A functional perspective to planning waste systems in developing countries - strategies for the public and private sector. A case study of Muzaffarnagar, India.

By

Julius Danek

BSc Hons Economics and Business Economics
University of Utrecht, 2013

SUBMITTED TO THE MIT SLOAN SCHOOL OF MANAGEMENT IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF FINANCE
AT THE
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

JUNE 2015

©2015 Julius Danek. All rights reserved.

The author hereby grants to MIT permission to reproduce and to distribute publicly paper and electronic copies of this thesis document in whole or in part in any medium now known or hereafter created.

Signature of Author:  

Signature redacted

Julius Danek  
MIT Sloan School of Management  
May 8, 2015

Certified by:

Signature redacted

Charles H. Fine  
Chrysler Leaders for Global Operations Professor of Management  
Thesis Supervisor

Accepted by:

Signature redacted

Heidi Pickett  
Program Director, MIT Sloan Master of Finance Program  
MIT Sloan School of Management
A functional perspective to planning waste systems in developing countries - strategies for the public and private sector. A case study of Muzaffarnagar, India.

By

Julius Danek

Submitted to MIT Sloan School of Management on May 8, 2015 in Partial Fulfillment of the requirements for the Degree of Master of Finance.

ABSTRACT

This thesis introduces a new framework for establishing waste systems in developing countries. The functional perspective is a stand-alone extension of integrated sustainable waste management. In January 2015 the functional perspective was applied to analyze the waste system of Muzaffarnagar, India, and to propose solutions to existing problems. The functional perspective was found to be helpful as a theoretical framework guiding waste system design processes for decision makers both in the public as well as private sector.

Thesis Supervisor: Charles H. Fine
Title: Chrysler Leaders for Global Operations Professor of Management
Acknowledgements

First and foremost I would like to thank my incredible team of advisors and supervisors. Jeremy Gregory, Randolph Kirchain and Libby McDonald were always helpful and would always nudge me into the right direction with my research and writing. I am glad they took their time every Friday to sit with me and supervise my progress.

Charlie, I would like to thank you for taking your time to be my supervisor, even though busy with opening a business school in Malaysia and heading the TATA center. I am truly inspired by your efforts.

Incredible were also my team of collaborators in India. Ching-ching, Ellen, Raluca and Cecilio, thank you so much for the great work. Special thanks go to Kate Mytty that always stood by my side when it came to thesis work and helped me clear my head many times. You were amazing at helping me keep my cool when things got chaotic in India. Sarah McMillian, thank you for the great research you did in Muz, the challenges you gave me and for always being there for me when I just had enough of writing my thesis, providing me with steak and just being a great friend.

Thanks to my roommates Abraham Neben and Priyank Kumar. Abraham, thanks for cooking dinner, keeping our house tidy (I am sorry I did not have time to always wash the dishes). Priyank, thanks to you and your family hosting me in India and giving me a roof over my head while conducting research.

Shreya Ishita, thank you so much to you and your family for giving me a home away from home in Delhi. Your father S.P. Singh showed me everything about Indian politics and what makes your country so special. Your mom always took good care of me and allowed me to gain an insight into your university system.

I want to express the deepest gratitude to several people paving my way to MIT. My bachelor thesis supervisor, Stephanie Rosenkranz, and her husband Utz Weitzel. They have guided my journey up to here – I don’t think I would have ever attended MIT without their on-going support and encouragement. Also, Khaleed el-Marsafi – you have always been a mentor to me. Jonathan Fleming, thank you for taking me under your wing and talking me into going to MIT.

Finally, I would like to thank my family. Mama und Papa, ohne euch beide wäre ich nie hier. Ihr habt immer an mich geglaubt, mir den Rücken gestärkt und mich darin bekräftigt, meinen eigenen Weg zu gehen. Ich liebe euch so sehr. Danke an meine liebste Schwester Stella und meinen Cousin Fabian, hoffentlich sehe ich euch auch bald am MIT. Oma Matziko, ohne dich hätte es mich am MIT nicht gegeben. Ich denke oft an Oma Erika, Opa und dich. Ich hoffe euch geht es gut.

Thanks to all of you for making this incredible journey possible.
Table of Contents

Introduction ........................................................................................................................................ 7
1. ISWM and its extension into the functional perspective .......................................................... 9
   1.1 The functional perspective to waste systems ...................................................................... 11
   1.2 Functions in waste .................................................................................................................. 12
       1.2.1 Meta-functions .............................................................................................................. 12
       1.2.2 Operational functions .............................................................................................. 13
       1.2.3 Changing functions and the assumption of constancy .............................................. 14
       1.2.4 Meta-functions, operational functions and institutional structure .......................... 15
   1.3 Functional perspectives in the context of developing countries ...................................... 15
2. Analysis in the functional perspective and the application of design thinking .................. 16
   2.2 Tools in analyzing operational functions ........................................................................... 18
       2.2.1 Regulation ................................................................................................................ 19
       2.2.2 Stakeholder analysis and power relations ................................................................. 20
       2.2.3 Markets for waste products ....................................................................................... 23
       2.2.4 Interacting with waste workers and households ...................................................... 23
       2.2.5 Understanding perceptions of waste ......................................................................... 24
       2.2.6 Quantitative top-down analyses .............................................................................. 24
       2.2.7. Informal sector analysis .......................................................................................... 25
       2.2.8 Survey results ........................................................................................................... 27
   2.3 Understanding prioritization of meta-functions: ................................................................. 27
   2.4 Synthesizing analysis results ............................................................................................... 28
   2.5 Summary .............................................................................................................................. 28
3. The case of Muzaffarnagar: analysis ...................................................................................... 29
   3.1 Background .......................................................................................................................... 29
   3.2 Methodology ........................................................................................................................ 30
       3.2.1 Stakeholder analysis and mapping power relations .................................................. 31
       3.2.2 Informal sector analysis ............................................................................................ 32
       3.2.3 Households surveys .................................................................................................. 32
       3.2.4 Waste audits ............................................................................................................. 33
       3.2.5 Understanding regulation and contracts .................................................................. 33
       3.2.6 Quantitative data collection, analysis and financial modeling ................................. 33
   3.3 Results .................................................................................................................................. 34
       3.3.1 Stakeholders in the Muzaffarnagar waste system ...................................................... 34
       3.3.2 The informal sector in detail ..................................................................................... 46
       3.3.3 Cost analysis ............................................................................................................ 49
       3.3.4 Revenue analysis ..................................................................................................... 52
   3.4 Putting the Muzaffarnagar waste system in the functional perspective ........................... 53
       3.4.1 Waste generation .................................................................................................... 53
       3.4.2 Waste collection ..................................................................................................... 55
       3.4.3 Waste processing .................................................................................................... 57
   3.5 Meta-functions in Muzaffarnagar ....................................................................................... 59
   4.1 Why improve household collection .................................................................................... 61
4.2 Defining problems ................................................................. 61
4.3 Designing solutions for improved household collection .................. 62
  4.3.1 Re-designing secondary collection sites ................................... 62
  4.3.2 Educating households .......................................................... 63
  4.3.3 Mitigating between Balmiki and A2Z ..................................... 64
  4.3.4 Introducing new technology .................................................. 64
  4.3.5 Integrating ragpickers and Kabadiwalas into formal system ........ 64
  4.3.6 Re-negotiating the A2Z contract ............................................ 65
4.4 Implementing solutions ............................................................ 65
4.5. Designing a pilot for improved household collection in Muzaffarnagar 65
  4.5.1 Establishing a baseline .......................................................... 66
  4.5.2 Improving household services ............................................... 66
  4.5.3 Improving secondary collection sites ...................................... 67
  4.5.4 Continuous Measurement of Pilot Results ............................... 67
  4.5.5 Further pilots and iteration .................................................... 68
4.6 Pilot summary ........................................................................... 68

Conclusion ...................................................................................... 69

Bibliography .................................................................................... 70

Appendix ......................................................................................... 77
Introduction

Waste poses a serious issue. The impact of our increased waste generation can be felt and seen throughout the world. Pollution through open waste burning, improper disposal, the lack of space for and the financial costs of waste disposal, and phenomena like the great pacific garbage patch cause ever-increasing problems (Humes, 2013) and it will not stop there. With ever-more sophisticated technology, increasing consumption, and the rise of a whole new middle class in developing countries with changed consumption profiles – China's share of citizens considered middle class rose from 4% to about 60% from 2000 to 2012 (Barton, 2013) – these challenges are poised to become even more difficult.

Over the past ten years, waste generation from 2.9bn urban residents at about 0.64kg per person per day increased to 3bn residents generating 1.2kg/kg per person per day. These staggering numbers are predicted to further increase to 4.3bn urban residents generating around 1.42kg/capita/day by 2025. This is a jump from 0.68bn tons per year ten years ago to 2.2bn tons per year in 2025 (Hoornweg & Bhada-Tata, 2012).

Especially countries in the developing world are under pressure. When looking for resources on waste management in developing countries, it is hard to overlook the numerous papers, newspaper articles and reports detailing the challenges that arise from failures in waste management. These challenges will only be aggravated, as the developing world is predicted around three billion people in population by 2050 (Haub, 2012).

Frequently cited problems in developing countries stem from increasing generation of waste, the lack of financial resources and its impact on municipal budgets, weak institutions, lack of understanding with regard to systemic impacts of waste systems and the effects of public waste on public health and city appearance (Brunner & Fellner, 2007; Chanakya, 2009; Guerrero, Maas, & Hogland, 2013; Hoornweg & Bhada-Tata, 2012; Ministry of Environment and Forests, 2000; Wilson, Velis, & Rodic, 2013).

To address challenges in waste management, researchers have since the late 80s started developing the framework of “Integrated Sustainable Waste Management” (ISWM). ISWM is a very flexible framework and serves quite well for an adaption to developing countries. This thesis seeks to present a stand-alone extension of the underlying notions of ISWM – systemic thinking, careful analysis, the interaction between the driver for waste management and its implementation, inclusivity, etc. – in the adaption of a functional perspective. The functional perspective as a framework introduces a different mode of thinking about systemic issues and the development of institutional structures to address them.

The functional perspective does not only serve as a framework but will also contain useful tools for decision makers in waste, primarily based on design thinking. The
functional perspective was conceived for a research project based in Muzaffarnagar, India, that took place in January 2015. The municipality of Muzaffarnagar initiated cooperation with MIT that sought to reform the struggling Muzaffarnagar waste system through academic research and the application of new technology.

This thesis is divided into four chapters. The first chapter will introduce the framework of the functional perspective, expand on its aims and will place it within the context of current waste management paradigms, especially ISWM. The second chapter will discuss the importance of analysis in the functional perspective and the tools used, such as design thinking. The third chapter will introduce the reader to the case of Muzaffarnagar and discuss the results and methodologies of our research efforts. The fourth chapter will cover the design of solutions, touching upon the specific function of waste collection.
1. ISWM and its extension into the functional perspective

Much emphasis in waste management research has been on the framework of Integrated Sustainable Waste Management, its application and its assessment methods. ISWM stemmed from the idea that waste problems cannot simply be solved by purely “technical fixes” (Wilson, 2007). ISWM emphasizes the notion that factors such as governance, stakeholder inclusivity and financial sustainability need to be more strongly considered when planning waste systems. ISWM thus lends itself naturally to developing countries, where solutions involving advanced technology are generally inappropriate and many informal actors are active in the waste sector.

ISWM is divided into three major dimensions: waste management stakeholders, practical and technical elements of waste systems, and aspects of the local context (van de Klundert & Anschütz, 2001). Figure 1 provides an overview.

Figure 1: The three dimensions of ISWM

Source: van de Klundert & Anschütz (2001)

Next to the three dimensions, ISWM emphasizes four main principles:
Box 1: Four main principles of ISWM

1. Equity: all citizens are entitled to an appropriate waste management system for environmental health reasons.
2. Effectiveness: the waste management model applied will lead to the safe removal of all waste.
3. Efficiency: the management of all waste is done by maximising the benefits, minimising the costs and optimising the use of resources, taking into account equity, effectiveness and sustainability.
4. Sustainability: the waste management system is appropriate to the local conditions and feasible from a technical, environmental, social, economic, financial, institutional and political perspective. It can maintain itself over time without exhausting the resources upon which it depends.

