with comprehensive indicators to the agribusiness sector (USAID 2008; FAO 2013).

Based on the assessment tools developed by the World Bank (2005), OECD (2008) and ANDE (2013) a list of suggested indicators for assessing the RRR investment climate domains is presented in Table 4. The list is not exhaustive but these indicators could be used as a guide to identifying and developing additional indicators that are relevant to the RRR sector.

Data Sources

Various data sources involving a combination of primary and secondary data collection are used in the investment climate assessments. Some of the indicators listed in Table 4 are available from secondary sources such as from local

TABLE 4. LIST OF INDICATORS MEASURING THE KEY DOMAINS.

DOMAIN	INDICATORS
Regulatory framework and infrastructure	▪ Cost to start and close a business ▪ Time to acquire land and start a waste business ▪ Time to get health/agricultural permits for waste reuse ▪ Tax incentives for the RRR sector ▪ Level of satisfaction with government services and programs ▪ Overall business satisfaction with the business environment ▪ Percentage of businesses that report paying a bribe ▪ Amount of bribes paid as a percentage of sales ▪ Access to electricity, water, transport and telecommunications ▪ Level of business satisfaction with availability of infrastructure
Finance	▪ Access to debt ▪ Amount of bank loans outstanding to RRR businesses ▪ Average interest rate ▪ Collateral requirements ▪ Percentage of early stage investments ▪ Number of foundations supporting RRR businesses ▪ Amount of donor grants to RRR-related activities
Business support services	▪ Number of RRR network associations ▪ Number of RRR networking activities and events ▪ Number of incubators and accelerators ▪ Average success rate for incubators
Markets	▪ Target market size (domestic/international) ▪ Competition (see market criterion)
RRR entrepreneurial performance	▪ RRR enterprise birth rates vs. RRR enterprise death rates ▪ Survival rates at 3 and 5 years ▪ Proportion of 3- and 5-year-old firms ▪ Rate of high growth firms based on employment growth ▪ Rate of high growth firms based on turnover growth

Source: Adapted from ANDE 2013; OECD 2008; World Bank 2005.

statistical agencies while others such as those on satisfaction with the business environment or infrastructure are likely to be sourced through surveys, ideally of existing RRR businesses. Some of the internationally recognized agencies for sourcing global datasets include the World Bank's Enterprise survey, *Doing Business* database, the WEF GCI dataset and the International Monetary Fund (IMF) World Economic Outlook. In addition to these sources, available regional or national datasets include the Regional Program on Enterprise Development dataset and industrial surveys (Box 6).

BOX 6. OPTIONS UNDER TIME AND BUDGET CONSTRAINTS.

Given time and budget constraints, data can be gleaned from information gathered under the other criteria (supply, demand, health/environment…). An RRR sector-specific assessment requires one-on-one interviews with institutional (governmental) representatives, financial experts and sector specialists while more generic information can be sourced from secondary literature. A shortcut is to engage – if available – with existing RRR businesses which are as close as possible to the selected waste streams and value proposition and willing to share their experiences about the institutional landscape, regulatory challenges and the investment climate.

CRITERION 3: Market Assessment

Having established a clear understanding of the legal and institutional environment in which RRR initiatives will operate, it is important to assess the output market for the targeted waste-derived product. In this context, it should be kept in mind that a compost project run by a PPP with the city waste management department might not have an incentive to actually *sell* compost and to *explore* the related market, given a) the usually secured public sector funding for private sector waste treatment, and b) the sufficient benefit of waste volume (and cost) reduction which composting offers the public sector. As a result, such a PPP often has little experience with the reuse market and marketing, which the analysis of incentives and institutional capacities under Criterion 2 has to consider.

The commercialization of any new product or introduction of a product in a new market requires an accurate or close to accurate estimation of the relative market size for the new product. The successful development of any subsector market depends particularly, *inter alia*, on market demand. Specifically, the question of whether a demand actually exists or could be created and the price end-users are willing to pay for this new product to cover the production costs, needs to be explored. As demand depends on many factors (e.g., sociocultural aspects and perceptions, substitute products available in the market, etc.), it is useful to structure the analysis by market segments, i.e., potential clients of the recovered resource, their actual and potential number and resource absorption capacity (such as who, what, when, where, how much, how often) and their willingness-to-pay (WTP) should be assessed. Market segments for a new organic fertilizer could, for example, be market-oriented urban farmers, flower producers, parks and gardens, real estate developers, peri-urban fruit plantations and so forth.

Once the market size has been estimated, and resources and time permit further study, the evaluation of the market structure (i.e., competition, differentiation of substitute products, barriers to market entry, among others) could be targeted. The characteristics that are engineered into the product, as well as the pricing, promotion and distribution or placement opportunities are all influenced by a clear understanding and appreciation of the industry's structure, conduct and performance (SCP). This is particularly important for RRR businesses as the related output products can be new 'alternative' products entering a fairly competitive market. An example is the introduction of fecal sludge-based fertilizers into a market well supplied with chemical fertilizers such as in Ghana.

Another important facet of the market assessment is demand forecasting – i.e., market outlook. Market forecasting is a crucial element for business owners in assessing business growth, including options for outscaling or upscaling and related future capacity requirements. Businesses need to adopt different strategies ranging from establishing key partnerships and price mark-ups to maintaining a competitive advantage and ensuring sustainability. In that regard, the market assessment should seek:

1. To assess the market value of the RRR products under consideration –
   a. To assess consumers' WTP and differences in WTP estimates across different consumer segments and related factors influencing consumer demand;
   b. To estimate the potential market size for the RRR product.
3. To assess the characteristics and dynamics of the market structure.
4. To evaluate the market outlook of the proposed RRR products and to what extent the RRR products would be viable over time in the market given existing or expected competition.
5. To define the firm's strategy as related to a) pricing, b) marketing and distribution, and c) optimal location for business establishment.

Based on these research objectives, specific indicators should be selected to allow for comparisons between the different RRR business model options in order to facilitate assessment of the opportunities and constraints in implementing and/or upscaling a specific RRR business model (Table 5). The methods to be implemented for the assessment of each indicator are presented in detail in Annex 2. A brief description follows below.

TABLE 5. INDICATORS FOR MARKET ASSESSMENT.

C1	Theoretical market segments and size
C2	Market value of recovered resource (via WTP) and possible market size
C3	Market structure – competitive advantage index
C4	Market outlook of recovered resource
C5	Pricing strategy
C6	Marketing interest, capacity and strategy
C7	Optimal location strategy
C8	Product distribution strategy

C1 and C2: Market Size and Value of the Recovered Resource

When introducing a new product into the market, businesses are particularly interested in two factors: consumer demand and production costs. Though cost estimations are comparatively simple and straightforward, the assessment of consumer demand for a novel product is more complicated (Lusk and Hudson 2004). Common methodologies vary and depend on the existing market for similar products; they identify how much a respondent is willing to pay for a certain amount of a new product, or if alternative valuations have to be used to assess consumers' WTP. There are numerous approaches (Figure 6) with different conceptual foundations and methodological implications and limitations (also in terms of time and resources required) and it requires trained economists and experienced interviewers to get meaningful results (Breidert et al. 2006) (Box 7).

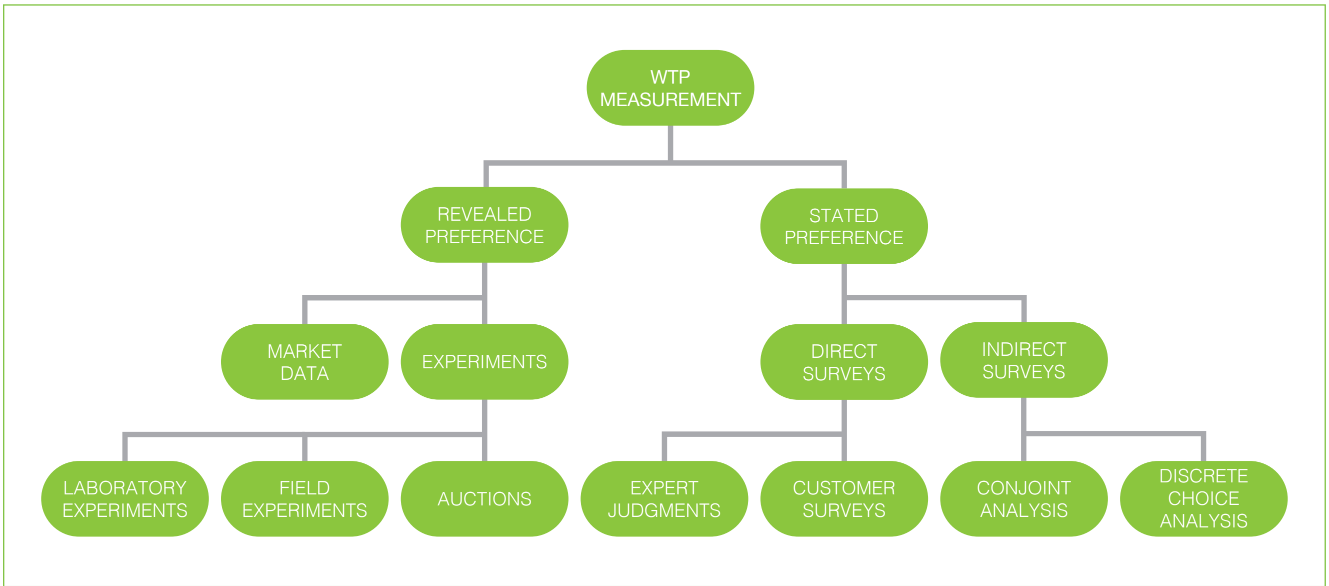
Indicator C1 will start with the identification of potential customers (theoretical market segments and their sizes) and test if these segments are generally open to the new product (or already using a comparable one). This forms the basis for selecting the most likely or promising segments for estimating the possible market demand as the aggregate value of the size of each market segment (consumer group) principally willing to buy the product multiplied by expressed average WTP. There are however many other factors to consider, including transport costs. Depending on the sales outlets and the location of the buyer, the costs to access the product will have to be factored into the WTP if the sales outlets are further away than the sources used at the moment. In other words, with increasing distance from the source (like a compost station) transport costs will diminish the WTP and actual market size. This shows the importance of (partnerships allowing) multiple sales outlets and bulk sales/purchase. The actual and future (potentially increasing) market size of an RRR product provides substantial information to help business owners and policy-makers decide on how much can be invested into operations while still making profit.

C3 and C4: Market Structure and Outlook

Businesses require information on the extent and characteristics of market structure for decision-making on strategies that ensure firm performance. An SCP evaluation model can be applied along the different stages of the product supply chain. The SCP approach assesses the structure of the market (number of actors involved), their conduct (what products/services they perform) and how these lead to the performance of the market in terms of prices, quantities traded and costs of performing various functions. This indicator will serve to provide insights of market performance and possible strategies that RRR businesses can adopt (measured in terms of price and accessibility) to gain a competitive edge in the market. For application of the analysis see Holtzman (2002) and Wanzala et al. (2009).

The evaluation of the market outlook helps to obtain a projection of demand levels in the future based on current or past evolutions. A 'Bass model' can forecast the long-

FIGURE 6. CLASSIFICATION FRAMEWORK FOR METHODS TO MEASURE WILLINGNESS-TO-PAY



Source: Breidert et al. 2006

BOX 7. OPTIONS UNDER TIME AND BUDGET CONSTRAINTS.

The most important part of the market assessment given time and budget constraints is the likely market size and WTP for the product. The WTP assessment can require a significant amount of primary data and can be time and cost intensive, while statistics might be available to estimate the size of farmers per farming system and region for example. In general, any econometric analysis for WTP estimations requires a sound sample size and stratification of likely market segments. This can be reduced if the market segments, for instance, focus on larger-sized customer segments which combine high demand and purchasing power. If these are large-scale plantations for example, then the number of interviews will be very small but the WTP might be high compared to analyzing smallholder farms. If no interviews are possible the market price of the closest comparable product currently used reflects what customers pay so far.

Under the market structure assessment, mostly secondary data can be used for the supply chain analysis. Previous studies have been conducted on the supply chain of the fertilizer market in many agriculture-dependent countries. This information can serve as a proxy for the market structure assessment of an alternative waste-based fertilizer. Further analysis on locations, pricing and marketing strategies can also take place during the drafting of the **Implementation** and **Business Plan**.

term sales pattern of a new product when a firm has not yet introduced the product or technology, but its market behavior is likely to be similar to some existing (analogous) products whose adoption pattern is known, like alternative nutrient, water or energy sources. For application of the model see Lilien et al. (2013). However, some waste-derived products (like an organo-mineral fertilizer) have higher potential than those already on the market and for sales forecast it might be appropriate to also explore new market segments.

C5 and C6. Pricing and Marketing Strategies

Information on the target market share, expected profit margin and growth forecast for the company will be required to decide on the marketing and pricing strategy. This will be further influenced by other factors (e.g., branding awareness, uniqueness of the product, customer segmentation, competition, demand elasticities, etc.). Moreover, different business objectives will determine the type of pricing strategy that an RRR business will adopt: a) premium pricing (setting the price of the product higher than similar products justified by a novel value proposition), b) penetration pricing (setting the product price lower than the competitive price to attract customers), and c) competitive pricing. Decision-makers are not only interested in the optimal quantity to be produced, but they also have to decide what type of markets will lead to maximum profit when the goods are supplied. There are many markets (international, local, and subsector markets) which they have to decide are the most optimal to target to ensure business sustainability. The challenge is to determine the optimal number of market segments, the optimal prices to be demanded per product in each market segment, and the resulting optimal number of products to be assigned to each market segment, in such a way that the profit per day or season will be maximized. For this, a dynamic programming approach based on the optimization of a profit function can be considered to help derive the optimal market segments. The approach will use data generated on WTP and the production cost data of the Financial Criterion. In particular, as the cost data at the stage of the feasibility study will have a significant error margin, the pricing indicator is about the best strategy locally but not exact numbers. Some references are provided in Annex 2.

C7 and C8. Optimal Location and Distribution Strategy

Depending on the waste stream there can be limitations on the choice of locations, e.g., for a wastewater treatment plant. In the case of solid waste, however, the location choice of, for example, a compost plant can depend on different factors, from the business objective to 'who pays for which transport' and the location of the landfill. In a PPP, for example, the private compost operator would probably like to minimize costs and be located as close as possible to the sales outlets (and customers). However, the public waste operator would prefer to have the compost station closest to the area of waste collection to reduce the transport volume to the landfill as early as possible. Thus, the nature of the decision usually requires that trade-offs be considered within the actual business plan. However, the location has multiple implications for other factors of the feasibility study, from studying local social acceptance, to assessing potential risks for the local environment, to assessing the market size which strongly depends on transport costs, and to decide about the most efficient distribution channels/strategies.

The research approach that can be adopted in the case of RRR businesses can follow the extended version of the transportation model called the trans-shipment model. King and Logan (1964) conducted one of the earlier studies to use the trans-shipment model to simultaneously consider the costs of shipping raw materials, processing and shipping of the final product which has been applied to composting (Danso et al. 2006; Folefack 2005). The method for the application of this approach is provided in Annex 2.

CRITERION 4: Technical and Logistical Assessment

Having estimated the size of the market and the quantity of waste resource input available, a preliminary decision can be made on the scale of operation of the business which will be limited at the upper end by whatever is smaller, the raw material supply or what can eventually be sold, and vice versa at the lower end by the respective lowest input or output number. It is important to note however that the determination of the optimal scale of operation – which influences the choice of the technology – is dependent on additional factors, such as legal limits, location(s) and local public acceptance, market forecast and investment costs. Thus the decision on the technology depends strongly on the other criteria analyzed in the overall feasibility study.

Given the required capital investment, it is imperative that the technical feasibility assessment is conducted with due diligence to avoid too low or too high production capacity (Amanor-Boadu 2003). Essentially, the criterion focuses on the actual technical approach/process applied for the output production; considering questions such as:

- Which technical options are available for the calculated production scenarios?
- What are the related energy requirements, capital and operational costs, repair sensitivity, local supply chain and level of expertise, etc.?
- What are the potential environmental and health risks of the suggested technological choices and which technology offers optimal control/mitigation of these risks? (links to criterion 7)
- Does the technology have a positive track record in the country and who was operating it?

The assessment of the level of resource requirements including labor, land, transportation/storage space, continuous energy and water supply, is also important as these factors will influence the selection of the technology. Another important component for the size of any plant is if a centralized or decentralized approach has been recommended, with or without possible transfer stations, based on the analysis of transport distances, volumes, location and marketing. Finally, particular attention has also to be given to local institutional and human capacity to operate and maintain any suggested technology, related processes and production cycle. Based on these criteria the technical options can be narrowed down and the final decision is based on the most favorable financial analyses, lowest risks and environmental sustainability.

Based on these considerations, specific indicators should be selected to allow for comparisons between the different RRR business model options – to better help assess the opportunities and constraints in implementing and/or upscaling of a specific RRR business model based on their technical feasibility (Table 6). Details of the methods to be implemented for the assessment of each indicator are presented in detail in Annex 2.

Data to support the assessment of the technologies and operations can be of both primary and secondary nature. Existing RRR business cases using the same or comparable technologies and their suppliers would be the best sources for data on different technical options, their complexity/efficiency, required vs. available technical expertise, and (capital and operational) costs (Box 8).

TABLE 6. INDICATORS FOR TECHNICAL AND LOGISTICAL FEASIBILITY ASSESSMENT.