Source: van de Klundert & Anschütz (2001)

Wilson et al. (2013) further refines the concept with an adaption of waste drivers ("mechanisms or factors that significantly impact development in solid waste management" (Wilson, 2007, p. 198)) into the model, in the form of physical and governance elements. The drivers he incorporates are physical, environment and the 3Rs (reuse, reduce, recycle). Figure 2 demonstrates the "two triangle" representation.

Source: (Wilson et al., 2013)

ISWM is a very sophisticated framework that has seen a lot of use and adaption. Velis et al. (2012) propose an adaption for the integration informal sector. Through the lens of ISWM, Guerrero et al. (2013) examine challenges for developing countries in waste management, and Wilson, Rodic, Scheinberg, Velis, & Alabaster (2012) use it to compare 20 cities world-wide in waste management. Based on ISWM, Wilson et al. (2015) developed a new assessment tool to benchmark waste
management systems worldwide.

The ISWM serves well as a framework. What is missing however is the notion that waste management systems underlie constant change. Drivers change, actors change, priorities change, technologies change. How for example do the drivers influence the waste system and how do decision makers infer them? The functional perspective as an additional framework will discuss these issues when formulating the ideas of meta-functions and operational functions. It further defines an even more systematically rooted and contextualized way to analyze and improve waste systems than ISWM and gives special emphasis to the development of proper institutions serving waste management functions.

The functional perspective defines waste systems as an ongoing, ever changing set of processes. It further connects the formulation of a theoretical framework with a clear set of tools. The functional perspective does not seek to replace ISWM but proposes an alternative framework for evaluating and building waste systems. The tools that the functional perspective gives to practitioners are rooted in the idea that institutional structures constantly change but that functions stay the same. Figure 3 provides an overview.

1.1 The functional perspective to waste systems

The functional perspective to waste systems in this paper has roots in the call for a functional approach in the design of financial systems by Zvi Bodie and Nobel laureate Robert Merton (Merton & Bodie, 2004). They establish a relationship between functions and institutional structure. Functions that are treated as "given" (facilitating credit, shifting risk) and institutional structures (financial companies, regulation, accounting standards, etc.) adapt according to geographical location, demography and time. This means an ever-changing landscape of institutional structure to address functional demands. Functions are seen as quasi-exogenous (they too, can change as we will see), whereas institutions endogenously develop from them.

What is a function? In finance we can look at how the lending system changed its institutional structure to serve an underlying function, i.e. to provide credit to individuals and businesses. The institutions that serve this function have changed significantly over time (minority groups charging interest, loan sharks, banks, collateralized loans, online peer to peer lending etc.) and vary by geography and demographics (Islamic banking, Bauspar-industry in Germany, etc.).

The actors creating the institutional structure may not be aware of the role they play in facilitating an underlying, systemic function. By responding to observable needs and demands they do so inadvertently. Applying a functional way of thinking however allows a more systemic, context-optimized approach to creating institutions.
Aims

The aim of a functional perspective is to find the institutions that best serve the underlying function with regard to local conditions, economic constraints and time, achieving functional optimization. The process of finding the right institutions should be an absolute priority of decision-makers. It requires the adoption of an open mindset and a broad perspective before conducting rigorous analyses of the current status quo and possible solutions.

In designing waste systems, especially in developing countries, many decisions are made ad-hoc and only target one specific area without paying attention to the impact on a systems level. The functional perspective seeks to mitigate these problems by proposing a holistic, systematic approach that employs quantitative and qualitative analysis with a focus on local context. The functional perspective can be applied to a waste system as a whole or to specific parts, such as household waste management or street sweeping.

1. Functions in waste

How do we define these functions in waste? Here, I will differentiate between meta-functions and operational functions.

1.2 Meta-functions

Meta-functions can be seen as the general drivers, similar to the definition by Wilson et al. (2013), behind the establishment of a waste system:

1. Improvement of public health (disease prevention)
2. Value creation (resource recovery and economic benefits)
3. Environmental conservation and protection
4. Aesthetics

These meta-functions are largely intangible. They manifest themselves in how the institutional structure of a given waste system is constructed. While meta-functions are present at all moments in time, their prioritization can differ significantly from country to country and over time. In industrialized societies like Germany or the US, the environmental function of a waste system plays a bigger role nowadays than it has in the past, and it has become more visible. This does not mean that advanced waste systems are not concerned with functions such as public health anymore, the public focus simply shifted to account for different priorities. This is also a development that can be observed in waste literature, where more and more focus has shifted on reusability, sustainability and the "closed-loop" paradigm (e.g. the use of the word "recycle" in English literature has increased 4 fold since the mid sixties ("Google Ngram Viewer: Use of word 'recycle' in English literature from 1960 to 2008.,” 2015)).

Functions also tend to have significant overlap with each other and institutions
addressing them can serve not only one but several functions (e.g. municipal waste guidelines). In developing countries, the functions of most concern are public health and value creation. The desire for improving public health is mostly driven from government side; value creation is driven by both the informal and formal sector through companies that seek to (re)-capture the economic value of waste.

1.2.2 Operational functions

Operational functions have to be considered when planning to engage in waste management. They are the determinants of the institutional structure of a waste system. The three major operational functions in waste are

1. Waste generation
2. Waste collection
3. Waste processing

Again, the priority of these functions differs by context and the major functions can be divided into sub-functions. These functions have thus far been stable over time.

1.2.2.1 Waste generation

Generation of waste is the process that creates the need to devise a waste system in the first place. Without waste generation there would be no waste systems. Waste generation occurs on consumer, firm and institutional level. While we mainly perceive the consumption of goods to produce waste, activities by firms, such as the conversion of inputs to outputs, significantly contribute to waste generation.

While it might seem counter-intuitive to include waste generation at first glance, it is the starting point of analyzing any waste system. The institutional structure in waste generations includes generators such as consumers and firms, measures to minimize generation (regulation, NGOs, etc.), and the component of waste composition. The function of waste generation can thus have vastly different institutional structures imbedded.

1.2.2.2 Waste collection

Waste collection describes all activities that involve the collection of waste from waste generators and transport to processing facilities. It has the function to aggregate and transport waste for proper processing. The type of waste can have an influence on how and even if collection is organized. Some forms of waste systems do not need collection at all, like home composting. Generally however, it is deemed reasonable to assume that waste generators do not possess the capabilities to process generated waste themselves. This is especially true in the case of materials that need specialized treatments, such as plastics.

The institutional structure in waste collection differs from country to country and even within countries. Some systems require citizens to drop their garbage at
collection points, while others provide complete door-to-door (D2D) collection (Lehmphul, 2014). Separation at household level is also a part of waste collection, embedded in the institutional structure of waste systems around the world – be it through regulation (e.g. Germany) or through perceived value creation (selling to Kabadiwalas in India).

1.2.2.3 Waste processing

The third operational function is processing. The goal of processing is to ensure that waste is properly disposed of and processed. Processing is probably the function that has the greatest variety of implementations. They include landfilling, incineration, composting, recycling, re-use, and many more. Waste processing can be split into two sub-functions: value-centered processing and disposal-centered processing.

Value-centered processing is obviously connected to the systemic function of value creation (chapter one). Waste is only considered to be “waste” or “trash” by the group disposing of it; in value-centered processing it becomes an input that can yield economic profits to the processor. This is done in a variety of ways, a few of which are listed:

- Extraction of raw materials through recycling
- Energy production (burning, methane extraction, etc.)
- Composting
- Re-use of waste through repairs or art

Disposal-centered processing is focused on “getting rid” of waste. This type of waste processing often happens due to limited value-centered processing capabilities (in the case of nuclear waste for example) or because value-centered processing does not make economic sense (expensive state-of-the-art incineration plants).

1.2.3 Changing functions and the assumption of constancy

Functions are not always fixed in time and may change accordingly. The meta-functions of waste systems have always included public health (pre-modern humans burying or burning their dead) and value creation (re-using food leftovers and equipment; salvaging) but not until recently has the meta-function of environmental conservation received great attention as a paradigm in waste systems. Similarly, operational functions such as collection and processing might not even have to be considered as a functions in the future, when the human race possesses Star Trek-like replicator machines (“Replicator (Star Trek),” 2014).

Notwithstanding very slow change, the functions outlined in this paper are highly relevant today and for the foreseeable future. Both meta-functions and operational functions in the form above will continue to persist on decision-makers and researchers’ agendas. Thus, for the sake of this paper’s analysis, the mentioned
meta-functions and operational functions are assumed to be constant across time and space.

1.2.4 Meta-functions, operational functions and institutional structure

Under the assumption of constancy, neither meta-functions nor operational functions will change their respective components. The prioritization of meta-functions is an input that is received by operational functions when setting up institutional structure. The synthesis of operational functions with meta-functions results in an institutional structure (figure 3).

Figure 3: How functions affect institutional structure

<table>
<thead>
<tr>
<th>Meta-functions</th>
<th>Operational functions</th>
<th>Institutional structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public Health</td>
<td>Waste generation</td>
<td>Regulation</td>
</tr>
<tr>
<td>Value Creation</td>
<td>Waste collection</td>
<td>Waste systems</td>
</tr>
<tr>
<td>Environmental Conservation</td>
<td>Waste processing</td>
<td>Private &amp; public institutions</td>
</tr>
<tr>
<td>Aesthetics</td>
<td></td>
<td>Informal sector</td>
</tr>
</tbody>
</table>

A great example is how the function of public health influenced the Indian government to establish the Municipal Solid Waste Rules of 2000 (Ministry of Environment and Forests, 2000), motivated by an outbreak of the plague due to dire waste conditions. The MSW rules set the tone of the institutional structure for India with regard to waste management for years to come. They provided regulation covering all three operational functions, illustrating how the prioritization of meta-functions influences operational functions and synthesize to result in institutional structure. The functional perspective differs from ISWM in this regard, putting extra emphasis on how meta-functions influence operational functions.

1.3. Functional perspectives in the context of developing countries

In the context of developing countries, meta functions differ from industrial nations primarily along the dimension of priority. The meta function of public health is paramount in waste systems in developing country (Brunner & Fellner, 2007) whereas in industrial nations it has shifted towards environmental conservation. The meta-function of value creation is very important in both, as the public and private sector world-wide continue to explore how to make waste systems financially sustainable.
2. Analysis in the functional perspective and the application of design thinking

A functional perspective to improve or establish waste management in a given setting is not merely an academic proposal but an acute framework for practitioners in the field to utilize. This chapter will describe a series of sequential strategies along the line of a functional perspective that will alleviate postulating institutional structures in waste management, optimized for local context. Additionally, the theme of the functional perspective in the context of developing countries will be explored in-depth.

The prime motif throughout the application of the functional perspective is the thorough analysis of the status quo of the institutional structure in question. This concerns both a high-level understanding of the waste ecosystem as well as low-level details. The tool of analysis can only be applied to the empirically observable and thus the institutional structure will come under scrutiny first. No matter the perspective, both an external party, e.g. a waste company engaging in contractual negotiations with a municipality or an internal stakeholder, e.g. a municipal government seeking to reform its waste system, have to reshape their efforts and ideas around information recovered from this ongoing analytical approach.

In this approach, first, the current institutional structure will be analyzed. Observations will be attributed to the different operational functions of generation, collection and processing. Concluding the analysis of institutional structure, the prioritization of meta-functions will be inferred from observations from the institutional structure. Insights from these analyses will allow decision makers to clearly define the problems they are facing. Next, according to functional optimization, an improved, contextual institutional structure will be formulated. Finally, the new institutional structure will be implemented wholly or through iterative processes, allowing feedback loops that can help optimize the theoretical construct in reality (figure 4).
While the functional perspective provides a theoretical road map, its practical application adheres to the framework of “design thinking”. Design thinking is defined as “a process, applicable to all walks of life, creating new and innovative ideas and solving problems; it is not limited to a specific industry or area of expertise. It can be as effective in technology or education as it may be in services or manufacturing. It could result in new products and services for customers or improved processes and productivity gains for internal operations” (Kaan Turnali, 2013).

“The Design Thinking process first defines the problem and then implements the solutions, always with the needs of the user demographic at the core of concept development. This process focuses on needfinding, understanding, creating, thinking, and doing. At the core of this process is a bias towards action and creation: by creating and testing something, you can continue to learn and improve upon your initial ideas” (ReDesigning Theater, n.d.).

Design thinking has not yet been applied to waste systems but promises to reap encouraging results (see chapter 3). It provides practical guidelines to both gaining an intimate understanding of a current situation and problems as well as formulating the solutions needed for arising problems. Design thinking is an ideal practical complement to the more theoretical nature of the functional perspective. A design thinking approach can be divided into five sequential processes; empathize,
define, ideate, prototype, test (Stanford d.school, n.d.). These five processes are the basic tools for analysis and solution formulation in the functional perspective.

Box 2: The 5 steps in design thinking

**EMPATHIZE:** Work to fully understand the experience of the user for whom you are designing. Do this through observation, interaction, and immersing yourself in their experiences.

**DEFINE:** Process and synthesize the findings from your empathy work in order to form a user point of view that you will address with your design.

**IDEATE:** Explore a wide variety of possible solutions through generating a large quantity of diverse possible solutions, allowing you to step beyond the obvious and explore a range of ideas.

**PROTOTYPE:** Transform your ideas into a physical form so that you can experience and interact with them and, in the process, learn and develop more empathy.

**TEST:** Try out high-resolution products and use observations and feedback to refine prototypes, learn more about the user, and refine your original point of view.

*Source: (ReDesigning Theater, n.d.)*

At every step along the functional perspective, different tools postulated by design thinking will be applied. While analyzing the current structure, it will mostly be the tools of empathizing and defining that will be used. In later stages, in the implementation of new structures, it tends to be ideation, prototyping and testing that are used most.

### 2.2 Tools in analyzing operational functions

To analyze institutional structure within the boundaries of operational functions, this paper proposes a synthesis of top-down, bottom-up analytical frameworks. Gaining a high-level grasp of structures, such as stakeholders, financial revenues and costs, technology used, and power relationships enables “connecting the dots” and understanding the bigger picture. Low-level details, like citizen behaviors and attitudes, individual salaries of waste workers, worker efficiency and happiness, and others on the other hand help understanding how a system is built up from the ground. These low-level details are very valuable in contexts where there is little or no formal waste management. Figure 3 maps analytical processes on a chart, categorized by qualitative or quantitative, and bottom-up or top-down.
This section will outline a few analytical processes/tools that can be used to conduct the functional analysis. The mentioned tools will be put into practice in the context of reforming household waste collection in Muzaffarnagar in chapter 4.

2.2.1. Regulation

Regulation is one of the most important components of an institutional structure. For the sense of this paper, regulation is understood as the sum of all rules and laws put in place by local, national and supranational institutions regarding waste. This includes environmental standards, laws, policies, subsidies and other regulatory designations concerning the generation, collection or processing of waste.

Regulation often is the predecessor to the establishment of formal waste systems and the resulting additional institutional structures. In many cases, it facilitates the process with additional prescriptive guidelines and by defining the execution of certain processes in waste management, as can be see in the example of India. With the municipal solid waste rules of 2000 (Ministry of Environment and Forests, 2000), the country laid the foundations for the establishment of a formal waste system. It both outlines guidelines as well as establishing restrictions. Similar to meta-functions, regulation can stem from observable needs and can be the result of political and economic processes driven by normative agency.
Carefully analyzing given regulation can give a very good idea about how a given society prioritizes meta-functions as well as how narrowly the further institutional structure of operational functions is defined. Regulation is extremely influential in all three operational functions, evidenced by the following examples:

- Waste generation: extended producer responsibility in Europe, mandatory source segregation in many countries (Lifset, Atasu, & Tojo, 2013; Mu Cui & Stephanie Schmaus, 2013)
- Waste collection: provision of designated dumpster containers to households in Germany, establishment of collection points in Bangalore (Chanakya, 2009; Parvathamma, n.d.)
- Waste processing: closing of landfilling, move towards incineration

Understanding regulation is an absolute must before moving on to examine local contexts. Even in places where regulation is not enforced, it provides insights into how society at large seeks to deal with waste. Upon analyzing regulation at larger and local scale, stakeholders can provide deeper insights into how a local system functions.

2.2.2. Stakeholder analysis and power relations

The approach to stakeholder analysis within the framework of a functional analysis in waste management leans heavily on the approach outlined by Snel and Ali in their 1999 paper. This paper proposes a slightly different division between different stakeholders, including the informal sector in the group of secondary stakeholders:

<table>
<thead>
<tr>
<th>Level</th>
<th>What</th>
<th>Who</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary stakeholders</td>
<td>Directly affected, either positively or negatively by implementation of solid waste management project</td>
<td>Households, citizens, receivers of waste services</td>
</tr>
<tr>
<td>Secondary stakeholders</td>
<td>Intermediary role, may have an important effect on the project/program outcome.</td>
<td>Municipalities, waste workers, state departments, NGOs, waste pickers, private sweepers, small entrepreneurs and contractors, private companies, waste-pickers, waste buyers, middle-men, etc.</td>
</tr>
<tr>
<td>External stakeholders</td>
<td>Not directly involved but may nevertheless be affected by a specific project</td>
<td>Residents of nearby communities</td>
</tr>
</tbody>
</table>


The stratification presented here can be altered according to context. Following the identification of stakeholders, mapping their importance and influence on a chart can be helpful. An example can be found in figure 8 in chapter 3.3.1.
Understanding how stakeholders relate to each other and what their influence is can be of major help when designing institutional structures. Initially, stakeholders are best understood within the top-down approach. Interviewing municipal officials, company executives, citizen representatives and other high-profile individuals will give a first sense of stakeholders involved. Analyzing the low-profile stakeholders is the next task. Interviews with formal waste employees, informal sector workers, and citizens can lead to an understanding of who the other stakeholders might be. Stakeholders usually encompass the following groups: households, municipality, formal waste sector and informal waste sector.

**Households:** The citizens of a city are both the source of the waste as well as the users of waste system, putting them into an interesting position. Trash collection services are typically a service taken for granted and a responsibility bestowed upon governments, thus usually funded by tax payer money.

Households play an important role, especially in terms of value creation. Source segregation, waste composition, waste volume and household collection fees are all important factors to consider when evaluating the economic impact of waste collection. Source segregation for example can lead to recyclables retaining higher values, e.g. dry waste recyclables separated from wet waste. For some cities in India it is customary for households to pay fees for waste collection, enabling waste pickers to derive income that way (Chikarmane, 2012).

It has also been suggested that communities with high social capital – trust, sharing and reciprocity – are significantly more likely to have successful waste systems than those with low social capital. Leveraging this fact and adjusting policies accordingly can give households a even more influential standing (Pargal, Huq, & Gilligan, 2000).

**Municipality:** India began its move towards organized solid waste management in cities with the enacting of the “Municipal Solid Wastes (Management and Handling) Rules 2000 (Ministry of Environment and Forests, 2000). The document defined rules related to collection, segregation, transportation, processing, and disposal of municipal solid waste in cities for relevant authorities. Additionally, rules were defined for the selection of dump sites and pollution prevention.

Municipalities would outsource parts or the whole of their new responsibilities to private companies. Sometimes the municipality would retain processing of waste and collection would be outsourced. However this model proved to be inefficient and gave rise to companies such as A2Z Infrastructure that offered solutions covering collection and processing.

India is renown for corruption at government levels and weak institutions, and the problem extends to waste management. Officials oftentimes do not adhere to covenants of contracts both with private companies and wastepickers collectives (SWaCH Pune Seva Sahakari Sanstha Ltd., 2014). This creates problems as business
models and profitability often depends on the cash flow allocated to them under contractual agreements.

*Informal waste sector:* This includes wastepickers, rag pickers, Kabadiwallas, itinerant waste buyers and junk-sellers. The informal waste sector provides significant and underappreciated services with regard to recycling in developing countries and in India. It has been estimated that 20-30% of recycling can be traced back to the activities of the informal waste sector (Wilson et al., 2013).

Wastepickers’ issues can mostly be attributed to the fact that they are not recognised by government entities or private companies, thus not being able to contribute to policy discussions (Gunsilius et al., 2011). Stemming from poor socioeconomic backgrounds and minorities, wastepickers are aware of their lack of participatory opportunities. Formalization of waste pickers is currently changing this situation, oftentimes successfully (Chikarmane, 2012; de Brito, 2012).

Wastepickers are actively looking for ways to alleviate their situation. While it may be more financially rewarding than other jobs, the hazards to health are significant and they face lower life expectancies and higher chances of contracting diseases (Medina, 2008). For wastepickers, education for their children is a very valuable good since it promises a clear way out of employment in the waste sector.

In India it is important to recognize the role of Kabadiwalas or itinerant waste buyers. They are not part of the formal system and receive the highest quality recyclables. Since Kabadiwalas interact with households directly – they buy their recyclables - they can also drive source separation (increasing revenues for households).

*Formal waste sector:* The formal waste sector includes private companies as well as companies owned by the public. These companies are officially contracted to take over waste management duties. In developed countries these private companies usually resort to technology-driven approaches to waste collection and processing. Since effective equipment entails high up-front costs, waste management is a very capital-intensive business.

This tech-driven approach often fails in developing countries. Much of the equipment is not tailored to operate in adverse or suboptimal conditions. Exemplary is the use of expensive compactors in developing countries that often cannot navigate narrow streets and that cannot be maintained properly due to a lack of expertise (Coad, 2011).

As mentioned above, profitability of private enterprises hinges on the ability and willingness of government entities to follow through with contractual agreements. In the case of A2Z, municipalities were up to six months behind with payments. In an environment with high interest rates such as India, six months can have a significant impact on operational profits.
Upon context-specific identification, the power relations between stakeholders can often only be found out through astute qualitative interviews with the different key-members. A possible strategy for the creation of institutional structure relates to forging “sustainable alliances between stakeholders”, a term coined by Anschitz and van de Klundert (2000), covered later in this paper. It is therefore crucial to understand any animosities, alliances or bonds that stakeholders might have among one another.

2.2.3 Markets for waste products

The markets for waste products play an important role when determining the financial sustainability of a waste system. As processing of waste often entails high capital and operating costs (plants, machinery, technical staff, etc.), decisions in this space have to carefully weighed against local and regional demand. In India for example, chemical fertilizer has been heavily subsidized by the government, often to the disadvantage of more natural and less harmful alternatives such as compost from waste (Anand, 2010).

Estimating demand is a difficult proposition. Rough estimates can be made by enquiring with local farmers as to their fertilizing needs, understanding energy needs by local firms (viability for RDF production or incineration) and analyzing wider markets. Understanding both the demand side for waste products and understanding what products can be made given a certain waste composition (see waste composition, 2.2.6), allows for informed decision-making in waste production. The resulting institutional structure should at best serve both the meta-functions of environmental conservation as well as value creation.

2.2.4 Interacting with waste workers and households

The best way to get to understand a system from ground-up is interacting with the people that are affected by it the most and have the most knowledge of it, i.e. waste workers and households. Waste workers fall into two categories, formal and informal. Informal will be explored in more detail in the “informal sector analysis”. Interacting can entail both more quantitative steps like using surveys as well as qualitative measures like the *empathize* process in design thinking. The *empathize* process is ideally suited for qualitative understanding, entailing three steps (Stanford d.school, n.d.):

- *Observe*: understanding behavior in the context of people’s lives and work
- *Engage*: a euphemism for interviewing, eliciting stories by listening as opposed to solely asking questions. Being guided by interviewees.
- *Watch & listen*: combination of observing and engaging, showing processes at hand
An initial understanding of these “bottom” processes will foster an intimate understanding of the positive and negative sides of the current institutional structure in operational processes.

2.2.5 Understanding perceptions of waste

Less of a concrete tool, understanding of perceptions of waste is a motif that spans through all interactions with anyone in the waste system and the general public. Paying attention to how people understand waste in their lives can be extremely helpful when designing institutional structures. Some societies are more prone to understanding waste as a resource, some just regard it as trash, others see it as a major detriment to the environment that needs to be taken care of. These perceptions are closely related to the concept of prioritizing meta-functions.