D1	Availability and accessibility of equipment and replacement parts
D2	Technology requirements index (technical [spare] parts, labor, land, total fuel/energy [transportation], expertise requirements)
D3	Performance and efficiency of the technology
D4	O&M requirements

BOX 8. OPTIONS UNDER TIME AND BUDGET CONSTRAINTS.

The most important part of the technical assessment given time and budget constraints is the identification of an appropriate technology which fits the required (marketable) production size, local conditions (e.g. power cuts, available land area), investment budget, as well as institutional capacity to operate and maintain the technology. Concomitant is the cost estimate for O&M which feeds into the financial analysis. The task is easier if comparable technologies are already in the vicinity or the investigating team has related experience from similar settings. Also the literature on adapted technologies for nutrient, energy and water recovery which fit low-income countries and tropical conditions is extensive. All these factors could possibly reduce the task of analyzing the local institutional and human capacity for technology O&M including related supply of spare parts, and the availability of land and other required inputs.

CRITERION 5: Financial Analysis

This criterion builds on the assessment of the previous criteria (technical assessment). It essentially evaluates the financial viability of the proposed RRR intervention. It is important to note that financial viability here does not necessarily imply profit maximization but could be a cost-recovery target depending on the objective of the RRR business implementer; especially given that the sanitation sector offers many opportunities for social business models aiming at improved living conditions or reduced environmental pollution.

Moreover, in a sector which usually depends largely on public financing, subsidies remain a normal revenue stream (aside from private capital) although an increasing degree of independence from the public support is now a standard requirement from investment banks (Drechsel et al. 2015). Potential investors – the private sector, public authorities and other developmental agencies – need to be able to properly and systematically evaluate RRR investment projects. A financial feasibility analysis of an RRR business model provides the basic operational and financial information for making investment decisions. Additionally, given the financial, technical and operational aspects, entrepreneurs require information on the optimal scale at which an RRR business model should operate.

The main questions asked here are: Is the business financially viable and under what conditions? Which incentives (gains, savings, subsidies, fiscal support) encourage different actor participation for a win-win situation along the RRR value chain? Can the RRR product be produced cost-effectively with positive profits and under what conditions? At what optimal production capacity based on the choice of technical process, related costs, etc., should the RRR business operate? The financial analysis of an RRR business model will set a product price based on cost estimates from the supply and technical assessment, which allows – based on the market size and WTP – to break even or achieve profit, whatever the objective is, after a certain period of time. The financial analysis will also have to consider earnings before interest and taxes (EBIT), depreciation and amortization to evaluate the level of profitability and operating performance of the proposed RRR intervention. If the product price becomes non-competitive in view of alternative products on the market, different adjustments across the criteria are possible: either the technology or logistical costs have to be reduced, or the value proposition enhanced to become more competitive, or public subsidies added as a revenue stream, e.g., based on socio-economic benefits (see criterion 7). Thus, alternative scenarios should be estimated for all factors influencing costs and benefits, for instance based on different levels of technical sophistication, production scale and the actual and potential (but realistic) transport capacity for waste supply and/or product distribution. For this purpose, specific indicators should be selected to allow for comparisons between the different RRR business model options to facilitate assessment of the opportunities and constraints in implementing and/or upscaling of a specific RRR business model (Table 7). Methods to be implemented for the assessment of each indicator are presented in detail in Annex 2.

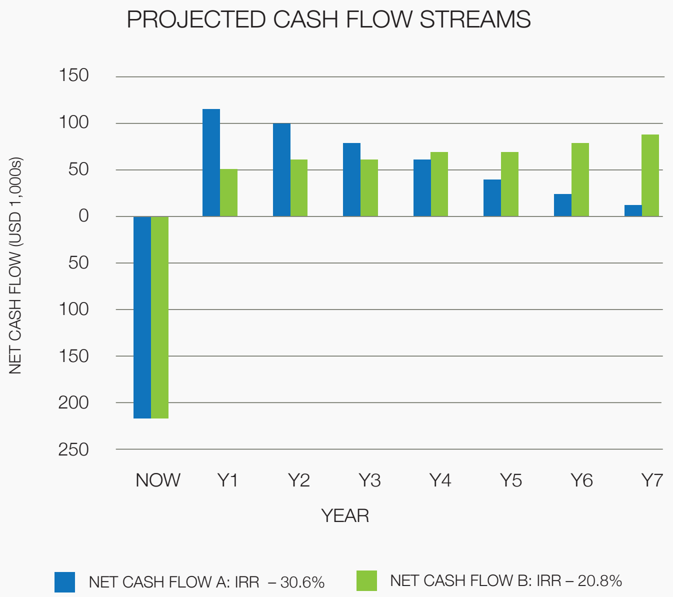
The profitability and financial viability of an RRR business model can be analyzed based on the **net present value** (NPV) and **internal rate of return** (IRR) valuation criteria. The NPV is defined as the difference between discounted benefit streams less the discounted cost streams. If the NPV is greater than zero, then the investment is financially viable, if it is negative, then the investments will not be recovered. IRR is the discount rate at which the NPV is equal to zero, and its value, compared to actual investment rates, can help in comparing different investment options (Box 9).

TABLE 7. INDICATORS FOR FINANCIAL ANALYSIS.

E1	Operating cost index - production cost indicators (e.g., investment requirements at start-up, O&M costs as a percentage of total production costs)
E2	Operational index (e.g., operating self-sufficiency, financial self-sufficiency)
E3	Payback period; financial benefit-cost ratio (BCR), development of subsidy dependency
E4	Economies of scale and financial sustainability across core business partners
E5	Firm performance (percentage of cost recovery, profitability ratio, inventory turnover ratio, market growth rate, NPV and IRR)
E6	Firm performance under risk (probability analysis)

BOX 9. FINANCIAL VIABILITY OF AN RRR BUSINESS.

This figure shows an example of the projected cash flow streams of a business. Net cash outflows at the outset and net cash inflows in later periods mean that costs initially exceed incoming returns, but if results appear as expected, returns eventually outweigh the costs. The IRR metric 'expects' this kind of cash flow profile. Case A (blue bars) has large early returns but these diminish year by year. Case B (green bars) has smaller returns at first, but they grow each year. As an indicator of risk, the higher IRR shows the preferred case as the discount rate (which includes an inflation component and a risk component) would have to reach 30.6% to eliminate the present value of this investment. However, if the actual financing cost rates and the actual reinvestment rates are much smaller than the IRR then the IRR will overstate the real value in Case A far more than in Case B.



Source: https://www.business-case-analysis.com/internal-rate-of-return.html

In addition to the NPV and IRR concepts, the effects that changes in factors have on the NPV will be analyzed using a sensitivity analysis and scenario analysis. A sensitivity analysis is important in determining which variables (particularly input resource factors) have an important effect on the output (NPV). Under the scenario analysis, optimistic and pessimistic scenarios should be evaluated, in addition to the base case scenario. The advantage of this approach is that the results can be easily interpreted and understood by the stakeholders. To account for uncertainty, sensitivity analyses should be conducted to evaluate profitability and financial performance across changes in alternative factors.

A mix of primary and secondary data can be used for the NPV and IRR analysis. Primary data can be derived mostly from the cost and revenue assessments under the other criteria, in particular waste supply, demand, the technical process (O&M) of value generation between waste and product, and costs of health and environmental risk management, which will feed into a financial cost-benefit assessment. The analysis can also draw on investment and production cost data of similar technologies and business models in the selected or other cities. Where the business models under study do not exist, the analysis will have to rely on secondary data. Depending on the RRR business model under consideration, the financial analysis will include initial capital investment requirements, fixed costs and annual operating costs. Table 8 provides (but not exhaustively) the general data, investment cost, production cost and sales revenue information required to conduct the analysis. Data

TABLE 8. INVESTMENT AND PRODUCTION DATA FOR AN RRR BUSINESS MODEL.

ITEM	UNIT	REMARK
GENERAL DATA:		
Plant capacity	m^3 or tonne or kwh $year^{-1}$	Depending on the RRR business model under study
Start date	Year	
Plant's operating hours per year	Hours $year^{-1}$	
Plant's useful life	Years	
INVESTMENT COST:		
Land	USD	
Building	USD	
Equipment 1	USD	E.g., machinery, transport, power generator where electricity supply is irregular, storage, etc.
Equipment 2	USD	
Engineering services	USD	
Licensing	USD	
Others (specify)		
i	USD	
ii.	USD	
Investment financed by owners	%	
Investment financed by loan	%	
Investment financed by donors	%	
PRODUCTION COSTS:		
Input cost (municipal solid waste [MSW], fecal sludge, farm waste, etc.) including transport	USD $tonne^{-1}$	
Operation and maintenance cost	USD m^{-3}, $tonne^{-1}$	
Labor cost	USD $tonne^{-1}$	
Utilities	USD $tonne^{-1}$	
Cost of financing	USD $year^{-1}$	
Depreciation (building/machinery)	USD $year^{-1}$	
Other costs (specify)	USD $tonne^{-1}$	
i. Tax		
ii. Marketing expense		
iii. Packaging materials		
iv. Transport to outlets or customers		
v. Health and environmental risk control		
SALES REVENUE:		
Total annual production	m^3, tonne $year^{-1}$	Depending on the business model under study
Price per unit of product	USD m^{-3}, $tonne^{-1}$	

on economic indicators such as interest rates, inflation, tax, escalation, annual write off, insurance and debt-equity ratios can be obtained from secondary sources. Depending on local conditions and the RRR business model under investigation, basic assumptions on annual production, input cost and output price on a year-to-year basis can be made to account for inflation rate, growth in the market and other factors which influence the cash flow from year to year, in consultation with industry experts and based on official country statistics. In a situation where the business model requires different partners to collaborate to perform the business (e.g., treatment and marketing), the analysis should consider both parties (Box 10).

BOX 10. OPTIONS UNDER TIME AND BUDGET CONSTRAINTS.

The financial assessment requires significant attention as it will provide the key data for determining the financial viability of the business model in the local context. Its success depends significantly on the quality of the data gathered under the other criteria (supply, market, technology, risk mitigation) supplemented with secondary data. The best strategy to save staff time in the financial analysis, given time and budget constraints, is close collaboration with the team that has been working on the other criteria from the start so that the required data are available and no time is lost for filling data gaps.

Traditional tools for project evaluation, such as NPV or IRR can be inadequate for coping with the high uncertainty that characterizes most RRR models in developing countries. In this situation, a Monte Carlo risk analysis can help to answer questions such as: a) What are the uncertainties associated with key performance indicators of the business model and how do they affect the overall financial viability of the business model? b) What are the probabilities and implications/effects of 'adverse' events on the viability of the business model, given changes in market demand, technology, capital markets, etc.?

Monte Carlo simulation utilizes information, be it in the form of objective data or expert opinion, to quantitatively describe the uncertainty surrounding key project variables as probability distributions, and to calculate in a consistent fashion the possible impact on the return of the project (Savvides 1994; Richardson et al. 2006). The results (Indicator E6, Table 7) can be presented in terms of the probability that the RRR business model will be an economic success and the probability of annual cash flow deficits. As depicted in Figure 7, a potential investor will know that there is a high probability (approximately 61% chance) of earning a positive NPV on investing in an agro-waste briquette business in Uganda.

CRITERION 6: Health and Environmental Risk and Impact Assessment

The implementation of any waste-related business will require an environmental and human health risk assessment. In the **feasibility study** the assessment aims to provide information on how far the possible risks are manageable and the cost involved (data/information that feeds into the financial analysis). A second objective is to quantify, if possible, any positive or negative impacts of the RRR intervention on the environment and human health assuming recommended risk mitigation measures are in place (incorporated into the economic analysis). The risk assessment has to consider the recommended technology options, likely scale of the enterprise and cover the occupational health and environmental risks (business level) as well as impacts at community level, such as groundwater contamination. The assessment should not be limited to the likely location of any enterprise, but also consider all strategic points in the production process, i.e., from waste input acquisition to transformation to use of the recovered resource. The overall assessment should thus allow the identification of: (i) potential hazards and those potentially at risk, e.g., workers, the public; (ii) mitigation strategies so that the proposed RRR intervention is compliant with international and national health and environmental standards/targets; and (iii) potential health and environmental impacts (positive and negative) of the RRR intervention at the system boundary level (Winkler et al. 2013; WHO 2015).

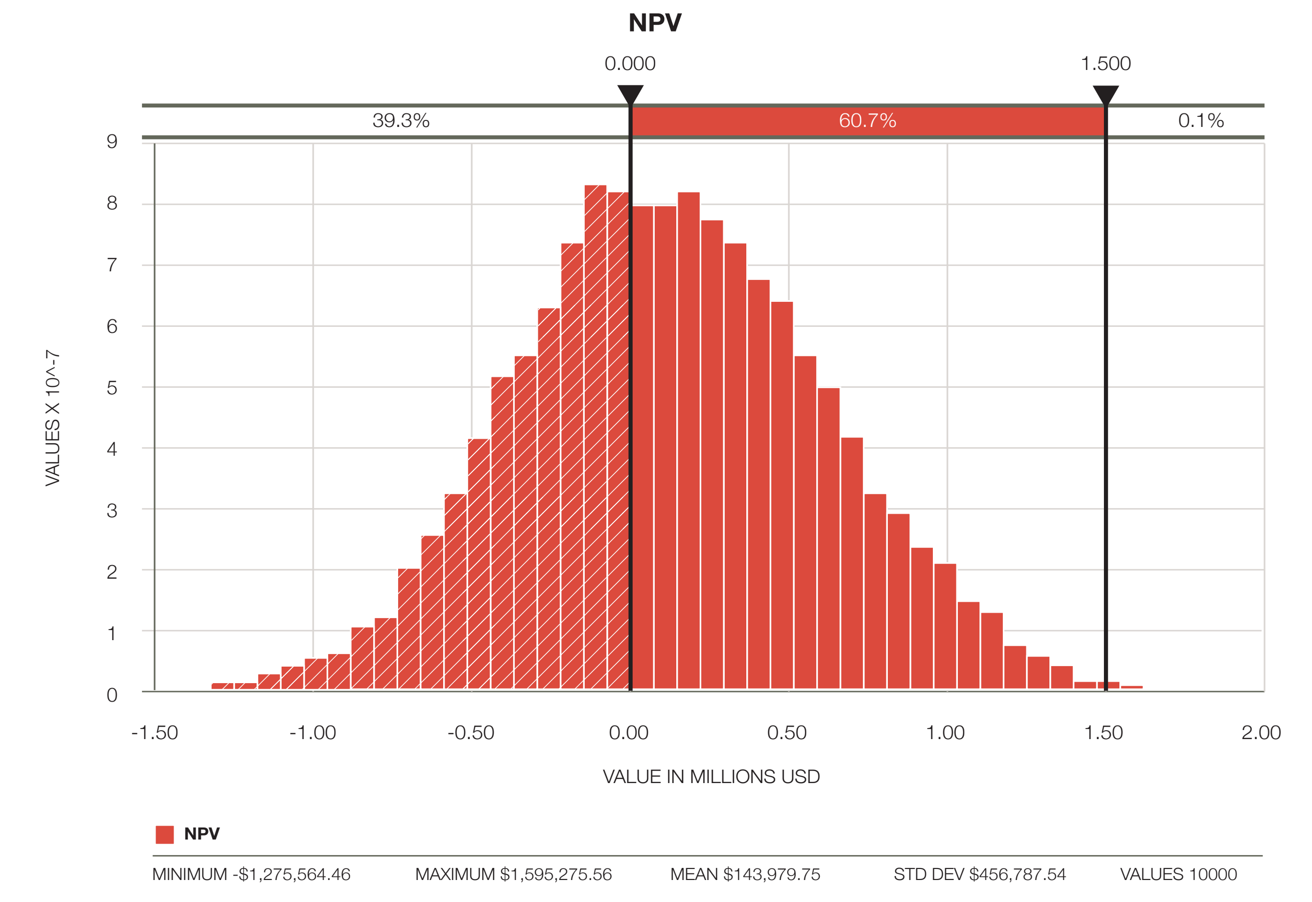
Ideally, any health and environmental risk and impact assessment requires **site-specific data** to know for example, local soils and topography, groundwater depth and the distance to residences and potentially exposed neighborhoods. The identification of the sites where the RRR business will eventually operate will however depend on a range of factors, like the availability of space, local stakeholder agreement, technical specifications, proximity to waste supply and/or potential customers and thus depend on the assessment of the other criteria, plus information on potentially sensitive areas from an environmental and/or health perspective.

Unless the location and exact technology have been predefined by local stakeholders, allowing the team to consider an environmental impact assessment (EIA), the feasibility study will require flexibility and triangulate (Figure 8) required information from local observations of sites and existing similar RRR interventions, secondary data using common guidelines for risk assessment and stakeholder interviews. Based on the triangulation of the likelihood and severity of possible risks, the assessment should cumulate in priority recommendations for risk mitigation and related costs. If compliance with these recommendations is likely, which requires individual assessment (and training budget), then the impact analysis can focus on the remaining risks and with more emphasis on the **positive externalities**.

These are often ignored in technical guidelines, given that the priority concern is safety. However, as RRR is closing important resource loops, its whole purpose is to provide positive impacts for the environment, support ecosystem services and benefit human health, nutrition and livelihoods through water, nutrient or energy recovery.