2.2.6. Quantitative top-down analyses

The aim of a quantitative analysis should be a systemic understanding of the costs, size and other data involved in the institutional structure. Several data categories are extremely helpful in this regard:

- Government budgets on all levels
- Financial statements:
  - Waste companies
  - Municipal corporations
- Census results:
  - Demographics
  - Population
  - Socioeconomic data
- Technological sophistication:
  - Equipment used
  - Maintenance
  - Contextual appropriateness
  - Comparison across countries
- Waste data
  - Composition
  - Flows
  - Amounts

Analyzing data allows for a systemic overview over a current institutional structure. Understanding cost structures and cash flows can lead to major improvements in the economic viability of a waste system. Government budget give insights into how government entities set their priorities with regard to waste and what the major budget expenses are. Financial statements of companies help understand how salaries for workers, equipment and transportation costs work together with overhead in order to create the cost structure of a current system.
Census results allow tailoring institutional structure around the specific demographics and socioeconomic distribution of a population. Poor areas might need a differently structured waste system than rich areas.

Technological sophistication is extremely important in the context of developing countries. Too often, technology is simply imported from developed countries in the hope of transforming waste systems immediately. The problem with this approach is that these technologies are usually ill-equipped for the local context and hard to maintain. Exemplary is the use of expensive compactors in developing countries that often cannot navigate narrow streets and that cannot be maintained properly due to a lack of expertise (Coad, 2011).

Data on waste might be the most important data. Understanding waste flows, the composition and the amounts of waste generated and processed allows for much better optimizing of operational functions. Composition and flows are important for the optimization of waste processing, whereas the amounts generated have a large impact on waste collection and economic viability.

2.2.7. Informal sector analysis

When it comes to waste management in developing countries, a common theme across all literature and efforts on the ground has been the division between the formal and the informal sector. The informal sector is defined by unorganised or informal workers lacking employment, work or social security (Government of India, 2007; Henley, Arabsheibani, & Carneiro, 2006). Wilson, Velis, & Cheeseman (2006) go further and characterize the informal sector as “small-scale, labour intensive, largely unregulated and unregistered, low technology manufacturing or provision of services” (p.1).

In the functional perspective, the informal sector is an important piece of the puzzle. Often it is a very efficient and integral part of the institutional structure but is not regarded as such by decision makers. Decision makers in formal waste management have been spent little effort on integrating it into their design of waste management systems. Historically, the informal sector and its many actors have played a major role in the municipal solid waste management of developing countries. It has been suggested that up to 2% of their urban population has found some sort of employment within the waste segment of the informal sector. Collectively they account for about 15 to 20 per cent of waste management. Usually the groups that participate in these practices are on the lower ends of the socioeconomic spectrum – minorities, women and the poor. There is even evidence that informal sector recycling can lead to better environmental outcomes than municipal recycling, resulting in larger decreases of greenhouse emissions (Gunsilius et al., 2011; Medina, 2008; The World Bank, 2014; Vergara, Damgaard, & Gomez, 2015).

These informal actors are usually engaged in recycling waste. In contrast to the recycling definition that we embrace in the west, in low and middle income
countries recycling is “not a service of cleaning or removal but a largely private economic activity based on valorisation and trading” (Scheinberg in Gunsilius et al., 2011, p.5).

Wilson et al. (2006) provide a food summary of the main activities of informal actors within the recycling system:

1. Itinerant waste buyers: Waste collectors who go from door to door and purchase waste from households
2. Street waste picking: Recovering materials from the streets or bins
3. Municipal waste collection crew: Taking material from municipal trucks transporting waste to dumpsites
4. Waste picking from dumps: Taking waste straight from the dumps
Using the example of SWaCH in Pune (Chikarmane, 2012), a fifth activity can be amended:
5. Informal household collection: Door to door waste collection by informal actors in a regular fashion, acting as replacement for municipal services.

Activities are thus mostly reduced to wastepicking and scavenging – coining the term “wastepickers” – “rag pickers” in India - to describe these informal workers. Recycling is mostly done by the informal sector in developing countries. The formal sector has not yet established structures that enable recycling effectively and cost-efficiently.

In a study of six cities in developing countries, Scheinberg, Simpson, & Gupt (2010) show that the informal sector can reap significantly higher monetary benefits from recycling and that it has recycled much larger percentages of waste than the formal sectors (table 1).

<table>
<thead>
<tr>
<th>City</th>
<th>Waste recycled by formal sector</th>
<th>Waste recycled by informal sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cairo</td>
<td>13%</td>
<td>30%</td>
</tr>
<tr>
<td>Cluj</td>
<td>5%</td>
<td>8%</td>
</tr>
<tr>
<td>Lima</td>
<td>0.3%</td>
<td>19%</td>
</tr>
<tr>
<td>Lusaka</td>
<td>4%</td>
<td>2%</td>
</tr>
<tr>
<td>Pune</td>
<td>0%</td>
<td>22%</td>
</tr>
<tr>
<td>Quezon</td>
<td>2%</td>
<td>23%</td>
</tr>
</tbody>
</table>

Source: (Scheinberg et al., 2010)

While the evidence seems to suggest that the informal sector is both cost efficient and effective in dealing with waste, it is still stigmatized by governmental institutions and society. Across the developing world, scavengers and wastepickers are subject to harassment by law enforcement and other groups (Castillo Berthier, 2003; Medina, 2000).
Developing countries have a tendency of reforming waste systems according to the standards of developed countries. Technology is imported and privatization occurs. This is problematic insofar as not all actors and nodes of activity in the current system are being evaluated for these reforms and the informal sector is often ignored in these decisions (Wilson et al., 2006). The disregard for wastepickers has many underlying factors. Socioeconomic backgrounds, non-existent organization and the very nature of their work contribute to their marginalization.

Analyzing the informal sector is therefore indispensable, especially in the context of developing countries. Since informal sectors are often difficult to characterize and little is known of them, one has to usually build a model up from the ground through interviews. Interviews should be aimed at extracting both quantitative (e.g. “how much do you earn”, “how many people work with you”, “what areas of the city do you cover”) as well as qualitative information (e.g. “what ethnicity are you”, “what challenges do you face”, “who are you selling to”).

Such questions allow both the characterization of material and cash flows in the informal sector as well as an understanding of their impact on the waste system, i.e. how much waste they collect, how much they recycle, what their earnings are, etc. Once these data are collected, an initial model idea can be formed - extrapolating from the data collected through interviews and other data sources (e.g. census data). An example will be examined in chapter 3.3.2.

2.2.8 Survey results

Stakeholder surveys are another useful tool to make quantitative inferences. Household surveys can be effective in understanding waste composition and generation. While a tedious process, the benefits outweigh the costs. Proper survey design should entail easy to understand questions than can be answered in a short period of time. Both quantifiable answers (Likert scales) and quantitative answers (open-ended questions) should be considered.

2.3 Understanding prioritization of meta-functions:

Since prioritization of meta-functions differs regionally and across time it is important to understand it in the local context. Exploring what meta-functions are more relevant in a given context is generally easy. Their prioritization directly stems from observable needs. Outbreaks of diseases due to waste or exposure of significant amounts of the population to toxic fumes of burning waste, as seen in Los Angeles (South Coast AQMD, 1997), is a clear indicator that public health is a priority.

Indicators can be both quantitative as well as qualitative in nature. Quantitative ones can include:

- Financial sustainability (value creation)
Qualitatively, meta-functional priority can be established by conducting interviews with decision-makers in the public sector, by observation within the local context (analyzing waste in streets for example) and by talking to local population. It is important to point out that it is impossible to make an exact, quantitative argument for prioritization of meta-functions. Usually prioritization reveals itself automatically from observing and understanding local context.

Once initial prioritization has been established, the instances of institutional structure within the scope of operational functions need to be examined. Prioritization can be re-evaluated and adjusted from those findings.

2.4 Synthesizing analysis results

The analysis of an institutional structure is on going. As attempts are made to change it, variables in the structure might change and might need to get re-evaluated. Once initial results have been aggregated, however, decision makers can move forward to designing solutions, discussed in chapter 4.

2.5 Summary

Chapter 1 and 2 have introduced the functional perspective and some of the tools used in it. Chapter 3 will introduce the reader to the case of Muzaffarnagar and how our research team applied the functional perspective in a variety of cases. Chapter 4 will expand on the final step, designing and implementing solutions.
3. The case of Muzaffarnagar: analysis

3.1. Background

Like so many things, formal waste management in India began with the story of a single person. Almitra Patel, an Indian activist, started enquiring into why waste kept on being dropped in the backyard of her village at the beginning of the 1990s. In 1996, she brought on a lawsuit against the union of India, which led the Indian Supreme Court to appoint an expert committee analyzing waste management in 300 municipalities in India. (Kirpal J, 1996; Sridhar, 2013)

The expert committee, formed by the Ministry of Urban Development released a manual on waste management to the Indian Supreme court in 1999. In the 700 page document, manuals for various types of waste management (primary collection, street cleaning, capacity building, landfilling, composting, etc.) are prepared (Ministry of Urban Development, 2000; Zhu & World Bank Institute, 2007). The manual also highlights several shortcomings in Indian waste management:

- 30-50% of municipal budgets are spent on waste management but disposal and collection services are inefficient and will not be able to handle the massive influx of rural population into urban areas
- 95% of waste budgets are spent on collection and transportation and only 5% on final disposal
- Most cities do not have long-term plans regarding waste management (Ministry of Urban Development, 2000).

Upon receiving the report, the Supreme Court established solid waste handling rules that were supposed to streamline waste processes across the entire country. In 1999, the 2000 Municipal Solid Waste (Management and Handling) Rules (from here on: 2000 MSW rules) were released and written into the law (Ministry of Environment and Forests, 2000).

How has the landscape in India changed since the publishing of the 2000 MSW rules and the various manuals? In 2009, Kumar et al. observed that of 59 cities analyzed for their paper, “No single municipality or local body has complied with the guidelines stipulated by MSW Rules, 2000” (p.885). The authors further criticize poorly designed collection and sweeping systems, ineffective and hazardous processing techniques and the lack of a systematic approach to waste management.

The gap between policy and implementation with regard to the 2000 MSW rules can be seen in collection rates in Indian cities, averaging around 70% (Nema A.K., 2004, as cited in Sharholy, Ahmad, Mahmood, & Trivedi, 2008). This means that a significant part of waste is not collected, usually in low-income areas. This is true for all waste types except recyclables. India’s informal waste sector is highly efficient in recycling valuable materials such as plastics, metals or electronics and it has been
estimated that between 40-80% of plastic get recycled in India (compared to approximately 10-15% in developed countries; Sharholy et al., 2008).

The poor waste management practices in India have led to a number of public health crises in recent years. There have been cases of increases in respiratory illnesses, and outbreaks of rabies and dengue fever (Annepu, 2013). E-waste and its improper recycling methods such as melting gold with acidic liquids pose a danger to people active in the sector (Monika & Kishore, 2010). Illegal dumping and disposal of biomedical waste threatens to cause major epidemics (Sairam, 2014).

As India's urban population is predicted to double by 2030 from 340m today, India's waste management problems become an even more urgent issue today. The government predicts that by 2047, India will be producing 260m tons of waste per year (Keya Acharya, 2012). These enormous masses of waste will not solely be generated in the renown megacities of India such as Calcutta, Mumbai or Delhi. A significant portion will stem from the currently 450 Tier 3 (T3) cities. The T3 cities, also referred to as Z cities, are defined by a population range of 0.1m to 1m inhabitants (Census Organization of India, 2011a; Government of India, 2008). These cities produce about 37% of India's total waste and are home to about 30% of India's population (Ranjith Kharvel Annepu, 2012).

Waste management research for these cities has been scarce, as most of it concentrated on the waste systems of megacities such as Mumbai, Delhi or Bangalore. Against this background, our research group spent three weeks in Muzaffarnagar, a T3 city in the province of Uttar Pradesh. Muzaffarnagar's population is estimated to be around 400,000 (Census Organization of India, 2011b), thus posing an ideal environment to research issues and challenges in T3 cities with regard to waste and to apply the functional perspective.

3.2 Methodology

The research for this paper was conducted in cooperation with Shriram college in Muzaffarnagar over the month of January 2015. The team conducting the research consisted of a diverse group from Shri Ram Group of Colleges, the MIT Tata Center for Design and Technology, and the MIT Development Lab, including the author. The MIT group consisted of several undergraduate\(^1\), graduate students\(^2\) and MIT research scientists\(^3\). The author conducted all stakeholder interviews, and coordinated and supervised the work in household surveys, the informal sector analysis, and waste audits together with Kate Mitty, Master candidate in urban planning at MIT (kmitty@mit.edu).

\(^1\) Raluca Ifrim '15, Cecilio Aponte '15, Sarah McMillian '15
\(^2\) Ching-Ching Liu & Ellen Huang – environmental engineering; Kate Mitty – urban planning; Julius Danek – finance
\(^3\) Randolph Kirchain, PhD & Jeremy Gregory, PhD – material systems laboratory; Libby McDonald – MIT Co-Lab; David Langseth – civil engineering
The research proved a unique opportunity to test the concept and tools of the functional perspective in practice. One aim was to provide the city of Muzaffarnagar and the management of the waste company A2Z – contracted by the city to provide waste management – with an analysis of the current waste system and the formulation of viable alternatives and solutions. The other aim was to formulate and test a replicable framework for waste management. To that end, the functional perspective was applied in the field, using the following tools:

1. Stakeholder analysis
2. Mapping power relations
3. Informal sector analysis
4. Household surveys
5. Waste audits
6. Understanding regulation
7. Quantitative data collection, analysis and financial modeling

This chapter will outline the tools that were used and the results of our analysis. Chapter 4 will touch upon solutions and the iterative process of piloting.

3.2.1 Stakeholder analysis and mapping power relations

Stakeholders were identified through systematic interviews with municipal officials, waste workers, A2Z employees, political leaders, waste pickers and Kabadiwalas. The analysis allowed separating stakeholders into different categories as well as breaking down their individual problems. Each stakeholder group was interviewed at least once, with several individuals giving their perspectives in each group. Table 3 gives an overview of interview partners.

Table 3: Interview partners in Muzaffarnagar

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Interview partners</th>
<th># of interviews</th>
</tr>
</thead>
<tbody>
<tr>
<td>Municipal government</td>
<td>Mayor of Muzaffarnagar</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Executive officer of municipal corporation</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Public Health department</td>
<td>2</td>
</tr>
<tr>
<td>A2Z Infrastructure</td>
<td>Executive Management</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Waste workers</td>
<td>3</td>
</tr>
<tr>
<td>Wastepickers</td>
<td>Individual waste pickers</td>
<td>37</td>
</tr>
<tr>
<td>Kabadiwalas</td>
<td>Individual Kabadiwalas</td>
<td>13</td>
</tr>
<tr>
<td>Bulk Generators</td>
<td>Hotels, banquet halls, restaurants, hospitals</td>
<td>20</td>
</tr>
<tr>
<td>Households</td>
<td>Individual households</td>
<td>68</td>
</tr>
<tr>
<td>Balmiki</td>
<td>Representatives</td>
<td>2</td>
</tr>
</tbody>
</table>
The interviews were conducted either at Shri Ram college or on the roads of Muzaffarnagar. Interview settings were purposely made informal; questions asked were not leading and usually open-ended such as:

- What are the biggest challenges you face?
- How do you usually tackle these challenges?
- Who are other actors in the waste system that you interact with?
- Where do you see your role in the system?

The interview techniques were adopted from the design thinking approach. After an initial round of approximately six interviews, a first picture began to emerge, giving a rough overview of who the stakeholders were. Further interviews and observations resulted in a better segmentation and a clear set of tangible challenges. Throughout the interviews, stakeholder power relations were probed and mapped. Some ongoing conflicts surfaced early in interviews, some did at a later point. Often it was the case that individuals that were placed lower in the hierarchy, like waste workers, would have significant knowledge of stakeholder relations.

3.2.2 Informal sector analysis

Interviews with 50 workers in the informal waste sector allowed insights into the impact that informal recycling has on the waste system in Muzaffarnagar. These interviews were conducted by first approaching rag pickers and Kabadiwalas during their work and conducting initial interviews. In most cases, follow-up interviews were conducted in order to obtain additional information that would only be asked after establishing rapport (questions about ethnicity, discrimination, access to social services, etc.). Most workers were initially distrustful, suspecting cooperation with police or government authorities.

The initial survey enquired about basic demographics, sales and price data for collected materials and the supply chain (appendix 1). Synthesizing this information enabled constructing a value chain for recyclables and provided estimates of the impact of the informal waste sector in Muzaffarnagar. Further interviews gave insights into the social fabric of the informal sector and access to government services such as health and education.

3.2.3 Households surveys

As no previous data had been collected on household waste, our research groups set up own surveys. The surveys were distributed to 68 households, conducted in 14 low-income, 27 middle-income and 27 high-income areas. The surveys covered questions about:

- Household demographics
- House location and characteristics
- Waste services delivered
- Garbage produced
- Willingness to pay for waste system
- Price data on sold recyclables

A sample survey can be found in appendix 2.

3.2.4. Waste audits

The supplement household survey data, household waste audits were conducted. The samples were collected from the same households that were interviewed. The high-income and middle-income areas were sampled twice, leading to a total of 122 waste samples. While conducting the waste audits, A2Z workers went on strike in the low-income area. As a result, the waste generation are in low-income households is slightly skewed upwards.

3.2.5 Understanding regulation and contracts

The key to understanding regulation were reading related documents, such as the 2000 MSW rules. Additionally, interviews with officials revealed the most urgent problems that the municipality faced in Muzaffarnagar. The fact that our research team got access to the contract between A2Z and the municipality tremendously helped understand how the Muzaffarnagar waste system was to be organized in an ideal state. This method is very much dependent on the access that an actor has to documents related to regulation and contracting.

3.2.6 Quantitative data collection, analysis and financial modeling

Data was obtained both through own research as well as acquiring it from other parties. A2Z provided profit and loss accounts, waste and fee collection data and employee data. The municipality provided data on their budgets. Through individual interviews, data was collected that gave insights into worker productivity, wages, equipment cost, etc.

Using this data, a financial model of the Muzaffarnagar waste system was built using both variables obtained top-down as well as bottom-up. This financial model allowed evaluating what parts of the system were most costly, which ones caused the greatest variability in results and what effects proposed changes to the system could have. To account for fluctuating variables, both Gaussian and uniform random distributions were used in a Monte-Carlo simulation of the Muzaffarnagar system.
3.3 Results

3.3.1 Stakeholders in the Muzaffarnagar waste system

Table 4: Stakeholders and roles

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary</strong></td>
<td></td>
</tr>
<tr>
<td>Households</td>
<td>• Pay for waste services,</td>
</tr>
<tr>
<td></td>
<td>• Expect daily pick-up of trash</td>
</tr>
<tr>
<td>Bulk generators</td>
<td>• Produce &gt; 14,400 kg of waste per year</td>
</tr>
<tr>
<td></td>
<td>• Supposed to pay for waste services</td>
</tr>
<tr>
<td></td>
<td>• Daily pick-up of trash</td>
</tr>
<tr>
<td><strong>Secondary</strong></td>
<td></td>
</tr>
<tr>
<td>Municipality</td>
<td>• Responsible for waste management in city</td>
</tr>
<tr>
<td></td>
<td>• Collect taxes and provide waste budget</td>
</tr>
<tr>
<td></td>
<td>• Employ street sweepers</td>
</tr>
<tr>
<td>A2Z</td>
<td>• Waste management company, responsible for primary and secondary collection, and disposal</td>
</tr>
<tr>
<td>Balmiki</td>
<td>• Part of a local case, provide private sweeping and cleaning services to households</td>
</tr>
<tr>
<td>Kabadiwalas</td>
<td>• Itinerant waste buyer</td>
</tr>
<tr>
<td>Rag pickers</td>
<td>• Pick-up recyclables from secondary dumpsites or streets</td>
</tr>
</tbody>
</table>

The stakeholders are tied together on many different levels. To complicate matters, the Indian caste system and religion still hold sway over how stakeholders interact in Muzaffarnagar. This leads to some entrenched interest groups pursuing power for their specific politically-, caste-, religiously- or profit-motivated aims. Our research identified seven different stakeholders, listed in table 4. The following section will give brief outlines of the stakeholders and their issues.
Households

There are approximately 65,000 households in Muzaffarnagar, with an average household size of around six people. Estimated waste generation is 0.315kg of waste per person per day, which comes to about 1.89kg per household. Households are entitled to a daily collection of waste by A2Z, provided they pay their waste fees of Rs. 30 per month (~$0.5). Households that cannot afford to pay the fee are decreed to dump their waste into one of the 45 secondary dumpsites established in the city.

Parallel to A2Z services, many households hire private sweepers (Balmikis) to clean bathrooms in their houses or to carry out trash. Regular sale of recyclables to Kabadiwalas (itinerant wastebuyers) gives households additional monthly incomes of Rs. 200-300 per month. Still with this additional income, only about 35%-40% of households pay their fee.

Household behavior and attitudes are indirectly responsible for several major issues in the current waste system. In general, India has in the past and present had problems with its citizens’ attitude towards garbage and waste. Traditionally seen as a task of lower castes, many Indians do not regard proper treatment and cleaning of waste as their problem (Pillalamarri, 2014; Sachs, 2014) and deny responsibility for it.
These attitudes were reflected in Muzaffarnagar. Piles of waste could be seen on roads, squares, rivers, drains and all other public places. Citizens believe it is the governments’ responsibility to take care of their garbage, leading to a classic stalemate position. Households clean their own house but often simply dump waste on street, refusing to pay the fee for waste services provided by A2Z. While citizens acknowledge the detrimental impact of waste, they are unwilling or unable to adapt their behavior accordingly. This also results in limited communication between A2Z and citizens, hindering a fostering of mutually beneficial relationships.

The reasons for this root in educational deficiencies, group behavior, and weak rule of law – and a classic case of the tragedy of the commons (Hardin, 1968). Our local collaborators used the term of “limited waste awareness” as a catch-all variable to reflect both educational deficiencies regarding the impact of waste, as well as the
inability to develop a different attitude towards it. A detailed discussion of the reasons and psychological reasons underlying this is well beyond the scope of this paper but further research can be found in Oskamp et al., 1991; Refsgaard & Magnussen, 2009; Taylor & Todd, 1995.

Table 5: Defining household problems

- Limited waste awareness regarding environmental impact of waste and development of positive attitudes
- Dumping of waste in unofficial areas leads to unclean public places and clogged drains
- Relationship between A2Z and households is fickle
- Many households do not pay waste collection fee

Bulk generators

Our research team defined a cut-off for large bulk generators at 14,400 kgs of waste a year, coming to about 39kg/day. Bulk generators include restaurants, hospitals, banquet halls, and hotels and businesses. Muzaffarnagar has total of about 25 hotels and 25 banquet halls (large generators), each producing an average of 76 tons of waste a year, i.e. 208 kg/day and 4000 small generators producing an average of 2.8 tons per year, i.e. 7.6 kg/day.

Figure 7: Bulk generator definitions and cut-off

The waste from these bulk producers is for the largest part food waste, thus mostly organic. Hospitals are obliged to contract private companies to get rid of their biomedical waste. While bulk generators produce significant amounts of waste – between 4-5% of the city’s total yearly waste can be attributed to bulk generators –
they do not receive any type of special service or attention by either the municipality or A2Z.

Bulk generators, regardless of quantity of waste produced, are classified by A2Z as commercial property and pay a higher monthly fee of Rs. 40. This fee is flat and independent of the waste produced. Still, very few bulk generators actually have formal waste management and even fewer are paying for it. Common practice is to dump waste either on the streets, in secondary dumpsites or feed it to animals. In some cases, even illegal burning of trash was observed. Recyclables were usually collected and sold to Kabadiwalas in weekly intervals. Not a single bulk generator had put accounting practices in place to keep track of how much waste they produced.