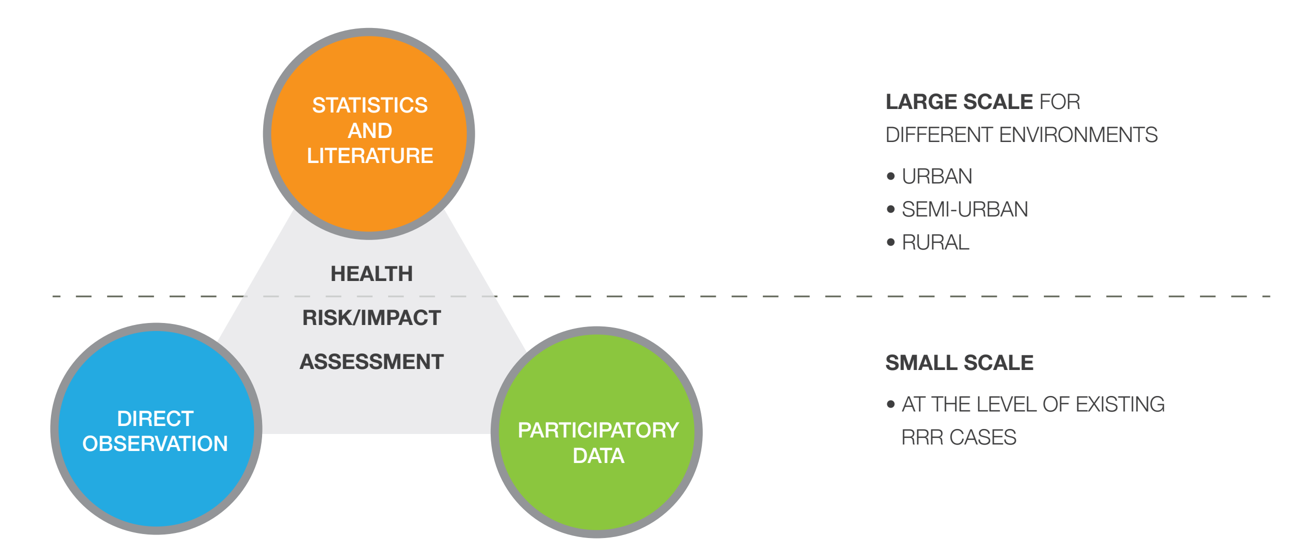
The assessment of health risks could build on the work of Stenström et al. (2011) and also Tilley et al. (2014), both focusing on wastewater and fecal sludge, and the WHO Sanitation Safety Planning Manual (WHO 2015) which also presents risk mitigation options. Further guidance on risk assessment and mitigation for nutrient and carbon recovery

FIGURE 7. AN EXAMPLE OF A PROBABILITY DENSITY FUNCTION OF NPV FOR A BRIQUETTE BUSINESS.



Source: Based on Gebrezgabher et al. 2016.

FIGURE 8. METHODOLOGICAL TRIANGULATION FOR THE HEALTH RISK/IMPACT ASSESSMENTS.



Source: Winkler et al. 2013.

from organic (solid) waste has been provided for example by NSW (2004) and EPA-SA (2013).

The criterion will have several interlinkages with other criteria: While the risk assessment can influence the **technology** recommendation, the risk mitigation may induce additional cost items to the **financial** analysis, and certainly influence the **socio-economic** analysis of possible externalities. These can also be gains if the business model serves the environment by removing pollutants, binding carbon or producing nutritious food. Positive externalities are particularly crucial in justifying investments in the sanitation and RRR sector, especially given that the sanitation sector is not seen as a 'money-making' industry.

Steps to Follow

The assessment can follow in principal the steps outlined in the WHO Sanitation Safety Planning Manual, although the manual targets more public than environmental health and situations where the business model has already been implemented. An important first step for the risk and impact assessment is defining the **system boundary** within which the assessment will be conducted (see Box 2). This is particularly important for the attribution and assessment of the potential health impacts and has to consider the value chain of the business and its risk/impact pathways, related potential exposure groups (e.g., operators, consumers, farmers) and their environments. Business models on water and nutrient recovery, for example, usually have farmers as users of the generated product, while the situation is obviously different for energy models with biogas, electricity or briquettes as the final product. In generic terms, typical key exposure groups that can be considered are as shown in Table 9.

TABLE 9. KEY EXPOSURE GROUPS.

RISK TYPE	EXPOSURE GROUPS
1. Occupational risk on site	Workers, employees
2. Occupational risk off site	Farmers/users of RRR product
3. Consumption risk	End users and contact persons
4. Social environment	Community near treatment facility and reuse locations

In terms of **exposure groups,** Table 9 shows typical exposure pathways linking exposure groups with potential risks. From an environmental perspective, natural resources themselves are considered as receptors (e.g., water resources); while from a public health perspective, air, water and soil are considered more as pathways than receptors. A generic risk assessment template can be developed and used, following the source-pathway-receptor model, resulting in a check list of hazard identification, exposure assessment, hazard characterization and risk characterization; it also gives an idea of environmental contamination and therefore the potential risks to public health. Subsequent to the identification and description of the **exposure pathways**, clear mitigation measures can be identified and evaluated using international and national environmental/health standards as a guide. It is important to account for local risk awareness and cultural acceptability as well as the cost elements to increase the adoption of suggested mitigation measures which should be the ultimate main output.

Table 10 presents common **mitigation/control measures** that can be put in place to prevent likely risks. The level of risk can be categorized according to the business model as low, medium or high considering (a) level of exposure, (b) hazardous level of the respective material, and (c) cost of mitigation measures. Emphasis should be placed on likely hazards under routine operations, not theoretically possible hazards e.g., due to external forces or grave misconduct. The likely positive (or negative) impacts of the RRR intervention at both the community and environment levels can then be assessed assuming that the suggested mitigation measures ***have been implemented.*** Secondary data could provide examples of impacts on how (far) increased supply of energy, nutrients or water from waste streams can support local economies and livelihoods (Box 11). An example is the modelling of the impact of risk mitigation related to wastewater irrigation via Quantitative Microbial Risk Assessment (QMRA) which showed that for every US dollar spent on risk mitigation in Ghana, USD 4.9 in public health expenditures could be saved (Keraita et al. 2015).

Table 11 presents a selection of generic indicators for the assessment of the health and environmental risks that could be representative of constraints in implementing and/or upscaling of a specific RRR business model. Methods to be implemented for the assessment of each indicator are presented in detail in Annex 2. For ranking of the indicators, the risk level can be expressed in **scores based on frequency and severity** under consideration of existing controls (see Table 3.3 in WHO 2015).

BOX 11. OPTIONS UNDER TIME AND BUDGET CONSTRAINTS.

Given time and budget constraints, there are various approaches from check lists to manuals designed for sanitation and waste management, including the WHO Sanitation Safety Planning Manual and Environmental Impact Assessment Guidelines, which can provide the required guidance for risk assessment and the identification of risk mitigation options. For the assessment of positive and negative externalities related to public health and the environment, data are usually scarce in developing countries, and secondary data from similar interventions could give an indication of risk frequency (likelihood) and severity (input dose).

TABLE 10. EXPOSURE PATHWAYS AND MITIGATION MEASURES.

EXPOSURE PATHWAY	DESCRIPTION	TYPICAL MITIGATION MEASURES
Direct contact	Handling, sorting, mixing, collecting, transportation	Protective wear – boots, gloves, coats and overalls, and hygiene
Insects	Carriers and vectors	Insect spraying, cleaning, netting
Air	Aerosols, particles and gases	Protective wear – goggles and masks, wind barriers, covering of waste piles
Water and soil	Effluent, leachate and leakages	Avoid untreated discharge, phyto-remediation
Food	Insufficiently treated waste products used in farming	On-farm risk (contact) reduction, produce washing and/or boiling, crop restrictions

TABLE 11. INDICATORS FOR HEALTH AND ENVIRONMENTAL RISK AND IMPACT ASSESSMENT.

HEALTH INDICATORS	ENVIRONMENTAL INDICATORS
OCCUPATIONAL RISK **F1.** Work-related risks (types, frequency and severity of potential accidents) at the resource recovery unit. **F2.** Risk of exposure to pathogens and toxic substances from inputs, output, and by-products of the process (waste acquisition to transformation into final product).	**ENVIRONMENTAL RISK** **G1.** Estimated atmospheric emissions (e.g., greenhouse gas [GHG] emissions) from the resource recovery process. **G2.** Estimated emissions (solids and fluids) to water bodies and soil.
RISK MITIGATION MEASURES **F3.** Health risk reduction strategies in place for the waste-to-resource process. **F4.** Practicable strategies available for adherence of the end-product to public health standards.	**RISK MITIGATION MEASURES** **G3.** Existing affordable mitigation strategies available for mitigation of likely emissions and impacts from reuse.
POTENTIAL HEALTH IMPACTS **F5.** Potential health benefits of the proposed RRR intervention **F6.** Comparative risk assessment in the local context.	**POTENTIAL HEALTH IMPACTS** **G4.** Potential positive and negative environmental impacts of the proposed RRR intervention and use of recovered resources in the long run.

Common research **questions** that can be assessed during the risk (mitigation) assessment process are:

- What are the positive impacts of the RRR waste transformation on environmental and human health, including those of the final product? Can these be quantified?
- What are the disease profiles of the location and how do they relate to existing RRR cases or might be amplified by new ones?
- What are the relevant biophysical, socio-economic and contextual features (from soil permeability, to demographic characteristics and wind direction) of likely project sites which determine the extent of environmental and health impacts?
- What are the known occupational health hazards in existing waste streams and which applied technology or behavior can minimize them?
- Who are the likely exposure groups along the RRR chain and how strong is their risk awareness?
- What are the relevant international and national standards (including health-based targets, quality standards and any auditing or certification requirements) that need to be achieved along the RRR chain (links to the institutional analysis under Criterion 2)?
- Which control measures/technologies (also called mitigation measures or risk barriers) are locally common and how effective are they?
- What are the alternative mitigation measures for hazards/hazardous events at each critical exposure point?
- What is the most effective combination of additional control measures in order to comply with relevant international and national standards and taking into account cultural and financial acceptability and capacity of the RRR business and exposure groups?
- What kind of capacity development, incentive systems and operational and verification monitoring are needed to ensure compliance, i.e., that the controls are working as required in the local context?
- Assuming locally applied risk mitigation is in place, what kind of (remaining) impact and benefits for the environment and public health can be expected at the community level and can they be quantified?

CRITERION 7: Socio-economic Impact Assessment

Given that the RRR subsector does not exist in isolation, related business development activities have the potential to impact other subsectors and players either adversely or create opportunities for increased benefits. In other words, although an RRR intervention may demonstrate financial feasibility, this does not necessarily imply economic feasibility. It is thus important that the potential impacts to society (as measured by socio-economic, health and environmental factors) are evaluated and accounted for prior to the implementation of an RRR intervention. The key research question here is: What are the expected social, health and environmental incremental benefits and costs (monetized) from the implementation of the specific RRR business model in the selected community or city?

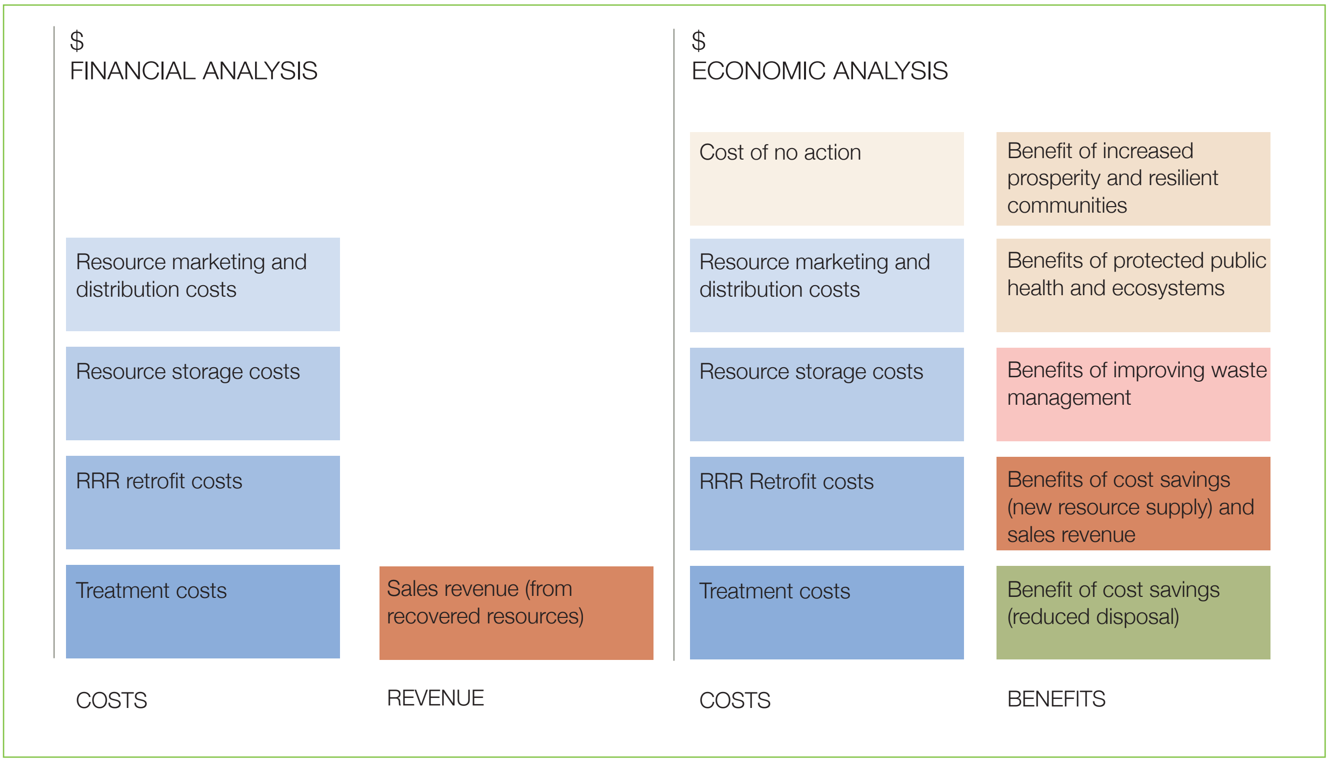
Whilst financial analyses are good in informing business decisions or to guide potential investors, particularly the private sector, on the potential returns on their investments; findings of positive socio-economic analysis will inform policy-makers (e.g., to catalyze/justify public co-funding) based on a broader perspective looking at the project's overall value to society. The socio-economic analysis, therefore, includes both benefits and costs that directly affect the business entity running the project and the effects of the project on households, governments and other businesses extraneous to the business (Figure 9). However, economic analysis is usually much more complex and challenging compared to financial analysis.

Usually, socio-economic assessments in the field of natural resource management are based on cost-benefit analysis (CBA) (FAO 2010; Hanjra et al. 2015). This approach is helpful in providing decision support for policy-makers on the choice of selecting an intervention and the associated beneficiaries in their community. An advantage of the CBA approach is based on its strength of incorporating both the direct and indirect benefits and costs of the proposed intervention in a given location as in the example of compost production generating direct profit from selling compost to farmers but also providing indirect benefits to the society by extending the landfill life time. In its simplest form, the CBA involves giving a monetary value to all the costs and benefits associated with a proposed plan, policy or project (Petts 1999), and thus can be used to determine whether the direct benefits of a particular RRR business model outweigh its costs.

The socio-economic impact analysis will have to rely largely on other criteria of the overall feasibility study, in particular the financial analysis for direct costs and benefits, but also on the assessment of potential environmental and health impacts, or information on the value chain of the recovered resource (based on the demand analysis) to monetize related direct and indirect, positive and negative effects from the implementation of the proposed RRR intervention.

Approaches such as contingent valuation can be used to evaluate the indirect benefits and costs of the proposed RRR intervention. It is necessary to ensure that all costs and benefits are included but are not duplicated, as a benefit foregone is a cost and a cost avoided is a benefit (Dixon et al. 1986) – thus only additional or incremental costs and benefits should be accounted for in the assessment.

FIGURE 9. FINANCIAL VERSUS ECONOMIC ANALYSIS OF RRR SOLUTIONS.



Source: Modified from GWI 2009.

The economic analysis usually compares the different **scales** and impacts of a particular business model, and compares its results with an **alternative**, like a business as usual scenario, such as open dumping, land filling and so forth. Thus, it is important that a **baseline** condition is defined which can also become the benchmark for comparison of alternative innovations to RRR (e.g., landfilling vs. composting [RRR] vs. incineration).

As mentioned under Criterion 6 and in Box 2, the system boundary is in particular important for assessing externalities on environment and health as there are obvious differences if an impact like increased food safety (e.g., from safe wastewater use in irrigation) is extrapolated to the population of a suburb or the whole town. The system boundary is typically bounded between the resource input acquisition and use of the recovered resource and should be aligned with the scale of operation used for Criteria 5 and 6.

Table 12 presents examples of indicators that can be considered for the socio-economic impact assessment of an RRR business model. Whilst most of the indicators under the other criteria will generically apply across most RRR business models, in the socio-economic assessment 'costs' and 'benefits' indicators will vary significantly based on the business model. For example, indicator H3 may be relevant for the assessment of a compost business model and not an agrowaste-based business model. Details of the methods to be implemented for the assessment of each indicator are presented in Annex 2. Although some indicators are similar to those for the *'health and environmental risk and impact'* assessment, the indicators here will be expressed in **monetary terms** for the set system boundary or for instance a set population (e.g. 100,000 capita^{-1}), allowing the comparison of 'costs' and 'benefits' under alternative scenarios.