Table 6: Defining bulk generator problems
- Very few have formal waste management and are paying for it
- Burning of trash
- No accounting of waste output
- No focus on bulk generators by waste management even though large output of waste

**Municipality**

The municipal corporation of Muzaffarnagar is decreed by the 2000 MSW rules to provide waste management services within the city limits of Muzaffarnagar. Prior to establishing a private-public partnership for waste management with A2Z in 2011, the waste system in Muzaffarnagar was handled solely by the municipal corporation.

In 2014, the total municipal budget amounted to Rs. 69 crore (one crore = 10,000,000). Rs. 25 crore of that budget were spent for municipal waste services, i.e. ~36%. Most of the work has been contracted to A2Z: primary collection, secondary collection, processing and disposal. The municipality itself retains around 850 municipal sweepers on payroll. 587 of these sweepers are "permanent" workers.

Permanent government jobs in the Indian context mean lifelong employment and benefits for workers, high costs and no possibility of severance for the government (Luce, 2008). The permanent government workers earn a multiple of their free-market pendants (20,000 Rs./month v 5200 Rs./month) and are the major item on the municipality budget, amounting to costs of about Rs. 21 crore – 30% of the municipality budget (!!!). Considering the fact that they cannot be fired, many workers do not even show up for work or do so half-heartedly.
The contracts for those permanent municipal workers were the result of a power strategy employed by the local sweeper cast, the Balmiki (see private sweepers). Threatening strikes and non-contribution to the waste system, they were able to systematically increase wages and number of permanent workers year after year.

The relationship between the municipality and A2Z is strained. The municipality is unsatisfied with services provided by A2Z and is holding back payments to them. Our research has also shown that it is very likely that rent-seeking behavior from both sides plays a role in these struggles, which would be a common theme in India ("A bad boom," 2014). Additionally, the contract between A2Z and the municipal government has been breached many times by both sides without consequences. This lack of institutional oversight and rule enforcement is seen throughout India, giving it number 182 on a ranking of countries with worst enforcement of laws and barely giving last place to Timor (Sundaresan, 2011). Adding to the struggle, few households pay their collection fees, putting a dent into municipal budgets.

The institutional failures plaguing India are well beyond the scope of this paper. There seems to be commitment at the top of the municipal government to improve the current waste systems but many issues that the city is struggling with stem from the past and pose significant systemic challenges.

Table 7: Defining municipality problems

<table>
<thead>
<tr>
<th>Problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Large amount of government budget tied into permanent contracts with municipal sweepers</td>
</tr>
<tr>
<td>• Rent-seeking behavior</td>
</tr>
</tbody>
</table>
A2Z

A2Z Infrastructure Ltd. was created as a subsidiary of A2Z Group in 2007 with the aim of becoming a leading integrated waste management services company. Their approach entails consolidating the processes of collection and transportation (C&T), and processing and disposal (P&D) of waste under the umbrella of one corporation. By 2014, A2Z employed 5,000 people and had waste management contracts in 24 Indian cities. A2Z for the first time offered a wholesome, integrated approach – a novelty in India. Previously different processes in waste systems would be outsourced to different agencies (Kansal, 2014).

In 2011, A2Z Infrastructure was contracted to deliver their integrated solution in Muzaffarnagar. A disposal and processing facility was setup in the outskirts of the city and provisions were made to give A2Z access to municipal equipment such as dumpers, front-loaders and tractors free of charge. A2Z established primary collection for the first time in the city's history and organized transportation from the 45 secondary dumpsites to the processing facility. At the facility, waste is sorted in different stages, resulting compost and RDF (refuse derived fuel) as end products.

To finance their operations, A2Z receives a tipping fee from the municipal corporation which is supposed to be increased incrementally over the next couple of years. Additionally, RDF and compost products are sold into local markets. A2Z employs around 310 people in Muzaffarnagar, 270 of which work in C&T and 40 in P&D.

A2Z faces a whole host of challenges in Muzaffarnagar, mainly related to financial, operational and governance issues.

Operational

The company is not able to deliver full services to all households. A2Z employs 170 door-to-door collectors for primary collection. At the current number of households, A2Z would need at least 325 door-to-door collectors to provide full service\(^4\). Currently, A2Z claims to cover around 84% of all properties (households and commercial) in Muzaffarnagar.

A2Z's processing plant is not working as envisioned. The road to the plant is rocky, causing vehicles to break down. Further, the electric connection to the plant is not

---

\(^4\) By A2Z's assumptions, one collector covers 200 households in a day. At a population of 65,000 this would mean at least 325 collectors, without staff on standby
industrial, allowing for only 6-8 hours of operation every day. This means that not all of the around 120 tons that arrive at the facility every day get processed, i.e. separated into plastic and organics. A2Z estimates to have a backlog of around 3000 tons of waste due to lack of electricity.

The transportation processes from secondary dumpsites to the plant are also highly inefficient. Secondary dumpsites are often not demarcated and have sprung up organically. This means that their locations in the city are often random and the city has until this moment not been able to expand the resources to plan and relocate them. A tandem team of a dumpster and a front loader (see picture 2) have to spend 10-15 minutes per dumpsite in order to clear them while halting traffic around them, making this process highly cumbersome.

Picture 2: Front-loader and dumpster clearing secondary site

Financial

While posting positive numbers in its first two years in Muzaffarnagar, A2Z has been writing losses as of recent. Since 2011, fuel and salary costs (which constitute around 86% of A2Z’s costs) approximately doubled. Additionally, the municipality owes A2Z six months worth of tipping fees, amounting to ~Rs.9.2m (~$150,000)
As a result of A2Z inability to provide full coverage for the city, the municipality decided to stall the payments of tipping fees to the company and not increase them as stipulated in the contracts. The delayed payments from the city are not only a result of undelivered services but also seem to result from rent-seeking behavior of city officials clearing payments to A2Z. The financial situation led A2Z to not pay employees for several weeks, causing strikes among door to door collectors.

In addition to not receiving contractual payments, A2Z's revenue streams from selling waste end products are not producing the hoped for cash flows. As of December 2014, A2Z had a stock of 7000 metric tons of loose RDF but had only sold 70 tons for around 900 Rs./ton in the months from Q2/14 – Q4/14. Over the same time period, A2Z sold 94 tons of briquetted RDFs at 5000 Rs./ton. The situation in composting products is much better. In the same time frame, A2Z sold 1600 tons of compost at roughly 1800 Rs./ton while producing 1945 tons. Regardless, A2Z still had stock of around 2500 tons of compost in December 14.

Demand for any A2Z product seems to be meager and seasonal. Interviews with farmers conducted by a different research group in January 2015 in Muzaffarnagar showed that they were often distrustful of recycled compost. The vast government subsidies to chemical fertilizers complicate the situation even further.

**Governance**

A2Z’s governance structure in Muzaffarnagar is not very well developed. Multiple times, business numbers and assumptions changed depending on the person interviewed or were even changed by the same person. Often, it was unclear who answered to whom and how the business was actually organized. Accounting practices were extremely obscure, using a mix of paper-based and computer-based accounting. A2Z’s management at times did not seem qualified enough for the jobs they were assigned to. Some managers never worked in the waste sector or a public private partnership before, and had never been in leadership positions.

<table>
<thead>
<tr>
<th>Table 8: Defining A2Z problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Unable to fulfill service obligations due to financial reasons and understaffing</td>
</tr>
<tr>
<td>• Inefficient processes in operations</td>
</tr>
<tr>
<td>• City infrastructure not well developed for current approach to waste system</td>
</tr>
<tr>
<td>• Accounts receivable with municipality</td>
</tr>
<tr>
<td>• Increases in salaries and fuel costs</td>
</tr>
<tr>
<td>• Unstable demand for waste end products</td>
</tr>
<tr>
<td>• Bad governance with obscure accounting structure</td>
</tr>
</tbody>
</table>
Balmikis

The Balmikis (sometimes referred to as Valmikis) are one of the scheduled castes in India. They are considered one of the lowest castes, even among the Dalit (untouchables). Traditionally their tasks were to clean public toilets and drains and sweeping streets. Today, Balmikis are largely still employed in the same type of jobs ("Balmiki," n.d.). The leaders of the Muzaffarnagar Balmiki community tell of some 10,000 Balmiki working in various professions. A large number of them are uneducated and struggling to secure steady employment.

Table 9: Balmiki groups

<table>
<thead>
<tr>
<th>Balmiki groups</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private sweepers</td>
<td>~1000</td>
</tr>
<tr>
<td>Municipal sweepers</td>
<td>~850</td>
</tr>
<tr>
<td>A2Z workers</td>
<td>~200</td>
</tr>
</tbody>
</table>

About 1000 work as private sweepers, employed by households to fulfill certain tasks like cleaning bathrooms and emptying waste bins. These sweepers will come into the house once a day and spend up to half an hour fulfilling these tasks before moving on to the next client. Waste bins are either emptied into the street or drains, or are brought to secondary dumpsites. In addition, almost all the municipal sweepers and A2Z workers are part of the Balmiki community.

Sometimes interchangeably used with the notion of a union, their interests are represented by community leaders. Each group (A2Z, private sweepers, municipal sweepers) are represented by their own leaders. In turn, the entire 10,000 Balmikis have additional leaders. Their political agenda is fairly simple, every Balmiki should be employed in a government job, paying an ample lifetime salary and benefits as municipal sweepers. In the past, Balmiki leaders threatened strikes in the waste system, coercing the municipality to dedicate more and more of its budget towards the municipal sweepers.

The arrival of A2Z in the city undermined the bargaining power of the Balmiki leaders, by taking over many of the waste functions in the system and receiving some of the government budget. Today, effective collaboration between the two parties is difficulties as A2Z and the Balmiki leadership compete for the power over the waste system in Muzaffarnagar. Additionally, A2Z and private sweepers compete for households, sometimes leading households to pay both A2Z and private sweepers. Interestingly, A2Z also provided much needed employment to some Balmikis, which resulted in a rift between private sweepers Balmikis and A2Z employed Balmikis.

Table 10: Defining Balmiki problems

- Loss of money and power since A2Z arrival
- Demand more permanent jobs and higher salaries
- Clash with A2Z and tensions between factions within caste
Households pay private sweepers and A2Z Kabadiwalas

Itinerant waste buyers or Kabadiwalas are at the heart of the informal sector in Muzaffarnagar. They can be divided into three categories, going up the value-chain: door-to-door, aggregator and wholesale Kabadiwalas. Door-to-door simply buy recyclables from households and resell them to the aggregators, which in turn sell them to the wholesale Kabadiwalas. Going up the value-chain also means an increase in incomes. At the wholesale level, materials get resold to industrial plants or dealers in Delhi. The whole system is characterized by low profit margins.

As part of the informal sector, Kabadiwalas are neither organized nor represented on a decision-making level. Often they are in debts to finance their capital purchases such as shops or vehicles. In addition to this, illiteracy among them is high and many Kabadiwalas do not even have access to basic social services like education or healthcare.

Table 11: Defining Kabadiwala problems

| • Low profit margins |
| • Debts |
| • Illiteracy and access to social services |

Rag pickers

Opposed to Kabadiwalas that buy recyclables from households, rag pickers in Muzaffarnagar operate mostly on the secondary dumpsites throughout the city and the heaps of trash strewn across the streets. The recyclables they pick up from secondary dumpsites are usually resold to Kabadiwalas. Working conditions are hazardous due to dealing with waste and child labor is prevalent. It is common for older rag pickers to simply oversee children doing the work.
Being mostly part of the Muslim minority, uneducated, illiterate and without any significant assets, rag pickers are the stakeholder with least influence in the system. Their livelihood situation is often precarious, living in slums on the outskirts of the city. Together with the Kabadiwalas however, the rag pickers have a significant impact on city waste management, explored in the informal sector analysis (3.3.2).

**Table 12: Defining rag picker problems**

| • Hazardous work conditions  |
| • Child labor              |
| • Illiteracy and access to social services |

The waste system in Muzaffarnagar is highly complex and the conflicts between stakeholders are numerous. A2Z, being a newcomer to the city, is struggling with internal issues as well as external conflicts with the Balmiki and the municipality. The municipality suffers under the legacy of prior work contracts and has to ensure that the waste system runs smoothly and is financially stable. The Balmiki have both internal and external conflicts and are upset about the loss of money and power they incurred with the arrival of A2Z.