As shown in Figure 5, the socio-economic analysis is the part of the feasibility study where most of the data and information of the other criteria are directly or indirectly accumulating to provide a comprehensive assessment of the implementation potential of the RRR business models under investigation (Box 12).

Thus for a single proposed RRR intervention (e.g., transformation of MSW to compost), the indicators from the socio-economic assessment (i.e., NPV, BCR, RoI) will

BOX 12. OPTIONS UNDER TIME AND BUDGET CONSTRAINTS.

Since the RRR sector is nascent particularly in developing countries, data access and availability can be very limited especially for economic costs and benefits. From that perspective and given time and budget constraints, the socio-economic assessment has to make use of secondary data and the other criteria, particularly, any applied impact and/or financial models (like ex-ante assessments) that can be contextualized to the study area.

TABLE 12. INDICATOR EXAMPLES FOR SOCIO-ECONOMIC IMPACT ASSESSMENT.

BENEFITS	COSTS
SOCIO-ECONOMIC INDICATORS	
H1. Estimated number of direct and indirect jobs created **H2.** Estimated energy offsets (electricity, fuel, etc.) **H3.** Incremental gain in crop yield **H4.** Foreign currency saved from reduced import of substitute products (e.g., chemical fertilizer, energy, etc.) **H5.** Cost savings (transport, labor) from averted waste disposal activities	**K1.** Estimated number of jobs lost due to RRR intervention **K2.** Estimated increase in energy demand from waste to resource transformation **K3.** Increase in on-farm labor requirements through compost use
ENVIRONMENTAL INDICATORS	
I1. Cost savings from estimated averted atmospheric GHG emissions **I2.** Water conservation index as measured by the averted direct emission of untreated waste into water bodies **I3.** Land conservation index as measured by the averted effect from waste reuse vs. the baseline scenario (e.g., direct disposal of untreated waste on soils) **I4.** Cost savings – market value of land used for landfills, economic value of land made unusable by direct disposal of untreated waste	**L1.** Costs of intervention disamenity effects as measured by: ▪ Costs of estimated atmospheric GHG emissions from the resource recovery process ▪ Estimated emissions (solids and fluids) to waterbodies and soil
HEALTH INDICATORS	
J1. Cost savings from averted human exposure to untreated waste (as measured by reduced level of exposure to pathogens and toxic substances) **J2.** Improved health through more nutritious food or cleaner energy produced with waste-derived fertilizer/fuel	**M1.** Level of exposure to pathogens and toxic substances from inputs, outputs and by-products of the process

play a particular role to demonstrate to those interested the potential viability of the business model in the local context.

The MCA approach outlined so far allows us to identify a set of key indicators that will steer the success or failure of the proposed intervention for each criterion. Analyzing the same indicator for different business models and locations allows one to compare these models or sites according to the indicator. As not all indicators have the same importance, it can be useful to set priorities among different indicators of one and the same criterion, or to have a summary indicator, which allows the comparison of different RRR models for each criterion. As a next step, one can try to set priorities across different criteria, which allows a quick comparison of different RRR models within one feasibility study.

These steps allow one to narrow the broad set of indicators down to the more crucial ones, but are also the most challenging and often the most criticized parts of an MCA as the importance of indicators can vary strongly between different locations and business models, and with every step of prioritization, potentially important information gets lost. In this regard, the subsequent sections which outline the processes for ranking the feasibility of the business model based on specific indicators and criteria, will only be a suggestion, free for adjustment to local conditions.

3.2.3 Prioritizing Indicators for Each Criterion

This subsection outlines the process that allows one to compare different RRR models for each criterion, i.e., to identify for each criterion the relative importance of factors or indicators that determine the possible success or failure of RRR business models. Using a selected number of indicators, the key success drivers and limiting factors of an RRR business model can be delineated and the model assessed for a specific criterion and ranked accordingly – as to whether it has a high, medium, low or no feasibility according to the specific criterion, for example, from a market perspective. It is important to note that all or only a subset of selected indicators for each criterion can be used for the ranking.

Feasibility Ranking for the 'Waste Supply and Availability' Criterion

This can be based on the following selected indicators: a) how much of the waste resource of the required quality is available; b) competitors' index for the waste resource; c) reliability of resource supply, seasonally and spatially; and d) support of the legal, institutional and regulatory environment. Whilst generic in nature, it is important to note that the selection of the indicators will depend on the context of the feasibility study - the waste stream under consideration, availability and quality of data, among other factors. Both qualitative and quantitative measures (with ranges) of the indicators can be used, depending on the availability of data and the individual indicators used to qualify the different feasibility levels.

The selection of the above-mentioned indicators for the supply criterion is based on the fact that the availability of the needed type of waste is obviously crucial for the setup of any related RRR intervention. Where, for example, 90% of the city is sewered, a septage-based business model might only work in (so far) unsewered city outskirts, while a business based on dried sewage sludge only has potential if regulations do not prevent the targeted reuse. However, availability can also be limited through competition. Thus another important factor is the effects of market competition for the same waste (re)source, which can sometimes be mitigated (alternative sourcing, usually further away, or of lower quality) or by paying more, i.e., mitigation comes at a cost. The temporal and spatial availability of waste in terms of quantity and quality is thus another prevailing factor in operational decisions of any RRR business; as is the status of the institutional and legal environment steering availability or access.

Some indicators could also be combined. The 'effective availability' of a waste resource has to consider alternative uses as well as its spatial, temporary or legal status. Based on such a smaller set of indicators, key success or limiting factors can be identified and used to rank the RRR business model as having a high, medium, low or 'no' feasibility from a 'waste supply and availability' perspective (Table 13).

Feasibility Ranking for the 'Institutional and Legal Environment' Criterion

This can be based on a number of assumptions about the institutional framework and the basic question is: Does the institutional framework support the RRR business model in terms of establishment, operation, survival and sustainability? The following broad categories of factors and related generic sub-indicators can be considered (Table 14):

1. Legal and policy content (written laws, policies, financing availability, etc.);
2. Implementation structure and process of the legal and policy frameworks; and
3. Local cultural values and awareness in relation to supporting RRR practices and products.

Similar to the previous criterion, the choice of indicators, their measurement levels and defined characteristics (qualitative or quantitative) will depend on the context of the study and RRR business model (related waste stream under consideration and product market) in question. For the sub-indicator in each broad category, a simple rating scale of 0 to 3 can been used to assess the 'positive' or 'negative' influence of the factor on business sustainability; with 1 indicating very low feasibility or the toughest institutional measures for implementation and 3 indicating high

TABLE 13. METHODOLOGY FOR FEASIBILITY RANKING OF THE 'WASTE SUPPLY AND AVAILABILITY' CRITERION.

RANKING OF KEY INDICATORS				FEASIBILITY RANKING
1. AMOUNT OF AVAILABLE QUALITY WASTE (A1)	2. RELIABILITY OF RESOURCE SUPPLY (A2)	3. COMPETITORS' INDEX FOR THE WASTE RESOURCE (A3)	4. STATUS OF THE LEGAL, INSTITUTIONAL AND REGULATORY ENVIRONMENT (A4)	
Waste resource under consideration is inexistent and/or inaccessible	Significant variations in availability and accessibility in quantity and quality of the waste resource	High level of competition for the waste resource	Access and use of the waste resource under consideration is not permitted by law	NO FEASIBILITY
Waste resource is available but accessible in limited quantity and/or quality	Moderate variations in spatial or temporal availability of the waste resource, related mitigation measures come at a high cost	Moderate level of competition – mitigatable effects at high cost	Use of the waste resource is permissible but there are significant access constraints related to national legislature	LOW FEASIBILITY
The waste resource is readily available and accessible in required quantities and qualities	Minimal variations in availability and supply of the required waste resource – variations can be mitigated (e.g., storage of the resource)	Minimal existing use of the particular waste resource (moderately low number and scale of related entities)	Access and use of waste resource is permitted by law with considerations that can be addressed	MEDIUM FEASIBILITY
Waste resource is readily available and accessible in required quantities and qualities	The waste resource is available in proximity and when needed	Limited to no existing use of the waste resource under consideration	Access and use of the targeted waste resource is permitted by law	HIGH FEASIBILITY

institutional feasibility or the easiest and most supportive institutional environment, while 0 indicates no institutional measures in place. In that regard, an overall rating score of less than 10 implies low feasibility, while an overall score of between 10-20 indicates a fairly medium level of success (institutional feasibility), and an overall score of above 20 indicates a high level of success (institutional feasibility).

Feasibility Ranking for the 'Market' Criterion

The key indicators of this criterion are: a) WTP for the RRR product or service, b) market size, c) market structure - level of market competition and ease of entry into industry, and d) market outlook. Generally, the market size and market structure will be the overriding indicators. For the WTP evaluation, for a specific business model to be considered of a medium or high feasibility, the estimated buyers' WTP has to be equal or higher than the current market price of the substitute product or service. The market structure evaluation can consider several sub-indicators: a) ease of market entry, b) level of market concentration, c) level of product differentiation, d) whether the main competitor is a price taker or price setter, and where possible e) the level of potential net profit margins. The selected indicators in Table 15 below whilst generic, can be applied for ranking the market feasibility of, for example, an agrowaste-based briquette business model. Specific measurement levels will need to be defined based on the nature of the RRR product or service in question.

Feasibility Ranking for the 'Technology' Criterion

The ranking of the technical feasibility indicators will focus on a) the availability of technologies, b) the technology requirements' index, c) technology performance and efficiency, and d) its O&M requirements versus incentives for performing the O&M job (Table 16). The choice of these indicators is based on the notion that limited availability and access to key production factors (including the technology) will negatively affect business sustainability. Whilst the 'technology availability' indicator is of primary importance, the RRR business cannot operate without equivalent ease of access to other production factors. Often, constraints related to the technology requirements index are the associated high costs of acquiring, for example, labor, energy, water, technology – which can translate into negative profits for the RRR business. The cost implication of the resource requirements can be more effectively assessed under the financial analysis. Thus, the overriding factor for this indicator will be availability of the resources, rather than access (as measured by cost of acquisition). The performance and efficiency indicator can be measured by the treatment performance level, i.e., the percentage of resource output recovered from the process (input-output ratio), if a more quantitative measure is desired. And, depending on the availability of data, aspects related to the robustness of the technology can also be considered – i.e., frequency of maintenance and repairs (O&M) required versus the negative and positive incentives the operator provides for effective

TABLE 14. METHODOLOGY FOR FEASIBILITY RANKING OF THE 'INSTITUTIONAL AND LEGAL ENVIRONMENT' CRITERION.

RANKING OF KEY INDICATORS			FEASIBILITY RANKING
1. ENABLING ENVIRONMENT (B2, B3, B5) ▪ RRR legislation and policy ▪ Financing RRR ▪ Investment climate for private sector engagement	**2. IMPLEMENTATION STRUCTURE AND CAPACITY (B1)** ▪ Implementing agencies and capacities ▪ Company establishment	**3. COMMUNITY ACCEPTANCE AND SUPPORT (B4)** ▪ Local values for waste and public RRR acceptance and engagement ▪ Compliance with laws and regulations	
1. No policy exists to support RRR and/or reuse is illegal 2. No budget support for funding RRR 3. Legislation restricts private sector participation in RRR	1. No dedicated sanitation department 2. No/low capacity of all institutions involved in sanitation/RRR resulting in poor waste collection, transformation, recovered resource marketing 3. No companies involved in RRR or waste management	1. No awareness about RRR and waste management 2. No acceptance by end users for RRR products because of culture and/or risk perceptions 3. No or very low compliance by citizens and private companies in following waste management and reuse rules/regulations	**NO FEASIBILITY**
1. Policy and legislation support for RRR 2. Low budget support for funding RRR 3. Legislations on PPP are weak and no incentives to encourage private sector participation	1. Dedicated sanitation department with focus on waste management only and no/limited knowledge of RRR 2. No/low capacity of the institutions involved in waste management resulting in poor functioning and need for costly outsourcing of functions 3. Time taken to legally register RRR and waste management companies is too long and a complicated process	1. Low awareness about RRR and waste management 2. Mixed response of end users on RRR products 3. Low compliance by citizens and private companies in following waste management and reuse rules/regulations	**LOW FEASIBILITY**
1. Policies and legislation support RRR 2. Budget support provided for co-funding RRR 3. Legislation supports PPP but incentives to encourage private sector participation are limited	1. Dedicated sanitation department with focus on RRR exists but has severe gaps in its functioning 2. Limited capacity in the institutions involved in waste transformation and the marketing of the new product 3. RRR and waste management companies can be easily set up	1. Awareness about RRR and waste management exists but is not high enough 2. End users accept and value RRR product(s) 3. Compliance by citizens and private companies can realistically be improved	**MEDIUM FEASIBILITY**
1. Policies and legislation support RRR 2. Sufficient budget support provided for funding RRR by the public sector 3. Legislation supports PPP and encourages private sector participation	1. Dedicated sanitation department with focus on RRR exists and functions well 2. Sufficient capacity exists in the institutions involved in RRR from waste transformation to the marketing of the generated products 3. RRR and waste management companies can be easily set up	1. High awareness about RRR and waste management 2. End users accept and value targeted RRR product(s) 3. Most citizens and private companies follow waste management and reuse rules/ regulations	**HIGH FEASIBILITY**

O&M. The choice of indicators and respective measurement levels used for the technical feasibility assessment, in particular, will depend on: a) the waste stream under consideration, and b) final recovered resource/output.

Feasibility Ranking for the 'Financial Assessment' Criterion

In contrast to the selected indicators for the 'Waste Supply' and 'Institutional' criteria, which can be predominantly qualitative, the indicators for the 'Financial' criterion are generally quantitative in nature. Among the multiple indicators possible,[4] the following three are suggested for evaluating the financial feasibility of RRR business models: a) mean NPV (should be positive), b) a mean IRR (should be greater than the cost of capital (discount rate) and c) probability of the NPV to be negative (P [NPV] < 0) which should be low. The choice of the probability of a negative NPV indicator is based on the fact that whilst investors are interested in profit value margins, accounting for business risk factors (P [NPV] < 0) tends to be a better indicator of

[4] Several financial metrics can be considered in addition or in place, including RoI, payback period, development profit, development margin, cash flow, benefit-cost ratio, amongst others (Björnsdóttir 2010).

TABLE 15. METHODOLOGY FOR FEASIBILITY RANKING OF THE 'MARKET' CRITERION.

RANKING OF KEY INDICATORS				FEASIBILITY RANKING
1. MARKET SIZE (C1)	2. WILLINGNESS TO PAY (C2)	3. MARKET STRUCTURE (C3)	4. MARKET OUTLOOK (C4)	
Market too small or unreliable to cover expected costs	WTP < current market price of all competitive substitute products	1. Difficult market entry 2. High level of concentration (monopolistic/ oligopolistic market) 3. High level of product differentiation of competitive products 4. Price taker 5. Potential negative profit margins (without subsidies) *[links to Financial criterion]*	10 years and beyond to reach growth stage	NO FEASIBILITY
Market small but reliable	WTP < current market price of the next best substitute product	1. Medium to difficult market entry 2. Medium to high level of concentration 3. Medium to high level of product differentiation of competitive products 4. Price taker 5. Potential negative profit margins (without subsidies)	10 years and beyond to reach growth stage	LOW FEASIBILITY
Market potentially large but also unreliable	WTP > current market price of the next best competitive substitute product	1. Medium level of ease for market entry 2. Low to medium levels of market concentration 3. Limited to no product differentiation 4. Oligopolistic fertilizer market but potential price setter 5. Potential that net profit margins are positive	5-9 years to reach growth stage in business life cycle	MEDIUM FEASIBILITY
Market appears large and reliable	WTP > current market price of all competitive substitute products	1. Easy market entry 2. Limited level of market concentration 3. Limited to no product differentiation 4. Price setting market 5. Potential that net profit margins are positive	<5 years to reach growth stage in business life cycle	HIGH FEASIBILITY

TABLE 16. METHODOLOGY FOR FEASIBILITY RANKING OF THE 'TECHNOLOGY' CRITERION.

RANKING OF KEY INDICATORS				FEASIBILITY RANKING
1. AVAILABILITY/ ACCESSIBILITY OF TECHNOLOGY AND SPARE PARTS (D1)	2. TECHNOLOGY REQUIREMENTS INDEX (D2)	3. PERFORMANCE AND EFFICIENCY OF THE TECHNOLOGY (D3)	4. O&M REQUIREMENTS (D4)	
Required technologies or spare parts not available	Limited to no access and availability of production factors	Low performance	High with low performance incentives	NO FEASIBILITY
Limited availability of technology (acquisition at relatively high cost)	Moderate access and availability to production factors but at exorbitantly high cost (above market price)	Low to medium performance	Low with low performance incentives	LOW FEASIBILITY
Moderate access and availability of technology at current market prices	Moderate access to production factors at current market prices	Medium performance	High but with good incentives and financial support	MEDIUM FEASIBILITY
Easy access and availability of required technology	Easy access and availability to production factors	High performance	Low with good incentives and support	HIGH FEASIBILITY

business success. An example of the methodology used to define financial feasibility is described in Table 17. It is important to note that the ranges presented are only indicative as the true financial merit of the proposed RRR business model will depend on other factors, including the context, business model under consideration, RRR product, availability and quality of data, and financial sustainability across the value chain.

TABLE 17. METHODOLOGY FOR FEASIBILITY RANKING OF THE 'FINANCIAL' CRITERION.

RANKING OF KEY INDICATORS (E5)			FEASIBILITY RANKING
1. P (NEGATIVE NPV)[a]	2. MEAN NPV	3. MEAN IRR	
0-30%	*Negative*	Less than discount rate	NO FEASIBILITY
30-50%	*Negative*	Less than discount rate	NO FEASIBILITY
50% and above	*Negative*	Greater than discount rate	NO FEASIBILITY
50% and above	*Negative*	Less than discount rate	NO FEASIBILITY
30-50%	*Negative*	Greater than discount rate	LOW FEASIBILITY
50% and above	Positive	Less than discount rate	LOW FEASIBILITY
0-30%	*Negative*	Greater than discount rate	LOW TO MEDIUM FEASIBILITY
30-50%	Positive	Less than discount rate	LOW TO MEDIUM FEASIBILITY
0-30%	Positive	Less than discount rate	MEDIUM FEASIBILITY
50% and above	Positive	Greater than discount rate	MEDIUM FEASIBILITY
0-30%	Positive	Greater than discount rate	MEDIUM TO HIGH FEASIBILITY
30-50%	Positive	Greater than discount rate	HIGH FEASIBILITY

[a] Defined as the probability of the NPV to be negative.

Feasibility Ranking for the 'Health and Environmental Risk and Impact Assessment' Criterion

The feasibility assessment identifies the health and environmental indicators that could potentially be the key drivers of business success or failure. The selected indicators for the full analysis can be used here for the ranking and feasibility assessment of the criterion, however a conglomerate measure may be useful in the instance where semi-quantitative or qualitative measures are used. The ranking of the risk associated with each hazard/ hazardous event aims at identifying which of them can be well controlled or are insignificant, while highlighting those that represent a major health risk.

For this purpose, a semi-quantitative risk assessment is performed based on the likelihood and severity of each identified hazard (indicators **F1** and **F2**). These two determinants are plotted in a matrix to arrive at an overall risk score. Tables 18 and 19 focus on human health risks but are generic in their structure for application to environmental risks (**G** indicators). When assessing the likelihood of a hazard, **the effectiveness of existing controls** (**F3**, **F4**) has to be considered. Importantly, the definitions for likelihood and severity given in Table 18 have to be applied in a consistent manner. Potential health benefits (**F5**) are ranked lower than risks, given that risk factors are commonly given priority in decision-making. Also **F6** is not considered given its higher data requirements.

The presented weights and ranges are only indicative as the choice of indicators, whether qualitative or quantitative, and their **local relevance** should determine the ranking approach adopted. The overall assessment/ranking of the indicators can be purely based on quantitative estimates, however semi-quantitative and qualitative approaches have been successfully used, like the Delphi method (Rowe and Wright 1999) often outperforming statistical options.

Feasibility Ranking for the 'Socio-economic Assessment' Criterion

Similar to the 'Financial Assessment' criterion, the indicators for the socio-economic criterion can be generally quantitative in nature. Three fundamental indicators that can be used for evaluating the socio-economic feasibility of an RRR business model are the: a) BCR, b) RoI, and c) probability of a negative or positive NPV (Janzen et al. 1999; Hayashi et al. 2004). These summary indicators build on the cost and benefit indicators shown in Table 20.

The BCR is derived as a ratio of economic, social, health and environmental benefits to the costs in monetary terms. The BCR is noted as a governing criterion for the feasibility assessment as a BCR greater than 1 for a proposed intervention or project is regarded as generating more societal benefits compared to the costs for implementing the project. The RoI describes the net income in relation to the resources that were invested. As in the financial analysis, again, the

TABLE 18. DEFINITION OF HAZARD LIKELIHOOD AND SEVERITY FOR THE RISK ANALYSIS (CASE OF HUMAN HEALTH).

WEIGHT	LEVEL	DESCRIPTION
LIKELIHOOD (or frequency)		
1	Very unlikely	Has not happened in the past and it is **highly improbable** it will happen in the next 12 months given the control measures.
2	Unlikely	Has not happened in the past and/or may occur **in exceptional circumstances**.
3	Possible	May have happened in the past and/or may occur at some time in the next 12 months **under regular circumstances**.
4	Likely	Has been observed in the past and/or is **likely** to occur in the next 12 months also with control or risk mitigation measures.
5	Almost certain	Has often been observed in the past and/or **will almost certainly occur** in most circumstances in the next 12 months.
SEVERITY (impact level, incorporating dose)		
1	Insignificant	**Negligible impact** on normal operations or health consequences in excess of background levels.
2	Minor impact	**Minor impact** on normal operations or health consequences in excess of background levels. Easily manageable disruptions to operation; no rise in complaints anticipated.
4	Moderate impact	Impact will lead to **moderate health effect** (e.g., fever, headache, diarrhea, small injuries) **or disamenity** (e.g., noise, malodor); complaints or community annoyance; operations may be disrupted for a short duration.
8	Major impact	Impact will result in **injuries, acute and/or chronic illness**. May lead to legal complaints and concern; operations could be significantly affected by the impact.
16	Catastrophic impact	**Serious injuries, illness, or even loss of life** can be the consequence of the impact. Major investigation by a regulator with prosecution likely; Can lead to complete failure of the system.

Plotting severity against likelihood results in Table 19 which allows one to define low to very high risk situations. Very high risk ≥ 32; High risk 13-32; Medium risk 7-12; Low risk <6.

Source: Winkler et al. 2013.

TABLE 19. RISK ANALYSIS MATRIX BASED ON INDICATORS F1 AND F2, CONSIDERING F3.

RISK = L X S • VERY HIGH RISK ≥ 32 • HIGH RISK 13-32 • MEDIUM RISK 7-12 • LOW RISK <6			SEVERITY (S)				
			Insignificant 1	Minor impact 2	Moderate impact 4	Major impact 8	Catastrophic impact 16
LIKELIHOOD (L)	Very unlikely	1	1	2	4	8	16
	Unlikely	2	2	4	8	16	32
	Possible	3	3	6	12	24	48
	Likely	4	4	8	16	32	64
	Almost certain	5	5	10	20	40	80

Source: Winkler et al. 2013.

business risk factor i.e., the probability of a positive NPV such that P (NPV) > 0 is recommended. The higher the BCR and RoI, the higher the financial feasibility of the proposed intervention, which will be even better if the probability of a negative NPV is small. An example of the methodology used to define the financial feasibility is described in Table 20. It is important to note that as in the case of the 'Financial Analysis' criterion, the ranges presented in Table 20 are only indicative as the true economic merit of the proposed RRR business model will depend on other factors, including the context and business model under consideration; as will the choice of indicators and respective measurement levels.

3.2.4 Prioritizing Indicators Across the Criteria

While the previous section showed examples on how to set priorities **among different indicators for each criterion**, it is also possible to set priorities **among the seven criteria**. This will allow comparison of different RRR models based on those criteria (and indicators), which are in the local context more crucial than others, as determined for example by the objectives of the investment (e.g., minimizing waste volumes or maximizing resource recovery; maximizing profits or minimizing environmental costs). Murray et al. (2011) show examples of how particular limitations or objectives can steer the choice of indicators.

TABLE 20. METHODOLOGY FOR FEASIBILITY RANKING OF THE 'SOCIO-ECONOMIC IMPACT ASSESSMENT' CRITERION.

RANKING OF KEY INDICATORS			FEASIBILITY RANKING
P (negative NPV)[a]	B:C ratio	RoI	
0-30%	< 1	< 100%	NO FEASIBILITY
30-50%	< 1	< 100%	NO FEASIBILITY
50% and above	< 1	< 100%	NO FEASIBILITY
0-30%	< 1	> 100%	LOW FEASIBILITY
30-50%	< 1	> 100%	LOW FEASIBILITY
50% and above	< 1	> 100%	LOW FEASIBILITY
0-30%	> 1	< 100%	LOW FEASIBILITY
30-50%	> 1	< 100%	LOW FEASIBILITY
50% and above	> 1	< 100%	LOW FEASIBILITY
30-50%	> 1	> 100%	MEDIUM FEASIBILITY
50% and above	> 1	> 100%	MEDIUM FEASIBILITY
0-30%	> 1	> 100%	HIGH FEASIBILITY

[a] Defined as the probability of the NPV to be negative.

At the end of this analysis it will be possible to compare different RRR models according to each criterion.

In general, it depends significantly on the situation and targeted business models that might be the most critical, and thus a flexible approach based on expert judgment will be required. Comparing, for example, different options for addressing municipal solid waste, the business models can differ significantly between energy generation or fertilizer generation, and for one option institutional and regulatory factors might be a key constraint but not for the alternative, while technology-wise this can be the opposite. With increasing similarities between the models the exclusion of particular criteria is also possible and a focus on priority criteria and related indicators is warranted.

The prioritization will be facilitated if the feasibility study follows a sound **baseline survey**, which ideally should already have answered the most critical assumptions related to some of the criteria, such as:

- Waste supply: If the required waste is actually available/accessible.
- Institutional/legal support: If there are unsurmountable barriers.
- Market demand: If there is any market.
- Technical needs: If the technology is generally available.
- Financial: If there is a prospect of revenue.
- Health/environment: If negative impacts are likely even if feasible control measures are in place.
- Socio-economic value: If benefits for society are likely.

Thus the key questions of the more detailed feasibility study are therefore more nuanced, not 'if or if not', but 'how much', moving from qualitative to quantitative answers. Looking across the criteria, some observations on their relative importance are however possible:

- If the required waste resource barely exists and/or for several reasons is inaccessible, the business is certainly ill-fated, even if all other factors are supportive. While the baseline survey would have already detected the lack of the waste resource, its actual quantity or the reason for its unavailability might only be understood in the feasibility study. However, accessibility could change with time and fortunately, the larger a settlement, the more unlikely is the probability of waste supply being a limiting factor. There are also exceptions, depending on the resource needs and city development. Septage, for example, might be declining in availability (or only in remote areas) where investments target sewer systems.
- Of similar significance are *institutional and legal* barriers, or missing local acceptance, which can make

the implementation of any reuse business impossible regardless of whether there is, for example, sufficient supply of the waste resource or technical feasibility. And although legal settings, negative perceptions or the unavailability of land, can change, the time frame for such a change can be unpredictable and too long for the setup of a business.

- *Market* demand and *financial* feasibility are closely related and rank one step below the other two criteria. Even with sufficiently available waste, and supportive legislations, the absence of market demand (or too much competition) for the recovered resource can imply a high financial risk, not only in view of profit but also cost recovery. However, markets can also be created, in contrast to the supply of the right waste source, but this may come at high costs especially in the start-up phase of the business.
- Limitations in *technology* availability, its performance and efficiency, and access to other key factors of production can significantly affect the potential feasibility of an RRR business model. However, these limitations can often be mitigated although at a cost. For example, difficulty in accessing labor can be mitigated via increased wage offers; or a non-supported technology option could be changed against another one.
- The *Health and Environmental* and *Socio-economic* criteria are often ranked lowest as they might not dictate the final RRR business model viability for implementation as: a) all major risks in the commonly proposed RRR business models can be mitigated and the related costs are already captured in both the technical and financial feasibility assessment, while b) the socio-economic assessment reflects additional benefits which are usually not of direct relevance for the business although they might determine public sector support.
- Finally, the socio-economic criterion could in some instances also be used as a stand-alone feasibility assessment criterion given its aim to capture the overall costs and benefits.

An example of a feasibility assessment summary for a business model transforming agrowaste into briquettes for energy generation is provided in Table 21 from a case

TABLE 21. OVERALL FEASIBILITY ASSESSMENT OF A BRIQUETTE BUSINESS MODEL FOR IMPLEMENTATION IN KAMPALA, UGANDA.

RANKING OF CRITERIA	CRITERIA	INDICATORS				LEVEL OF FEASIBILITY PER CRITERIA
1	**Waste supply and availability**	**Quantity of waste resource effectively available** Waste resource is available and accessible in limited quantities LOW FEASIBILITY	**Competitors' index for waste resource** High level of competition with mitigatable measures at high cost LOW FEASIBILITY	**Reliability of resource supply** Moderate variations in availability and accessibility in quantity (farming season dependent) LOW FEASIBILITY	**Institutional and regulatory environment** Waste reuse permissible and supported under the institutional and legal environment HIGH FEASIBILITY	**LOW FEASIBILITY**
1	**Institutional analysis**	**Legal and policy content** National policy and legislation support reuse (existing budget to support initiative) MEDIUM FEASIBILITY	**Implementation structure and process** Existing agencies or mechanisms for implementing the legal and policy provisions to support the waste reuse and business model MEDIUM FEASIBILITY	**Local cultural values, norms, civil society support** Existing and growing interest in briquette use and businesses, supportive cultural values MEDIUM FEASIBILITY		**MEDIUM FEASIBILITY**
2	**Market assessment**	**Market demand** Estimated willingness-to-pay > Current market price. HIGH FEASIBILITY	**Market structure** 1. Medium level of ease for market entry 2. Low to medium levels of market concentration 3. Limited to no product differentiation 4. Oligopolistic fertilizer market but potential price setter 5. Potential net profit margins – positive HIGH FEASIBILITY	**Market outlook** 6-7 years to reach growth stage in business life cycle MEDIUM FEASIBILITY		**HIGH FEASIBILITY**

CONTINUED

TABLE 21. OVERALL FEASIBILITY ASSESSMENT OF A BRIQUETTE BUSINESS MODEL FOR IMPLEMENTATION IN KAMPALA, UGANDA. *(CONTINUED)*

RANKING OF CRITERIA	CRITERIA	INDICATORS				LEVEL OF FEASIBILITY PER CRITERIA
3	Technical assessment	**Availability of technologies** Moderate access and availability of required technology at current market price MEDIUM FEASIBILITY	**Technology requirements' index** Easy access and availability to production factors (labor, personnel expertise requirements, land and energy requirements) HIGH FEASIBILITY	**Ease of access to equipment and replacement parts** HIGH FEASIBILITY	**Performance and efficiency of the technology** Medium level of treatment performance level or efficiency MEDIUM FEASIBILITY	MEDIUM FEASIBILITY
4	Financial assessment	**P (NPV< 0) =** 39.3% MEDIUM FEASIBILITY	**Mean NPV =** USD 143,980 is greater than zero HIGH FEASIBILITY	**Mean IRR =** 22.58% greater than discount rate MEDIUM FEASIBILITY		MEDIUM FEASIBILITY
5	Health and evironmental risk and impact assessment	**Health risk score** Moderate risk and mitigatable measures at high cost MEDIUM FEASIBILITY	**Estimated net health impact** Insignificant to moderate negative impact LOW FEASIBILITY	**Environmental risk score** Low to moderate risk and mitigatable measures at reasonable cost MEDIUM FEASIBILITY	**Estimated net environmental impact** Insignificant to moderate positive impact MEDIUM FEASIBILITY	MEDIUM FEASIBILITY
6	Socio-economic assessment	**P ($NPV<NPV_{mean}$)** = 52.5% - NO FEASIBILITY	**B:C ratio =** 5.26 HIGH FEASIBILITY	**RoI =** 87% MEDIUM FEASIBILITY		LOW FEASIBILITY
		Overall feasibility ranking =				LOW FEASIBILITY

study in Kampala, Uganda (details on the ranking approach adopted in this case can be found at http://sdcrrr.iwmi.org).

In the Kampala case, upon consultation with the relevant stakeholders and after a baseline survey, a feasibility assessment for seven different business models was carried out. Table 22 shows that the models targeting the production of a nutrient source for farming have the highest feasibility for implementation in Kampala (models 5, 6 and 7), whilst the energy-based and wastewater reuse models

TABLE 22. OVERALL FEASIBILITY RANKING OF THE BUSINESS MODELS.

RANKING CRITERIA	OUTPUTS	LEVEL OF FEASIBILITY OF THE BUSINESS MODELS						
		ENERGY			WASTEWATER	NUTRIENT		
		BM 1	BM 2	BM 3	BM 4	BM 5	BM 6	BM 7
1	Waste supply and availability	Yellow	Yellow	Yellow	Yellow	Green	Green	Green
2	Market assessment	Blue	Yellow	Yellow	Yellow	Green	Blue	Blue
1	Institutional analysis	Green	Blue	Yellow	Green	Green	Green	Yellow
3	Technical assessment	Green	Green	Green	Green	Green	Green	Green
4	Financial assessment	Green	Orange	Dark green	Green	Green	Blue	Blue
5	Health and environmental risk and impact assessment	Blue	Green	Green	Yellow	Blue	Blue	Blue
		Green	Green	Green	Green	Green	Green	Green
6	Socio-economic assessment	Yellow	Yellow	Yellow	Green	Green	Green	Green
	Overall ranking of the BM	Yellow	Yellow	Yellow	Yellow	Green	Blue	Green

LEGEND:

BM 1: Dry Fuel Manufacturing: Agro-Waste to Briquettes

BM 2: Energy Service Companies at Scale: Agro-Waste to Energy (electricity)

BM 3: Onsite Energy Generation by Sanitation Service Providers (fecal sludge to electricity)

BM 4: On Cost Savings and Recovery (wastewater use for irrigation, energy and nutrient recovery)

BM 5: Large-scale Composting for Revenue Generation (MSW to compost)

BM 6: High Value Fertilizer Production for Profit (combination of MSW and fecal sludge to organic fertilizer)

BM 7: Compost Production for Sanitation Service Delivery (fecal sludge-based compost and urine as a fertilizer)

(Orange) **NO FEASIBILITY** (Yellow) **LOW FEASIBILITY** (Green) **MEDIUM FEASIBILITY** (Blue) **HIGH FEASIBILITY** have a lower feasibility. The methodology highlighted, for each model, the key success drivers and limiting factors as shown in the previous table.