Citizens of Muzaffarnagar, when asked, are not happy about the current waste system but there are no individual incentives to change anything. Bulk generators
are underserved and not monitored in the current system. The informal sector, while having a very positive impact on the city, is marginalized and works in terrible conditions.

Figure 9: Impact and influence spectrum of stakeholders

A. Stakeholders with high impact and low influence will require special initiatives to protect their interest; this applies to Kabadiwalas and rag pickers
B. Stakeholders with high impact and influence have the highest priority in order to ensure an effective waste system.
C. Stakeholders with low impact but high influence may be sources of significant risk and must be monitored. Important here are the Balmikis.

Source: adapted from Snel & Ali (1999)

The stakeholder analysis was extremely helpful when our team started dissecting the institutional structure of the Muzaffarnagar waste system. Understanding the different actors and their perspectives was crucial to facilitating solutions that aligned with everyone's interest and included marginalized groups like the rag pickers or Kabadiwalas.

3.3.2 The informal sector in detail

Rag pickers

Of the rag pickers interviewed, the overwhelming majority was male. 57% of them utilize carts in their work, mostly rented. These carts are usually financed through loans obtained from Kabadiwalas that are higher up in the value chain. A cart can increase a rag picker's productivity by allowing him or her to store up to 100kg of recyclables in it. Higher volume can translate into better prices at aggregator Kabadiwalas.
Table 13 contains a few basic statistics about rag pickers. Their young age average reflects the fact that many of them started their work even below 14. Income also varies with age, the older a rag pickers, the higher his or her income. Rag pickers average around Rs. 6000 (~$100) per month, a salary that puts them above their peers at A2Z or temporary municipal sweepers, groups that both earn around Rs. 5000 per month.

The profit margins for rag pickers are the highest in the informal sector. As they do not need to buy recyclables but collect them, they are able to capture the full initial value of items collected. A good example is polyethylene that rag pickers and Kabadiwalas are able to sell for Rs.7/kg on the market but that Kabadiwalas have to buy from households for Rs.3/kg, thus only realizing about Rs.4/kg in profits. On the
other hand, rag pickers face a much more hazardous work environment and are considered to be of lower status than Kabadiwalas.

**Figure 12: Rag picker age distribution**

![Age Distribution]

---

**Kabadiwalas**

The three categories of Kabadiwalas – door-to-door, aggregator and wholesale – each make about the same profit margins but are differentiated through the volume they process. Most of the door-to-door Kabadiwalas own their own carts with an average purchase price of Rs.4000. Many of the wholesale or aggregator Kabadiwalas specialize in certain materials like electronics or metal, allowing more aggregation. Additionally, these two groups usually rent or own storage space, a tremendous advantage over rag pickers and door-to-door Kabadiwalas, as storage space allows accumulation of goods and thus increases bargaining power. In total, we observed around 20 different categories of waste with different prices, ranging from 4Rs./kg for polyethylene up to 2000Rs./kg for human hair.

The value chain from door-to-door to aggregator to wholesale Kabadiwala also is also equal to a social ladder. With accumulating capital, Kabadiwalas can purchase assets such as more carts and storage space and thus progress their business. At the level of the wholesale Kabadiwalas, businesses can be larger operations with multiple employees and up to several hundred square meters of storage space.

**Analyzing informal sector impact**

Analyzing geographic distribution of informal sector activity and community estimates, combined with household data on sold recyclables allowed extrapolation on the size of the informal sector and its impact. We estimate that Kabadiwalas recycle around 3343 tons of waste a year and rag pickers another 1643 tons. This implies that a total of 4986 tons per year of waste gets recycled through the informal sector alone, i.e. 13.6 tons per day. The importance of the informal sector for local industry is thus not to be underestimated as they provide locally sourced materials.
For comparison, the municipality estimates that the municipal sweepers cleaning the streets of 10-15 tons per day and A2Z receives around 110 tons per day at its processing facility. Considering the average amount of rupees that the city pays to dispose of one ton of waste, this translates into savings of about Rs. 2.5 crore (Rs. 25,000,000 ~ $410,000) – almost the amount budgeted for A2Z services. The informal sector is the only recycling actor in the Muzaffarnagar waste system. A2Z itself does not engage in any recycling activity, not counting composting organics and producing RDF.

By its nature, the informal sector runs parallel to formal waste management systems. Muzaffarnagar has an excellent informal waste sector due to the openness of its formal waste system, giving rag pickers access to secondary dumpsites and few cases of police harassment. How can this system further be improved though? Some answers lie in formalization and the inclusion of rag pickers and Kabadiwalas into formal systems, discussed in chapter 4.

3.3.3 Cost analysis

To analyze the cost structure of the current waste system implemented by A2Z, this paper developed a financial model. The costs were broken down into monthly costs per ton, not accounting for capital purchases needed. Capital purchases were left out intentionally as the aim of the model was to provide an overview of the running costs of a waste system.

The model was built with data collected from ground up as well as with data received from various financial documents gathered from A2Z. As many financial documents that we were provided with left major gaps in certain numbers, we supplemented these top-down data with data that we collected ourselves from A2Z employees and government officials, leading us to develop a fairly strong financial model. The major variables of this model and their explanations are listed in appendix 3.

Since the model was based of the current system, some implicit assumptions were made. Door-to-door collectors would go from household to household, until their vehicles (tricycles, see picture 4) would fill up, then return to secondary dumpsites to empty them. The number of waste collectors needed to cover the specified number of households is thus a function of their efficiency, i.e. of how many trips D2D collectors could make per day and the capacity of their vehicles.
From the secondary dumpsites, the dumper and front loader teams would then pick up the waste and transport it to the processing facility. The facility costs are assumed to be fixed, i.e. insensitive to the amount of waste processed. This could be seen in the financial numbers that A2Z presented to us. The costs did have some variability from month to month but not correlated with amount of waste.

Some variables were under strong volatility, such as the amount of waste generated by household. For the model, this variable was assumed to be normally distributed with a mean of 1.5kg of waste per day generated per household and a standard deviation of 0.2kg. Based on this, Monte-Carlo simulations of the model were run to determine the cost structure.

The results from the financial model indicated that primary collection from households was the major cost point in the current waste system, accounting for about 51.5% of total costs, at a 95% confidence interval of 48% - 55%. The remainder of costs was fairly evenly split between secondary collection and processing costs. In primary collection, the main cost are the salaries paid to D2D collectors, accounting for 80% of primary collection cost.
Under the assumptions made on the current conditions of the waste system, the total cost to collect one ton of waste from households, transport it to the processing plant and to dispose of it there hovered around 1127 Rs. This cost per ton is primarily influenced by three variables in primary collection:

- Salary per door-to-door collector (figure 13)
- Daily trips of door-to-door collector to secondary dumpsite (figure 14)
- Capacity of D2D vehicles (figure 15)

The relationship between these variables and the cost per ton of the entire system is approximately linear for smaller increases or decreases. Holding all other variables constant, a 10% increase in salary costs leads to a 4% increase in costs per ton. A 10% increase in the number of daily trips leads to a 5% decrease in costs per ton. A 10% increase in capacity approximates a decrease of 5% in costs per ton. The marginal returns to increases or decreases in these variables flatten out at higher levels however.

Figure 13: Door-to-door collector salary and effect on costs per ton
These charts can tell how large the effect of primary collection is on the total cost per ton to dispose of waste. These effects are one of the major reasons why primary collection is a great candidate for improvement. To improve primary collection, efficiency of door-to-door collectors, i.e. capacity and trips to dumpsites, are great levers to begin with.

### 3.3.4 Revenue analysis

In addition to analyzing costs, a financial model was built to analyze revenues that end-products could yield. The results showed that A2Z's conversion process from raw RDF into briquetted RDF might not make economic sense. For 1 ton of briquetted RDF, A2Z received revenues ranging from 4000 Rs./ton to 5000 Rs./ton.
For 1 ton of raw RDF, they received revenues ranging from 900 Rs./ton to 1200 Rs./ton. As 1 ton of raw RDF results in 0.3 tons of briquetted RDF, the revenue benefit from briquetted RDF is marginal, not accounting for the additional cost that the conversion from raw RDF to briquetted RDF brings. This insight leads one to question whether the conversion makes economic sense in the first place.

However, this analysis does not consider the demand for both products. Further modeling and more sample data could unearth further results. The question is how A2Z could drive up demand for its end-products. A possibility would be to try product runs with pre-separated waste and determine whether these resulting products would have higher quality thus leading to higher demand. Pre-separation would also decrease production costs as fewer separation machines would be used.

3.4 Putting the Muzaffarnagar waste system in the functional perspective

The analysis presented above allows us to understand the institutional structure of the Muzaffarnagar waste system. A highly delicate environment, governed by multiple stakeholders that are in conflict with each other. The following section will provide insights into the waste systems under the functional perspective, analyzing both operational as well as meta-functions.

Figure 16: Operational functions in Muzaffarnagar

3.4.1 Waste generation

The primary generators of waste in Muzaffarnagar are households with an estimated 123 tons of waste generated per day\(^5\). Bulk generators add about 41 tons per day to that tally\(^6\). This amounts to a total generation of waste of 164 tons/day in municipal limits. Large industry does not count to that number, first because most of

---

\(^5\) 1.89kg of waste/day * 65,000 households

\(^6\) (2800kg of waste/year * 4000 small generators + 76000kg of waste/year * 50 large generators) / 365 days
it is located outside municipal bounds, second because it has their own waste management system.

Waste composition from household waste audits showed that 59.50%, of waste was organic and 40.50% inorganic. Of the inorganic waste, most recyclables such as plastics, bottles, cardboard, etc. were sold off to Kabadiwalas. No data is available on the composition of bulk generator waste.

Table 14: Results from waste audits in Muzaffarnagar, India

<table>
<thead>
<tr>
<th>Income Category</th>
<th>Area Name</th>
<th>Date</th>
<th>Total Weight (kg)</th>
<th>Total HHs</th>
<th>HH Members</th>
<th>Organic</th>
<th>Inorganic</th>
<th>Daily Weight per Person (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Income</td>
<td>Rehdaspuri</td>
<td>23-Jan-15</td>
<td>53.15</td>
<td>14</td>
<td>111</td>
<td>0</td>
<td>0</td>
<td>0.479</td>
</tr>
<tr>
<td>Middle Income</td>
<td>Dwarikapuri</td>
<td>14-Jan-15</td>
<td>16.40</td>
<td>27</td>
<td>142</td>
<td>55.18%</td>
<td>44.8200%</td>
<td>0.115</td>
</tr>
<tr>
<td>Middle Income</td>
<td>Dwarikapuri</td>
<td>22-Jan-15</td>
<td>31.55</td>
<td>27</td>
<td>142</td>
<td>64.50%</td>
<td>35.50%</td>
<td>0.222</td>
</tr>
<tr>
<td>High Income</td>
<td>Jat colony</td>
<td>21-Jan-15</td>
<td>56.45</td>
<td>27</td>
<td>121</td>
<td>50%</td>
<td>50%</td>
<td>0.467</td>
</tr>
<tr>
<td>High Income</td>
<td>Jat colony</td>
<td>22-Jan-15</td>
<td>35.2</td>
<td>27</td>
<td>121</td>
<td>68.32%</td>
<td>31.68%</td>
<td>0.29</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>59.50%</td>
<td>40.50%</td>
<td>0.315</td>
</tr>
<tr>
<td><strong>Std. Deviation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.08</td>
<td>0.08</td>
<td>0.158</td>
</tr>
<tr>
<td><strong>High</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>67.90%</td>
<td>48.90%</td>
<td>0.472</td>
</tr>
<tr>
<td><strong>Low</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>51.10%</td>
<td>32.10%</td>
<td>0.157</td>
</tr>
</tbody>
</table>

Source: (Mytty, 2015)

Waste generation in Muzaffarnagar is not discouraged, analyzed, restricted or regulated in any other way. There is zero waste separation on household level or bulk generator level. Public locations and streets contain almost no containers or public dustbins for people to dispose of their waste. There is no awareness surrounding waste or its consequences. An often-observed attitude was that as long as “my own house” was clean, what happened to waste outside of it was “none of my business”. Interestingly this behavior was even prevalent among the students we collaborated with after 4 weeks of intensive waste research. As opposed to disposing of waste properly into bins (as discussed and emphasized many times), the students would still throw their plastic wrappers and trash on the floor, waiting for someone else to collect it.
3.4.2 Waste collection

Primary

Primary waste collection in Muzaffarnagar is mainly done by four groups:

- **170 A2Z sweepers** provide daily waste collection to about 80% of household and commercial properties in the city, collecting an estimated 97 tons/day.
- **1000 Private sweepers** collect the trash from houses they cover, around 15-20% of households. Ideally, they dump this trash in the secondary dumpsites around town but more often it just ends up getting dumped in drains or the streets.
- **800 Municipal sweepers** clean the streets of waste and bring the swept waste into secondary dumpsites. They are estimated to collect around 10-15 tons per day.
- **Kabadiwalas** purchase recyclables from households and resell them to aggregators higher up the value chain.