3.3 Implementation Phase: Development of a Business Plan[5]

In the conceptual framework for a step-wise assessment of the implementation potential of RRR business models as shown in Figure 3, the feasibility study will help to decide on the most suitable business models for implementation. Following this decision, the entrepreneur/implementer will have to draft a business or implementation plan outlining the business strategy and targets for the amount to be invested, i.e., the size of the business which will steer land, labor and technology needs, etc. and should be accompanied by the locally required EIA.

The development of the implementation plan is particularly important as its completion is the biggest success factor for a new business. Given the objective of the implementer, specificity of location, scale, available financing and other factors, the implementation plan will, in detail, chart the critical steps in starting and ensuring the sustainability of the proposed RRR intervention. In that regard, a simplistic approach to outline and develop the business plan is to first define the envisioned stages of the business life cycle of the proposed intervention, i.e., phase 1 – start-up phase till financial break-even point, phase 2 – business consolidation and development, and phase 3 – scaling up and out phase. This stage-wise method can then be overlaid with the value chain approach to clearly define the key specific activities and entities to engage for the business, which is particularly crucial in the start-up phase. A detailed implementation plan will include implementation methods, performance goals, deadlines and milestones, and interim evaluation points.

Implementation Phase 1 – Start-up Phase

The start-up phase is typically characterized by a) proofing of the business concept, b) a period of new growth, c) exploration of new markets and competitive distribution strategies and channels, d) capturing a larger market share, and e) establishing new revenue streams. During this phase, if the implementers do not already have secured financing, they will need buy-in of the business concept by investors. Clearly defining the production scale and related business financing needs and financial objectives (i.e., financial performance goals) is a key component in the business plan development. For example, does the business want to achieve a double digit growth rate for each future year? How does it plan to reduce the variable costs through efficiency gains and reach profitability within the first year? Additionally, it is important that strategies for financial risk mitigation are clearly defined, which can buffer investor risk 'anxiety' and ensure business sustainability.

Subsequently, the key activities that the business plans to engage in and the required resources need to be clearly defined. A value chain approach is an effective tool that can be used as it ensures that all the key activities (e.g., from input sourcing and procurement to production and sales, licensing, EIAs) and resource requirements (e.g., waste input, technology, personnel expertise, labor, land, water, energy, etc.) are identified. In Phase 1, the business focus is on matching the business opportunity with available and cost-effective skills, experience and interests. Thus, it is important that the business allocates its resources and engages in activities in which it has a comparative advantage. Production performance goals, timelines for activities, marketing strategies, and structure and roles of different stakeholders should be clarified in this stage.

A key challenge in the start-up phase will be market acceptance and penetration. In that regard, a well-defined and competitive marketing strategy that outlines: a) the market segments and size to be targeted, b) distribution plan for existing and exploration of new markets, and c) pricing strategies to capture a larger market share, is crucial. Strategic partnerships are another key factor that need substantial consideration. Accurate identification and formation of strategic partnerships, e.g., for financing (donors, government, financial institutions), technology transfer (e.g., research institutes), marketing and distribution agencies, complementary product business partners, will ensure that the business allocates its resources in activities where it has a comparative and competitive advantage. Other focal aspects to include in the implementation are: decision on a business ownership structure, professional advisors and secured public sector support.

Implementation Phase 2 – Business Consolidation and Development

It is probable that the RRR business will make it to this stage if the start-up phase is clearly defined and executed. Phase 2 is typically characterized by a) increasing revenues, b) new market opportunities, c) smooth running of the business process – stabilization, d) surfacing competition, and e) fine-tuning of the business model. With growing and strong profits come competition. In that regard, the business model may need to be fine-tuned to ensure business growth and stability. A revised marketing strategy (cutting costs, increasing revenues) and new partnerships (e.g., for input procurement, accessing new output markets via existing and established partner distribution systems, technical research to tailor products to market needs) might be needed.

Implementation Phase 3 – Scaling Up and Out

Depending on the (social, environment or simply business) impact targets, the entrepreneur or implementing agencies will, in Phase 2, update their business plans for the scaling up and out of the intervention. The scaling up and out phase

[5] Business plan and implementation plan are used interchangeably in this report.

of the business cycle is expected to be characterized by a new period of growth into new markets and distribution channels. This stage is often the choice of the business owner/implementer to gain a larger market share and find new revenue and profit channels or increased impact or beneficiaries. Moving into new markets or regions requires the planning and research of a seed or start-up stage business. The key outlined process for the start-up phase may more than likely be applicable for scaling out (replication) of the proposed RRR intervention but not so much in a scaling-up situation of the already existing business.

Thus, given the different constituting phases of an RRR business/intervention, the detailed implementation plan will consist of the implementation methods, performance goals, deadlines and milestones, and interim evaluation points for plan updates. The key components for the plan include:

a. Defined stages/phases of the RRR business life cycle
b. A finely tuned business model for the planned investment size and local opportunities/constraints
c. A decision on the legal structure of the initiative (dependent on the type and size of business)
d. Production performance goals and timelines for activities (over at least the period covering the start-up and business development phase)
e. Financial performance goals, growth expectation scenarios and financial risk management strategies
f. Structure and roles of different stakeholders
g. Resource requirements and benefits for society
h. Marketing strategy vis-à-vis actual or possible competitors
i. Definition of strategic partnerships

The proposed RRR intervention/business model is ready for marketing to finance providers subsequent to completion of the business plan.

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ANNEX 1. BASELINE SURVEY QUESTIONNAIRE (EXAMPLE)

This is an example of typical questions used in a baseline survey undertaken by the authors in about ten cities across Asia, Africa and Latin America for the selection of cities which were the most supportive for RRR businesses at scale, and the preselection of RRR processes and business models which will likely find positive local reception. The survey targeted organic waste and wastewater for water, nutrient and energy recovery at scale, i.e., not household- or neighborhood-based recycling.

The baseline survey included a terminology annex and was commissioned to local experts based in the respective city. The experts were asked to seek assistance from academic colleagues as well as the public sector or local practitioners to cover the different disciplines the questions address. In general, only information based on secondary data and/or interviews with local experts were expected.

Interest in RRR

1. What kind of RRR from waste takes place in the city or any of its districts?
2. Are the authorities in charge of solid waste and/or wastewater interested in feasibility studies for (further) RRR options in their city? Please note which authority confirms interest.
3. Is there private sector interest in innovative resource recovery models? Which sector? In what kind of waste to resource transformation is interest shown? Can this be verified via indicators, citations or examples?
4. Are there public complaints (e.g., newspaper reports) about uncontrolled waste reuse or actual or potential health risks (please provide any proof/documentation if so)?
5. What are the major constraints to waste use or waste-resource recovery relating to institutional/legal, cultural or perception aspects?
6. Who is responsible for safety related to ongoing formal or informal RRR activities? If there is anyone, which activities are of concern?
7. Do any comprehensive investment or feasibility studies exist for RRR from any waste streams which went beyond a small case study?
8. Which waste-based products are already produced and used (e.g., waste compost, treated wastewater) in and around the city (distinguish between formal and informal sector activities), and which could be, and why?
9. Are there any organic waste-to-energy plants? If so, what is the installed capacity (agro-industrial or domestic) thermal and electric, in megawatts? Please list ownership, kind of waste/source of fuel, and if possible capacity for each.
10. Please list ongoing and past projects by research, public and private sectors engaged in any kind of wastewater or organic waste reuse. Distinguish between funded pilots and established businesses. Do you know about new plans?

Project-supporting Policies

11. Are there policies, plans and/or strategies supporting safe RRR from selected waste streams? What are they? What is encouraged? What is not? Which organizations are involved in the preparation and implementation of regulations?
12. Please list key sector policies supporting or restricting RRR solutions.
13. Are authorities aware of (or practicing) the WHO (2006) guidelines for the safe use of wastewater, greywater and excreta in agriculture?
14. Are there special incentives, policies or regulations that support the generation of electric or thermal energy from organic wastes (i.e., biogas or combustion/gasification of agro-industrial or domestic waste)?

Demand for RRR in Industry, Farming, Construction, Landscaping, etc.

15. What is the water availability (monthly rainfall, freshwater sources) and/or how strongly is water reused in different sectors on the public or private agenda?
16. Are any industrial fertilizers subsidized for certain crops? Any details?
17. Which farming systems (or forestry, landscaping …) are or are most likely to use organic waste fertilizer, and on which crops/plants?
18. What are the most common energy sources at urban and rural household levels and of small industries and what percentage of rural/urban households has access to electricity from the grid?
19. Are there gaps between energy supply and demand? If so, how frequent are they, and how are the shortfalls met?
20. Are private companies allowed to generate, bank, transmit, and/or distribute energy?

Waste Supply and Management in the City

21. What is the population and level of solid waste collection coverage (percent of population serviced; year of reference)? Is this conducted by the municipality or private sector or both?
22. Is there waste source separation at the household level in any district, or any segregation after collection?
23. What level of the city is sewered (percentage of households connected to sewerage)? What percentage of wastewater directed into sewers is actually treated and to which level (i.e., primary, secondary, tertiary)? What is the estimated percentage of treatment plants that work as designed?
24. How many households or estimated percentage of the city depend on on-site sanitation systems for fecal sludge (FS) storage? What kind of onsite FS systems are there in percentage (pit latrines, public toilets, (shared) household septic tanks, urine diverting dry toilets, etc.)?
25. Who is responsible for emptying septic tanks and latrines? Are there trucks with vacuum pumps (also called cesspit tank operators, etc.)?
26. Are the municipality or private sector or both in charge of FS collection? How many septic trucks are approximately operating across the city? Share of vacuum trucks vs. manual collection?
27. Where are most of the on-site systems in the city: in slums/low-income class areas or also in high-class areas, etc.?
28. Where is the collected FS from on-site septic tanks deposited/dumped? What are the percentage estimates: a) in septage ponds, b) other treatment plants, c) in waterbodies/ocean, in land depressions/environment, in farms for crop production, elsewhere (please specify)?
29. What is the approximate FS share disposed in official places per year vs. unofficial sites?
30. Please provide a brief description of the major commercial activities in animal husbandry, food industry and other agro-industrial (e.g., cotton) processing subsectors in the city? Who are the big players generating larger amounts of agrowaste?
31. Are there any data on how much organic waste the major 5+ companies operating in these subsectors generate for example per year?
32. What kind of industries (e.g., beverage, chemical, textile, food, (sugar, coffee, etc.) are there in the city discharging waste? Is the industrial waste treated in each case? Which ones are not?

Risks

33. Are there any reports on the probability of chemical contamination (heavy metals) of organic and/or liquid waste streams? Could you cite related reports/papers?
34. Have any microbial food safety/health issues been reported due to wastewater irrigation? By whom? Citation/reference?
35. Have any environmental concerns from waste reuse, wastewater irrigation been reported?
36. Are institutional and regulatory processes for risk assessment (e.g., EIA) and monitoring (e.g., sanitation safety planning) mandatory and enforced?

Please add a list of used references (web links where possible) and a list of experts and authorities consulted with affiliation and email contact details. Please also add information on institutions with the capacity to undertake interdisciplinary feasibility studies for RRR business models (from waste supply to agricultural demand) which could build on this survey but focus more on particular waste streams or resource demands and in-depth assessment of quantitative information.

ANNEX 2. SUMMARY OF INDICATORS, RESEARCH QUESTIONS AND RELATED METHODS

TABLE A2.1 INDICATORS FOR CRITERION 1 – WASTE SUPPLY AND AVAILABILITY.

RESEARCH/INTERVIEW QUESTIONS	INDICATORS	POSSIBLE APPROACHES AND METHODS
▪ What are the waste sources, amount generated, quality thereof that are currently collected?	**A1.** Sources, quantity, quality of generated and available waste	This indicator requires the identification and categorization of the major waste generation sources of the waste streams of interest (wastewater, septage, organic waste …) within the defined spatial system boundaries for the proposed intervention. The total amount of waste generated and the collected share should be assessed. In principal, only the latter counts unless the business will invest in improving waste collection. *Municipal solid waste:* The waste management departments of the area should have a good understanding of how much is collected and from where (by the authority or via private sector contracts), and also how much they cannot collect with their current capacity. Interesting for businesses where transport costs have to be minimized are those waste sources which offer good quality waste (high percent organic materials, limited contamination) from a few distinct sources, like markets, institutions, agroindustry, sawmills, slaughterhouses, etc. Questions should also ask about existing organic waste segregation. If any industry has its own waste collection system, it can be interviewed. *Fecal sludge:* Accessible fecal sludge here refers to that from on-site sanitation systems. Data on the predominant types of sanitation systems used both at the household and institutional levels, emptying frequency and transport services are not easy to source. Entry points for data collection are census data on household characteristics, interviews with sanitation experts and cesspit operators (septage collection services) and records collected at septage treatment plants or known dumping places. *Wastewater:* Key data needed for assessing the sources of wastewater generation are: a) the percentage of sewerage coverage in the locality under consideration (i.e., the number of households, institutions with sewerage connection; and b) location and size of sewer networks and wastewater treatment facilities. These data can be easily sourced from municipal sources. If the authorities in charge of waste and wastewater are not accessible, amounts have to be estimated from population numbers and common waste generation statistics. Data on waste quality might be with the authorities, projects, universities.
▪ Is the waste found all over town and available every month?	**A2.** Reliability of resource supply	This indicator assesses the variations of generation and accessibility in quantity and quality of the different waste streams. In terms of quality, the composition of waste, particularly the organic components can vary from season to season (Harris et al. 2001). As waste demand can be seasonal (e.g., fertilization of crops), it is important that the required waste is available in time for processing it (unless the storage capacity of the processed waste is high). Data on seasonality of waste generation in terms of quality and quantity (e.g., agrowaste – rice husks dependent on farming seasons) can be obtained directly via interviews with waste generators. Moreover, certain waste sources might be scattered over town or in proximity implying lowest transport cost while offering highest reliability, quantity and quality and lowest costs. All this should be taken into account in the estimation of the effective availability of the specific waste stream (but see also A3).
▪ What is the current use of the waste i.e., which potentially competing alternative destinations exist?	**A3.** Competitors' index for waste resource	This indicator characterizes how much waste is effectively available given that it can also have value for competing uses (sawdust, for example, might be used as fuel; fecal sludge for biogas generation). There can also be direct competition from other composting projects which have to be assessed in terms of inputs and outputs. To compete for a limited waste supply, the waste amount which can be absorbed might matter (i.e., waste producers might prefer one company taking a large share than many smaller companies) or the price paid for collection/delivery. If competition is high, other waste sources, maybe further away can be considered to estimate the effectively available amount of the resource. Competition around waste input might be highest in smaller towns and cities, while with increasing city size, competition might shift to the output market. Primary data collection can be conducted via interviews with current users of specific wastes, waste generators and collectors, amongst others.
▪ Is the waste supply legal and who are the actors along the sanitation service chain providing the resource?	**A4.** Status of legal, institutional and regulatory environment	While legal and institutional issues are assessed in more detail under another criterion, it is analyzed here as waste availability and supply can be strongly limited through regulations. Using national policies vis-à-vis existing businesses, an overview of the legal environment as it relates to different waste streams can be developed. A stakeholder identification and analysis can be used to map out the different stakeholders in the specific waste stream system under consideration, their roles, ownership rights, attitudes, interest and influence, and existing formal and informal agreements and contractual structures in the waste stream under consideration. Secondary data can be used for this assessment, however primary data collected via interviews with relevant stakeholders should be useful to support the findings.

TABLE A2.2 INDICATORS FOR CRITERION 2 - INSTITUTIONS, REGULATIONS AND INVESTMENT CLIMATE.

RESEARCH/INTERVIEW QUESTIONS	INDICATORS	POSSIBLE APPROACHES AND METHODS
▪ What organizations and boundary partners involved in sanitation influence RRR in the locality under consideration and what are their responsibilities and interlinkages? ▪ What are the processes and instruments for implementation, monitoring and enforcement? ▪ Are there any gaps in the types of stakeholders that would make it difficult to establish RRR initiatives/businesses?	**B1.** Structure and capacity of institutions	This indicator assesses the structure and dynamics within the institutional system, to essentially identify the level of support the current organizational setting provides to current and future sanitation and RRR initiatives. A literature and web review of the key institutions should be conducted to develop a list and description of their roles, responsibilities, and capacities (i.e., institutional size, internal structure, guidelines…). Boundary partner (supplier, private contractors, etc.) identification can be conducted through expert consultations. Additional primary data can be collected with questionnaires for a SWOT analysis of stakeholders as well as their perceptions via open interviews with municipal authorities, their clients and other groups with sector knowledge (NGOs, Community-based Organizations (CBOs), projects, development banks and local donor community, and the private sector). Institutions can be clustered according to waste collection, treatment/resource recovery, product marketing for reuse, product users and regulators.
▪ What policy and regulatory/ legal documents exist in support of or in opposition to RRR and sanitation? ▪ Is legislation enforced? ▪ What supportive legal incentives are there for existing and future RRR interventions? ▪ How easy is land access? ▪ Are there any stakeholders that will make the implementation of RRR initiatives particularly easy or difficult and how influential are they?	**B2.** Policy and legal framework support	This indicator analyzes the policy and legal framework, sanitation policies, medium- and long-term plans and level of governmental support for implementation of sanitation and RRR initiatives. A detailed literature review and expert consultation can be used to produce a list of policies, and description of key policy elements. Based on the institutional structure developed under Indicator B1, identify organizations responsible for policy formulation, implementation and enforcement. Using data from focus group discussions or interviews with government officials, community leaders and community members, assess their level of support, perceptions, options, by-laws, realization potential of RRR initiatives. To assess how far regulations are enforced, local RRR practitioners and sector specialists should be interviewed. Particular emphasis should be given to regulations safeguarding public health and the environment (e.g., need for EIA).
▪ What is the level of budgetary or fiscal support for RRR initiatives, if any? ▪ Are there investors, banks or donors in the city who are interested in funding sanitation and RRR businesses?	**B3.** Level of budgetary and other incentives for engagement	The assessment of this indicator will seek to answer the following questions: ▪ What budgetary allocation is made for sanitation and RRR in the region? ▪ How are these allocations (to sanitation and RRR) provided, e.g., via grants, loans, subsidies? ▪ What percentage of this budgetary allocation has been paid out to date (to sanitation and RRR)? ▪ What is the process by which funding can be obtained for RRR and is it a complicated process? The fastest way to information might be via local experts, practitioners, international development banks, the Chamber of Commerce, business associations and local financing institutions.
▪ What are communities' awareness on laws around waste, sanitation and RRR? ▪ Are communities aware of the RRR objectives? ▪ What kind of RRR options communities know, how do they perceive/support/reject them, and can we explore communities' perceptions about other RRR options?	**B4.** Community support	This indicator analyzes the degree of community acceptance, i.e., social acceptability – public perception of use of products derived from waste and related RRR activities. Focus group and in-depth discussions with community leaders, CBOs and/or community members on environmental issues, waste management can be used to collect data on their perceptions, options, by-laws, realization potential. These data can then be analyzed to produce rankings of acceptability and support. Regarding 'community' the larger society is referred to here, which, for example, has to accept a compost plant in its neighborhood, which goes beyond the particular community segment which might buy the compost (see also the Market Assessment Criterion).
▪ What is the status of the capital market as related to the willingness of financial institutions to invest in RRR initiatives, probable terms of financing available from banks and other investors, and the nature of financing mechanisms? ▪ What are the local determinants of a supportive investment climate and implications for new business set up and development in the RRR sector?	**B5.** Status of investment climate for RRR operations	This indicator assesses the status of the investment climate and the implications for the success of existing and future RRR interventions. Secondary data can be sourced for information on: macro-environment factors (macro-level stability – employment rate, fiscal, monetary, exchange rate policies, and political stability, crime and corruption), institutional factors (business set up regulations, legal and tax systems, time requirements for permits), financial factors (ease of access and relative cost of finance support), infrastructure and micro-level factors (technology transfer, quality of management) on the productivity of capital investment; and challenges in accessing land. There are various options in the literature on how to measure the productivity of capital investment as a measure of the investment climate (Dollar et al. 2003; Escribano and Guasch 2008). However, secondary data alone will not replace interviews on the ground with RRR practitioners who tried successfully to set up their business (opportunities and bottlenecks).

TABLE A2.3 INDICATORS FOR CRITERION 3 – MARKET ASSESSMENT.

RESEARCH QUESTIONS	INDICATORS	POSSIBLE APPROACHES AND METHODS
▪ What are potential market segments and their sizes? ▪ Are these segments already using a related product or could they be open to it? ▪ How much of the product would these clients need over the year and when under different growth scenarios?	**C1.** Theoretical market segments and size	The following steps can be followed for the estimation of the theoretical market size: 1. Identify the major potential users of the product in the locality under consideration, considering agricultural and nonagricultural uses. 2. Estimate the approximate size of these segments and the approximate need of the resource (amounts over the seasons). 3. Collect indications if these customer segments could be interested in the product or if there are for example regulations against the product in the specific segment (e.g., EU import regulations). 4. Stratify the segments, e.g., by farm size, cultural or educational differences, etc. which could influence their (dis)interest in waste reuse, and quantify as far as possible the size of each segment.
▪ What is the market value of the resource? ▪ How much are consumers per market segment willing to pay [vs. their ability-to-pay] for the created RRR product? ▪ What factors are likely to affect the demand for these products? ▪ What is the possible market size?	**C2.** Market value of recovered resource (via WTP) and possible market size	This indicator measures the willingness to pay of potential consumer segments for the recovered and transformed resource. Some segments can be larger groups (e.g., cereal farmers), some very small groups (plantation owners or real estate builders). Building on C1, the following steps are suggested: 1. Estimate the production cost for the product, given the prevailing market prices, and/or estimate the price of alternative products in the market (e.g., organo fertilizer prices). 2. Estimate the factors that are likely to affect the demand for the products. 3. Estimate the demand for the product based on user interviews on their current practices, perceptions and the willingness to pay for the new product vis-à-vis their general ability to pay. 4. Based on their willingness to pay (yes/no), size of the segment and expected resource usage, estimate the market size of generally interested customers. 5. Based on the expressed monetary amount the end user is willing to pay, compared with the likely costs of the product plus transport, calculate the possible market size for and across the demand segments. 6. Use appropriate growth rates to estimate the market trends for the product over a specified number of years (e.g., 5-10 years). Depending on the RRR product and size of the segment, either stated and/or revealed preference methodologies can be used (Otoo et al. 2015; Lusk and Hudson 2004; Kimenju and Groote 2008). The choice of the method and size of the segment will determine the final sampling strategy.
▪ What is the structure of the market for the recovered resource? ▪ How do competitors set their prices?	**C3.** Market structure - competitive advantage index	This indicator assesses the level of competition in relevant industry(ies) that the RRR product will be sold in. To set the stage, a supply chain (SC) framework can be used to identify the constraints and distortions affecting the functioning of the markets and adaptation measures for RRR businesses. The SC analysis considers the market size, key players in the SC, regulatory framework and subsidy programs. Using data on the number of firms in the industry, estimated quantity of output/scale/size of firms (aggregate), measure of competitiveness of substitutes or alternative products, product quality, the SC evaluation model can then be applied along the different stages of the SC for the new alternative product(s): ▪ The **structure of the market** will assess four aspects: market concentration, product differentiation (as measured by businesses' awareness of differentiated products), market integration (e.g., extension of credit) and conditions for entry in the sector (threshold capital requirements, sources of funding). Firm-level data will be used to compute the indices for the degree of market concentration, competition, market share, etc. ▪ The **market conduct** evaluates the behaviors (whether players are price-taking or price-making agents: pricing and promotion) and activities of related businesses. Do players collude or set prices individually? ▪ The **performance** of key players in the SC as reflected in different cost elements can be analyzed using a structural pyramid of players, functions and the performance of the product markets. The key result is an overview of the constraints/factors affecting the functioning, capturing supply-side constraints (e.g., business environment, taxes, tariffs) and demand-side factors (access to financing, production risk, purchasing power, etc.)
▪ What is the market outlook, market trends/ growth? ▪ To what extent will the RRR product be viable over time in a competitive market?	**C4.** Market outlook of recovered resource	This indicator essentially examines the maturity and decline stages of the life cycle of an RRR product. Indicators of the decline phase under consideration include: price pressure caused by competition, decrease in brand loyalty, emergence of substitute products, market saturation. To mitigate data limitation constraints, a discrete Bass model (Bass 1969) can be used to assess the market outlook for RRR products. The most critical determinants of the model are the innovation (p) and imitation (q) coefficients and the potential market size. In the absence of data on p and q, the study can use an average estimation of those coefficients from previous studies (Sultan at al. 1990).

(Continued)

TABLE A2.3 INDICATORS FOR CRITERION 3 – MARKET ASSESSMENT. *(CONTINUED)*

RESEARCH QUESTIONS	INDICATORS	POSSIBLE APPROACHES AND METHODS
▪ What are the most effective pricing strategies (price mark-ups by segment/ marginal profitability by market segments) for the RRR product?	**C5.** Pricing strategy	The estimation of optimal pricing strategies will be based on the objectives of the firm and applies in particular to profit-maximizing businesses. Check the strategy that represents a pricing strategy used by your closest competitors, if any. For a new RRR product on a market the target could be *Premium pricing* based on the unique value of the new product or when the product is the first to be marketed and the business has a distinct competitive advantage. Premium pricing can be a good strategy for companies entering the market with a new product and hoping to maximize revenue during the early stages of the product life cycle. However, where there are already strong competitors, other strategies might be appropriate, such as Penetration Pricing. Care has to be taken that extra transport costs of the customers are considered (Indicator C7) unless the product distribution (retail) network (see Indicator C8) is similar to any alternative product. There are many guidance documents, e.g., https://en.wikipedia.org/wiki/Pricing_strategies, on the use of econometric analysis to better understand the determinants of the probability of a business choosing a particular pricing strategy.
▪ What are the optimal market segments and marketing strategies for the business? ▪ What strategies are available to maximize profits and minimize risks associated with the optimal market segment?	**C6.** Marketing interest, capacity and strategy	This is an important indicator as many PPPs within the waste sector (where revenue streams are mainly based on treated waste volumes, not sold recovered resources) have an underdeveloped marketing capacity. Based on indicator C2, the different market segments should be compared to identify which segments should be considered for preference customers (largest size/high WTP/ bulk purchase possible). A dynamic programming model can be used for the derivation of the optimal market segmentation via the optimization of a profit function (a function of price of the good, quantity, total demand, variable costs and fixed costs). Given the initial profit function, optimal quantities can be derived for a single market or multiple markets. The next step will be to extend the model to several multiple markets. Stochastic variables can be introduced to account for risk and uncertainties and redetermine the optimal market segments. This analysis can also help Indicator C5, by comparing the stochastic and deterministic model results for the optimal pricing strategy for the business.
▪ Where is the optimal location to site an RRR business processing plant? ▪ What are the optimal numbers and sizes of the RRR processing plant(s)? ▪ What factors (like transportation) are likely to affect the implementation of the optimal plant in a given location?	**C7.** Optimal location of business	Within the given geographical boundaries, the best location of the RRR plants can depend on many factors, like land availability and price as well as neighborhood acceptance. From a logistical and financial perspective, the site should help to minimize transport costs, i.e., consider at one end the location of the waste input suppliers (unless the waste gets transported to the RRR plant, like in a sewer system) and at the other end the location of the customers (market segments) of the RRR product (unless the users buy at factory gate, which will be a limited market segment). Other factors can also play an important role, like the operational areas of competitors, the availability of transfer stations/marketing outlets to reduce transportation costs for waste access and product sales, highway accessibility, etc. Knowing the willingness to pay of the customer segments and the likely distribution and pricing strategy, the willingness to pay factor has to also cover any extra transport costs of the customer if these exceed the access distance to the usual replacement product. Based on these factors, various business-siting scenarios can be mapped and transport costs calculated and optimized (Medina-Lopez 1981; King and Logan 1964).
▪ What are the distribution strategies (efficiency of distribution systems) of the business? ▪ Which partner can help cutting distribution costs?	**C8.** Distribution strategies	The estimation of optimal distribution systems for an RRR business model can be based on a transportation model. The following steps can be considered for the analysis: 1. Identify and map a potential distribution system to reach key customer segments. List existing distribution channels and related storage facilities and their providers as potential partners. 2. Develop a supply chain based on the mapping of potential distribution channels, demand market (customers) to detail the characteristics of the entire production and distribution process (i.e., production, packaging, product storage facilities, distribution costs, etc.). 3. Based on the assumption of optimal plant location and information from the distribution system mapping, a linear programming model can be developed to estimate optimal distribution systems for the RRR product in question. The objective of the model is to minimize distribution costs subject to a set of constraints (production constraints, storage capacity constraints, inventory constraints, demand constraints). For this, optimal distribution channels can be estimated based on storage expenses (lower), direct shipments (fewer storage locations and costs): a) first, run a base case scenario using data from existing RRR business cases; and b) run scenarios to understand the impact of changes in the distribution channels. Possible scenarios to be considered: (a) elimination of agents, (b) direct sales of the product to retailers, (c) use distributors as channel partners – cheaper storage costs, and (d) elimination of intermediate storage location.

TABLE A2.4 INDICATORS FOR CRITERION 4 – TECHNICAL AND LOGISTICAL ASSESSMENT.

RESEARCH QUESTIONS	INDICATORS	POSSIBLE APPROACHES AND METHODS
▪ What suitable technologies are available locally for the proposed RRR intervention?	**D1.** Availability of technologies	This indicator provides an overview of the technologies that have potential to be used for the proposed RRR intervention. Here, we seek to identify the technologies that have been successfully implemented for similar RRR interventions and in similar localities. A detailed literature review will first identify a preliminary list of potentially suitable technologies, covering treatment performance level or efficiency/measure of system robustness, percentage of resource output recovered from the process (input-output ratio), labor, land, water, energy, maintenance and safety requirements. Additional primary data collected from existing RRR business cases and suppliers of technologies on the local availability of the technology, related experience and resource requirements should be used to support the secondary data.
▪ Are there resource constraints related to labor, land, energy or other factors of production?	**D2.** Technology (resource) requirements index (spare parts, other production factors)	This indicator assesses the level of resources required, availability and accessibility based on local conditions/availability. Based on the assessment above, the suitability of a preliminary set of technologies should further be assessed with the following questions to local experts: ▪ Are the quantitative and qualitative (e.g., moisture content) waste input requirements matched by the locally available materials? This information can be sourced from the assessment of the *Waste supply and availability* criterion. ▪ Is the required labor force available (in terms of numbers across specific expertise)? ▪ Is the required energy available in the times and seasons needed, and at an acceptable price? ▪ Can the water requirements be met, in terms of quantity, quality, cost and reliability? ▪ Can the land requirements be met and what are the related costs? This concerns the location and topography (e.g., need for non-flooded flat land). At this stage, a ranking of the selected preliminary set of technologies can be done to narrow down the number of technologies. Assigning each resource requirement a 'level of importance', they can be ranked from lowest to highest importance and based on this assessment omit technologies for which the resource requirements are unavailable/inaccessible or already render the RRR intervention unfeasible based on costs.
▪ What is the level of performance and efficiency of the proposed technology?	**D3.** Performance and efficiency of technology	This indicator assesses the performance level and efficiency of the proposed technology. The following questions will form the basis of the assessment: ▪ What is the treatment performance level, i.e., percentage of resource output recovered from the process (input-output ratio) compared to the likely size of the plant? ▪ How robust is the technology, especially under conditions of irregular power supply in terms of frequency of repairs and maintenance? ▪ What is the degree of technical complexity as related to the equipment, infrastructure, O&M and locally available technical expertise? ▪ What are the major limitations associated with the production process? How adaptable are the proposed technologies to different geographical regions, climates, waste streams and scales of operation? And, what are the related costs? Using a SWOT analysis matrix, the subset of technologies derived from Indicator D2 can be further ranked based on data on the availability of different technologies, resource requirements, technical efficiency and complexity, and costs. This will produce a refined list of one or a number of technologies that can be proposed for the RRR intervention. Expert opinions can be sought to validate the results. It is important to note that the final selection of the technology will have to consider the findings of the financial analysis (to match the expected revenues) and socio-economic impact assessment which accounts for potential environmental costs.
▪ Are the required technologies, finance, regulations and incentive mechanisms available to support timely repair and maintenance?	**D4.** O&M requirements	This indicator is dedicated to a common gap in the operation of technologies in low-income countries, i.e., their common breakdown. The indicator evaluates further the suitability of the proposed technologies for the RRR intervention by assessing the internal and external support and supply chain requirements via local expert interviews: What support companies or internal structures are required and available to provide technical support for a) setting up of the technology, b) provision of spare parts, and c) repair and O&M services? What are the possible constraints and related costs for the provision of these products and services? In particular, are there incentive mechanisms in place to support regular checks and compliance with O&M protocols? And can the system respond to detected problems in a timely manner (O&M budget size, repair service hot line, limited bureaucracy). Existing RRR business cases and suppliers of technologies would be the best sources for data gathering.

TABLE A2.5 INDICATORS FOR CRITERION 5 – FINANCIAL ANALYSIS.

RESEARCH QUESTIONS	INDICATORS	POSSIBLE APPROACHES AND METHODS
▪ Is the business financially viable and under what conditions? ▪ Can the product be produced cost-effectively with positive profits and under what conditions? ▪ Is the firm operating at an optimal production capacity based on the choice of technical process, related costs, etc.?	**E1.** Operating cost index – production cost indicators **E2.** Operational index (e.g., operating and financial self-sufficiency) **E3.** Payback period; financial benefit-cost ratio **E4.** Economies of scale and financial sustainability across core business partners **E5.** Firm performance (percentage of cost recovery, profitability ratio, inventory turnover ratio, market growth rate)	These indicators assess the financial return on investment of a proposed RRR intervention. Cost and revenue data from the waste supply, market demand and technical assessment of the RRR business model will feed into the financial analysis. The analysis can try to use investment and production cost data of similar business models in the locality. Where the business models under study do not exist, the analysis can be based on secondary data. The following steps can be undertaken: ▪ Step 1: Identifying business cases in the target area along the lines of the RRR business models under study. ▪ Step 2: Define scenarios for different technologies and scale wherever necessary to mirror the business model to local context of supply and demand. ▪ Step 3: Identify key input data points based on scenarios developed, type of technology used and scale of the business. ▪ Step 4: Identify distribution of business-related revenues (including government subsidies) and costs for all parties if more than one is involved in the offer of the value proposition (e.g., a PPP). ▪ Step 5: The profitability and financial viability of an RRR business model can then be analyzed based on the Profit and Loss Statement (P&L), operational breakeven, NPV, IRR and payback period valuation criteria.
▪ What are the uncertainties associated with key performance indicators of the business model and how do they affect the overall financial viability of the business model? ▪ What are the probabilities and implications/effects of 'adverse' events on the viability of the business model, given changes in market demand, supply chain, technology, capital markets, etc.?	**E6.** Firm's performance under risk	This indicator evaluates the business performance under uncertainty/risk and builds on the results from the assessment of indicators E1 to E5. A **Monte Carlo** risk analysis can be used for the risk assessment of RRR business models. The Monte Carlo risk analysis will involve the following steps: ▪ *Select valuation criteria:* The NPV, IRR or depending on the business model under analysis, other criteria can be used as valuation criteria. ▪ *Identify sources of uncertainty and key stochastic variables:* Possible sources of uncertainty can relate to technical development, change in government policy, inflation and variation in input and output prices, competitors' actions, climate change, etc. For every source, stochastic variables (investment cost, yield, price of inputs, price of output, etc.) which can potentially affect the economic performance of the RRR business model are identified. ▪ *Define the probability distributions of stochastic variables:* Probability distributions for all risky variables are defined and parameterized. ▪ *Run the simulation model:* Determine the cash flow for each year using sampled values from the probability distributions and calculate the NPV using the sampled value for project life. The simulation is performed for a number of iterations, typically larger than 1,000, by picking random values from the statistical distributions and results in a set of NPVs that can be described by a particular distribution. ▪ *Determine the probability distribution of the simulation output (NPV):* The simulation model will generate empirical estimates of probability distributions for NPV, so investors can evaluate the probability of success for an RRR business model.

TABLE A2.6 INDICATORS FOR CRITERION 6 – HEALTH AND ENVIRONMENTAL RISK AND IMPACT ASSESSMENT.

RESEARCH QUESTIONS	INDICATORS	POSSIBLE APPROACHES AND METHODS
Health risk and impact assessment		
A. Occupational and consumer (user of recovered resource) health risk ▪ What are the potential critical exposure points along the value chain of the RRR intervention under consideration? ▪ What are the known occupational health hazards associated with the implementation of the RRR intervention (from waste acquisition to transformation)? ▪ What are the potential risks to the different exposure groups (e.g., workers, consumers, farmers)? ▪ What are the potential health impacts (positive and negative) at the specific system boundary level?	**F1.** Work-related risks (types, frequency and severity of potential accidents) at the resource recovery unit **F2.** Risk of exposure to pathogens and toxic substances from inputs, outputs and by-products of the process (waste acquisition to transformation into final product)	These indicators assess the potential occupational and contact health risks ensuing from the implementation of the proposed RRR interventions. An important first step for the risk and impact assessment is defining the system boundary within which the assessment will be conducted. This is particularly important for the size of the potential risk groups. 1. The identification and assessment of health hazards **(risk pathways, frequency and severity)** and potentially exposed groups (e.g., plant operators, users/consumers, farmers) are the first steps of the assessment and require a clear understanding of the associated value chain of the proposed RRR intervention (from waste collection to reuse). 2. Categories of potential hazards to be considered include: a) existing hazards associated with normal operation of the system (e.g., faulty infrastructure, system overloading, lack of maintenance, unsafe behaviors); b) potential hazards due to a system failure or accident (e.g., treatment failures, power failures, equipment breakdown, operator error, unsafe behaviors); and c) potential hazards related to seasonal or climatic factors (e.g., flood or drought conditions, seasonal behavior changes). 3. A generic risk assessment template (see WHO 2015) can be developed and used following the source-pathway-receptor model, resulting in a semiquantitative check list of hazard identification, exposure assessment, hazard characterization and risk characterization, and also giving an idea of environmental contamination and therefore the potential risks to public health. In the (likely) absence of primary data from existing RRR cases, a literature review of known occupational health hazards associated with the implementation of similar RRR interventions can be used. 4. Next, a detailed assessment of the health risks (including source of pathogens, risk of exposure to pathogens and other toxic substances) associated with potential hazards/hazardous events for each of the concerned exposure groups is conducted. The assessment should be adjusted assuming risk mitigation measures are in place (see below).
B. Risk mitigation measures ▪ What are the relevant national standards to be observed and complied with for the proposed RRR intervention? ▪ What (additional) risk mitigation processes/measures can be put in place along the value chain? ▪ What institutional arrangements exist for health risk assessment, mitigation and monitoring, and how effective are they? ▪ What is the most cost-effective combination of control measures to guarantee a safe end-product? ▪ What operational and verification monitoring is needed (parameter and critical limit) as well as incentive systems for compliance to ensure that the controls are working as required?	**F3.** Health risk reduction strategies in place (e.g., safety equipment, training) for the waste to resource process **F4.** Practicable strategies available for adherence of end-product to public health standards	1. As a first step, a detailed literature review of the relevant national health and environmental standards (including quality and safety thresholds and any auditing or certification requirements) is required. 2. Next, a comparative assessment should be conducted between indicators F1 and F2 and relevant international and national standards (including health-based targets, quality standards and any auditing or certification requirements) to evaluate the gaps (if any) for risk minimization in view of the proposed RRR intervention. 3. Based on Step 2 above, existing and possible mitigation options for the identified health risks based on relevant international and national health-based targets and standards should be defined. It is important that the proposed mitigation measures account for both cultural acceptance and financial/cost implications. 4. The risk assessment under F1 and F2 has to be repeated assuming control measures are in place to identify remaining risks. 5. An operational and verification monitoring plan based on the proposed mitigation measures can be drafted to support the RRR intervention (compliance with safety measures; end-product quality monitoring). Data can be sourced from both primary and secondary sources (i.e., existing RRR cases with similar processes as the proposed RRR intervention, literature review [e.g. WHO 2006, 2015], peer-reviewed literature, demographic and health surveys, climate charts, etc.), and statistics from the national routine health information system (i.e., summary statistics from governmental health facilities) and from occupational health services. Additional data can be sourced from key informant interviews with relevant entities that have expert knowledge on the different waste streams under consideration. Information on the acceptance of different control measures (optional), cultural acceptability and financial/cost implications can also be obtained from interviews with relevant entities (e.g., owners, workers) of existing RRR cases and local occupational health experts (Winkler et al. 2013).
▪ What are the likely health benefits from implementation of the proposed RRR intervention?	**F5.** Potential health benefits of the proposed RRR intervention	RRR interventions can also lead to direct and indirect health benefits which have to be quantified as far as possible for the socio-economic analysis where they will be valued. Benefits can include job creation and income, the production of food (via waste derived fertilizers), better indoor air quality (via energy production) as well as improved sanitation/waste management if the RRR industry can catalyze more attention and incentives for waste collection. If data cannot be derived from similar industries and the literature, estimates at least of the size of the beneficiary groups should be attempted.

(Continued)

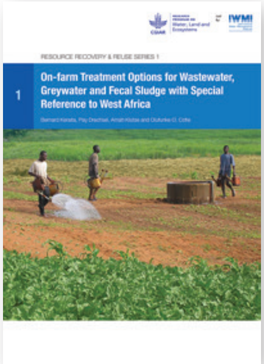
TABLE A2.6 INDICATORS FOR CRITERION 6 – HEALTH AND ENVIRONMENTAL RISK AND IMPACT ASSESSMENT. *(CONTINUED)*

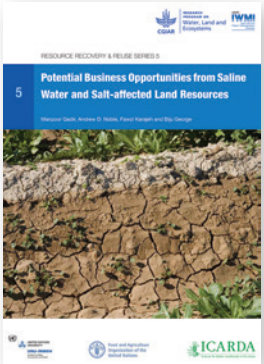
RESEARCH QUESTIONS	INDICATORS	POSSIBLE APPROACHES AND METHODS
▪ How do the RRR-induced risks compare at the community level with similar risks not related to the proposed RRR intervention?	**F6.** Comparative risk assessment in the local context	Quantitative (ex-ante) risk assessments are most advanced in the domain of microbial risks and risk mitigation. Potential health impacts can be calculated for situations with and without RRR intervention, or with and without risk mitigation measures if data on the local disease profile can be obtained. The analysis can also compare different risk mitigation options and, if their costs are known, estimate their cost-effectiveness (e.g., Drechsel and Seidu 2011). The analysis will require primary and secondary data and use the disability-adjusted life years (DALYs) as a generic health indicator.
Environmental risk and impact assessment		
▪ What are the potential environmental risks and impacts of the proposed RRR intervention?	**G1.** Estimated atmospheric emissions (e.g., GHG emissions) from the resource recovery process **G2.** Estimated emissions (solids and fluids) to waterbodies and soil	At the stage of the feasibility study, site-specific details on the final technology to be used and location will not be available, and the risk assessment has to remain generic to outline areas which will likely require attention later on. The following steps can be used for the assessment: 1. Detailed descriptions of the (sourcing, production and marketing) process of the RRR intervention using a material flow analysis to see where nutrients leave the system into the environment (for example). 2. Similar to the health risk and impact assessment, a generic assessment template can be developed and used following the source-pathway-receptor model, resulting in a check list of environmental hazard characterization and risk characterization, and therefore the potential environmental risks. 3. Next, a comparative assessment should be conducted between the identified emissions and relevant national and international standards to evaluate the gaps (if any) in compliance with the legal requirements of the proposed RRR intervention. Data can be sourced from both primary and secondary sources including: existing RRR business cases, legal documents from environmental agencies, UNFCCC methodological guideline documents, literature and reports on RRR interventions with similar processes, etc.
	G3. Existing affordable mitigation strategies available for mitigation of likely emissions	1. Based on indicators G1 and G2, possible mitigation options for the identified environmental risks based on relevant international- and national-based targets and standards should be defined. It is important that the proposed mitigation measures and regulations account for their cultural acceptance, local feasibility and financial viability. 2. An operational and verification monitoring plan based on the proposed mitigation measures can be drafted to support the RRR intervention.
	G4. Potential positive and negative environmental impacts of the proposed RRR intervention and use of recovered resources in the long run	The assessment of the potential environmental impact of the RRR product will remain a qualitative estimate based on the analysis of its properties/safety and literature data on comparable cases like long-term wastewater irrigation. With the use of secondary data, both environmental harm as well as benefits can be evaluated based, for example, on the following steps: ▪ Estimated potentially observable changes in ecosystems (e.g., farm soil quality, eutrophication, change in vector habitat); ▪ Estimated cost savings in transport (e.g., of waste to landfills), area of landfill saved from waste reuse or landfill lifetime, extended area of landfill, savings in CO_2 emissions (costs of CO_2 equivalent saved, depending on baseline CO_2 emissions); ▪ Estimated change (loss or gain) in productive land and water for agriculture (sodic soils, salinization, pollution with biological agents and chemicals) and biodiversity – plant and animal species numbers and diversity indicators (where applicable).

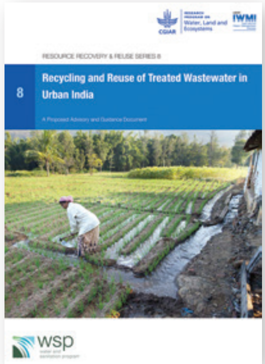
TABLE A2.7 INDICATORS FOR CRITERION 7 – SOCIO-ECONOMIC IMPACT ASSESSMENT.

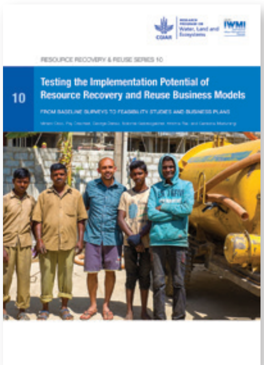
RESEARCH QUESTIONS	INDICATORS		POSSIBLE APPROACHES AND METHODS
▪ What are the expected (monetized) financial, social, health and environmental benefits and costs from the implementation of the proposed RRR intervention(s) within the selected system boundary?	**Socio-economic benefit indicators**	**Socio-economic cost indicators**	The socio-economic impact assessment can be based on the following steps: 1. As with all other indicators trying to quantify impacts, the same system boundaries apply for all activities (from waste collection to transformation to use) and entities across the relevant value chain of the proposed RRR intervention. 2. After defining the system boundary, the preintervention baseline scenario for comparison of the alternatives (i.e., proposed RRR intervention and other alternatives) should be determined. 3. With the setup of the baseline vs. alternative scenarios, indicators can be selected for assessing the financial and economic costs and benefits. These indicators will largely build on the other criteria, especially those where quantitative changes were predicted. 4. Upon the definition of the parameters for the assessment, the financial analysis (Criterion 5) will serve as the base data source, complemented by data from Criterion 6. Most health and environmental impacts, as far as they are quantified, simply need to be monetized. For environmental data, emission rates, carbon equivalents, cost of pollution (and abatement costs) can be collected from secondary sources and contextualized to the specific locality and system boundary under consideration. Ideally, the health impact indicators are expressed as DALYs, using literature data for their economic valorization in the national context. 5. To account for risks and uncertainty, the parameters are categorized as deterministic and stochastic variables based on literature survey and expert opinions. This is an important step for the analysis to account for changes in policy, input and output prices, etc. 6. Most, if not all, of the data from the other criteria will feed into a cost-benefit analysis. The monetized socio-economic, health and environmental indicators allow to estimate the net benefits. The socio-economic feasibility of an RRR business model can then be analyzed based on the NPV of the benefits and costs, BCR and RoI. A BCR is first calculated to evaluate economic feasibility. A BCR is the ratio of benefits to costs where both benefits and costs are expressed as discounted present values. In other words, costs and benefits to occur in the future are converted into present values, and the present value of benefits is divided by that of costs. An intervention is generally economically feasible if the BCR is at least 1.0. As government subsidies are a valid revenue stream, and can support a BCR over 1, economic feasibility might require alternative strategies in the long term (PIMAC 2008). 7. Subsequently, a Monte Carlo risk analysis method can be used as described under the Financial criterion to simulate the NPV for each year using sampled values from the probability distributions for the project's life.
	H1. Estimated number of direct and indirect jobs created **H2.** Estimated energy offsets (electricity, fuel, etc.) **H3.** Incremental gain in crop yield **H4.** Foreign currency saved from reduced import of substitute products (e.g., fertilizer, energy, etc.) **H5.** Cost savings (transport, labor) from averted waste disposal	**K1.** Estimated number of jobs lost due to RRR intervention **K2.** Estimated increase in energy demand from waste transformation **K3.** Increase in on-farm labor requirements through compost use	
	Environmental benefit indicators	**Environmental cost indicators**	
	I1. Cost savings from estimated averted atmospheric GHG emissions **I2.** Water conservation index based on averted direct emission of untreated waste into waterbodies **I3.** Land conservation index based on averted effect from waste reuse vs. baseline scenario **I4.** Cost savings – market value of land used for landfills (economic value of land made unusable by direct disposal of untreated waste)	**L1.** Costs of disamenity effects of intervention as measured by: ▪ Costs of estimated atmospheric GHG emissions from the resource recovery process ▪ Estimated emissions (solids and fluids) to waterbodies and soil	
	Health benefit indicators	**Health cost indicators**	
	J1. Cost savings from averted human exposure to untreated waste (reduced level of exposure to pathogens and toxic substances) **J2.** Improved health through more nutritious food or cleaner energy produced with waste derived fertilizer/fuel	**M1.** Level of exposure to pathogens and toxic substances from inputs, outputs, and by-products of the process	

RESOURCE RECOVERY AND REUSE SERIES









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RESEARCH PROGRAM ON Water, Land and Ecosystems

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CGIAR Research Program on Water, Land and Ecosystems

The **CGIAR Research Program on Water, Land and Ecosystems (WLE)** combines the resources of 11 CGIAR centers, the Food and Agriculture Organization of the United Nations (FAO) and numerous national, regional and international partners to provide an integrated approach to natural resource management research. WLE promotes a new approach to sustainable intensification in which a healthy functioning ecosystem is seen as a prerequisite to agricultural development, resilience of food systems and human well-being. This program is led by the International Water Management Institute (IWMI) and is supported by CGIAR, a global research partnership for a food-secure future.

Resource Recovery and Reuse (RRR) is a subprogram of WLE dedicated to applied research on the safe recovery of water, nutrients and energy from domestic and agro-industrial waste streams. This subprogram aims to create impact through different lines of action research, including (i) developing and testing scalable RRR business models, (ii) assessing and mitigating risks from RRR for public health and the environment, (iii) supporting public and private entities with innovative approaches for the safe reuse of wastewater and organic waste, and (iv) improving rural-urban linkages and resource allocations while minimizing the negative urban footprint on the peri-urban environment. This sub-program works closely with the World Health Organization (WHO), Food and Agriculture Organization of the United Nations (FAO), United Nations Environment Programme (UNEP), United Nations University (UNU), and many national and international partners across the globe. The RRR series of documents present summaries and reviews of the sub-program's research and resulting application guidelines, targeting development experts and others in the research for development continuum.

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