Secondary

A2Z cleans the city's 45 secondary dumpsites once per day as stipulated by its contract. The logistics for picking up from the dumpsites are unnecessary complex and inefficient. The capital costs for procuring the necessary equipment (front-loader and dumpster) are very high. Fuel costs, maintenance costs and manpower needed to operate these machines contribute to high operating costs. An additional problem is the mistimed coordination between municipal sweepers and the A2Z pick up crews. Sweepers will often dump their waste into the secondary dumpsites after A2Z already has collected from them, leading to the issue of constantly filled dumpsites.

Since most of the secondary dumpsites grew organically, they are neither mapped nor marked. Only about 5 of the 45 have proper demarcations and are fenced. Usually, the waste will often stretch onto the streets, with traffic being diverted around it and animals roaming the street. This open disposal is helpful for rag picker access on the one hand but detrimental to city aesthetics and hygenics on the other.
According to A2Z, around 120 tons of waste arrive in their processing facility every day. Comparing this to generation numbers, there is gap of around 40 tons. 10-15 tons per day will be scooped up by rag pickers from secondary collection sites or bought from household by Kabadiwalas. The remaining 25-30 tons however end up in the streets, gutters, rivers or as food for animals (in the case of organic waste).
3.4.3 Waste processing

Waste processing in Muzaffarnagar occurs centralized at the A2Z plant. Before A2Z’s arrival in Muzaffarnagar, there were several landfills located throughout the city that saw the dumping of waste. At the A2Z facility, for the first time value is being extracted from waste in Muzaffarnagar – from organic as well as inorganic waste in the form of production of compost and RDF. A2Z is therefore engaged in value-centered waste processing.

The waste that arrives at the facility is mixed and not separated. Several separating machines (waste tumblers with different hole sizes, see “Pre-sorting” in table 6) separate the organic from inorganic waste on increasingly granular levels. Between separating processes, organic waste is periodically stored in windrows. All inorganic materials are collected and fed into RDF generating machines. Any materials that cannot be processed are professionally landfilled by A2Z. Due to the missing electricity at the plant however, there is a backlog of around 4000 tons of waste, stored in the backyard of A2Z’s plant.
For every 100 tons of unsorted garbage that A2Z receives, the company produces 18.9 tons of compost and 20.9 tons of raw RDF. In case 100% of the raw RDF is converted into briquetted RDF, this would result in 5.3 tons of briquetted RDFs. The rest of the material either gets lost along the composting process or is debris that will be landfilled.

<table>
<thead>
<tr>
<th>Cost Center</th>
<th>Pre Sorting 100 mm</th>
<th>Windrows 4</th>
<th>Pre Sorting 35 mm</th>
<th>Pre Sorting 16 mm</th>
<th>Pre Sorting 4 mm</th>
<th>End Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compost</td>
<td>82</td>
<td>41</td>
<td>36.9</td>
<td>26.9</td>
<td>18.9</td>
<td>18.9</td>
</tr>
<tr>
<td>RDF</td>
<td>15</td>
<td>0</td>
<td>4.1</td>
<td>1.8</td>
<td>0.0</td>
<td>20.9</td>
</tr>
<tr>
<td>Debris</td>
<td>3</td>
<td>0</td>
<td>0.0</td>
<td>0.7</td>
<td>0.0</td>
<td>3.7</td>
</tr>
<tr>
<td>Normal Loss</td>
<td>0</td>
<td>41</td>
<td>0.0</td>
<td>7.4</td>
<td>8.1</td>
<td>56.5</td>
</tr>
<tr>
<td>sum =</td>
<td>100</td>
<td>82</td>
<td>41.0</td>
<td>36.9</td>
<td>26.9</td>
<td>100.0</td>
</tr>
</tbody>
</table>

As mentioned in chapter 3.3.1, A2Z is unable to find enough buyers for its waste products. Even if the plant would be at full processing capability, it is doubtful whether A2Z would actually be able to capitalize on it financially. Farmers in the area mentioned unproven quality of compost as an issue. A2Z did not seem to have a grasp of the local demand for its product and did not seem to employ any efficient marketing strategies.
3.5 Meta-functions in Muzaffarnagar

Meta-functions are not as easily analyzed as operational functions. Their effect on the institutional structure of a waste system is intangible and can only be inferred through deduction and observation. Through our conversations with decision makers in Muzaffarnagar and through various policies that were enacted, we were able to make assumptions on how meta-functions were prioritized in Muzaffarnagar.

Very frequently, the topic of public health was mentioned. The municipality engages sanitary inspectors for each of the 45 wards that give weekly updates to three sanitary managers and the overseeing health officer for Muzaffarnagar. They keep track on how clean streets are and monitor how likely disease outbreaks are. It is fair to say that public health was and still is the main reason to establish waste systems in Indian cities, even though the situation has improved from several decades ago.

The aspect of value creation was another important underlying factor for some of elements of the Muzaffarnagar waste system. The business model of A2Z in parts relies on deriving value from the waste it collects, transforming it into various end-products. Additionally, the entire informal sector is structured around the aspect of value creation through re-selling of valuable materials.
With increasing wealth of a community, the importance of aesthetics increases. In communities with higher per capita incomes, streets would be cleaner than in communities with lower income per capita. The main streets of Muzaffarnagar, solely occupied by businesses and traffic often displayed larger amounts of open trash. This led us to conclude that aesthetics was only a concern for people as long as certain income levels have been reached and only concerning their own community, especially their own backyard.

Concern for the environment or pollution through waste was virtually non-existent. As Ida Ferrera observes: “When individuals decide on how much to consume and what to consume, they do not take into account how much waste they produce. Because the external costs of waste generation (such as air and water pollution) are ignored by individuals, more waste is produced and disposed of than is socially optimal.” (Ida Ferrera in OECD, 2008, p. 19).

This is precisely the case in Muzaffarnagar. Citizens receive very little education with regard to waste, its’ consequences and how it is managed. Interview partners mentioned that in primary school they talked about waste for a brief moment but it was never mentioned again. Currently, prime minister Modi’s clean India campaign is trying to change that and has successfully spawned grassroots organizations and movements calling for better waste management in India, but it has not taken hold in Muzaffarnagar yet (Dutt, 2014; Express News Service, 2014; “Swachh Bharat Abhiyan,” 2015).

Waste management in Muzaffarnagar thus seemed to be driven by the following meta-functions (in descending order):

1. Public health
2. Value creation
3. Aesthetics
4. Environmental conversation

These insights can be applied when planning a new or improved waste system in a city such as Muzaffarnagar. By understanding what the primary motivations are to have a waste system in the first place, it makes the adaption of waste management concept to local contexts easier.
4. Changing Muzaffarnagar’s institutional structure: improving household collection

4.1 Why improve household collection

It is clear that the current institutional structure of Muzaffarnagar does not optimize its operational functions. Some of the biggest issues that our team found were the unwillingness of households to pay their waste collection fees, the limited waste awareness of the public, the inefficiency of waste services delivered by A2Z and the conflicts between stakeholders. To improve the current system, step-by-step solutions need to be implemented that optimize certain functions within the system and require cooperation from all stakeholders as a means to alleviating their conflicts.

The situation in Muzaffarnagar is too complex to be solved with a single, “magic” solution however. To this end, we sought the operational function that could best be optimized, aiming for stakeholder consensus, financial viability, improved efficiency and a change in public perception of waste. The operational function of collection seemed to be a best fit in this case, specifically, household collection. Household collection seems to hold the greatest levers for improvements. In household collection, the current waste system delivers a service that is far from optimal. The current collection rate of 84% places Muzaffarnagar only in the medium bracket for waste services delivered according to the 2015 Wasteaware indicators (Wilson et al., 2015). The competition between private sweepers and A2Z hinders effective service and the financial situation of A2Z does not allow for more staffing.

The inefficiency of services also bloats the financial costs that A2Z faces in primary collection, as evidence by the financial models. To devise efficient solution, this paper makes use of the functional perspective and design thinking. How can we find the variables that optimize the function of waste collection in the Muzaffarnagar context? This paper proposes to use financial modeling, iterative processes and step-by-step design of small-scale pilot projects as tools. This is in accordance with function optimization. As the pilots start yielding first results, further iterations can be adjusted more efficiently, triggering positive feedback loops.

Extensive quantitative analysis and modeling, and small-scale projects bring the additional benefit of increased accountability. Participating parties will have more difficulties to engage in rent-seeking behavior and oversight will be easier.

4.2 Defining problems

Analysis through the functional lens allowed a deep understanding of the current institutional structure of the waste system in Muzaffarnagar. In order to design solutions to the issues discussed in chapter 3, this section will break down the problems in household collection. Table 16 introduces the issues in household collection, the affected stakeholders and meta-functions.
Table 16: Defining problems in operational function of collection - household collection

<table>
<thead>
<tr>
<th>Issue</th>
<th>Stakeholder</th>
<th>Meta-function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Households are not paying fee</td>
<td>• Households</td>
<td>• Value creation</td>
</tr>
<tr>
<td></td>
<td>• A2Z</td>
<td></td>
</tr>
<tr>
<td>Services are inefficient and do not reach every household</td>
<td>• Households</td>
<td>• Aesthetics</td>
</tr>
<tr>
<td></td>
<td>• A2Z</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Municipality</td>
<td></td>
</tr>
<tr>
<td>Waste gets dumped on streets by private sweepers</td>
<td>• Balmiki</td>
<td>• Aesthetics</td>
</tr>
<tr>
<td></td>
<td>• Households</td>
<td>• Public health</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Environmental conservation</td>
</tr>
<tr>
<td>Household collection is expensive</td>
<td>• A2Z</td>
<td>• Value creation</td>
</tr>
<tr>
<td>Secondary dumpsites are unorganized and not fenced</td>
<td>• A2Z</td>
<td>• Aesthetics</td>
</tr>
<tr>
<td></td>
<td>• Municipality</td>
<td>• Public health</td>
</tr>
<tr>
<td>Public awareness with regard to collection services and</td>
<td>• Households</td>
<td>• Public health</td>
</tr>
<tr>
<td>waste management is low</td>
<td>• A2Z</td>
<td>• Environmental conservation</td>
</tr>
<tr>
<td></td>
<td>• Municipality</td>
<td></td>
</tr>
</tbody>
</table>

4.3 Designing solutions for improved household collection

Based on the problems defined in 4.2 and the prioritization of meta-functions inferred in 3.5, it is possible to begin designing solutions. Public health was the meta-function most important in the context of Muzaffarnagar, so issues related to it should be tackled first, working down the list from there. A good point to start in household collection is a re-design and re-organization of the secondary dumpsites throughout the city.

4.3.1 Re-designing secondary collection sites

Secondary collection sites have sprung up organically in Muzaffarnagar. Only 5 of the current 45 sites have actually been properly fenced by the city (picture 8). A re-design would begin by documenting all these 45 dumpsites, determining their usage (how much waste does the dumpsite receive on a daily basis, at what times do waste workers from municipality and A2Z arrive, etc.) and examining the availability of government owned land in the city.
From the usage of the current dumpsites and the availability of land it will become possible to plan new secondary dumpsites. These dumpsites could both be fenced-off as well as optimally placed in order to allow A2Z door-to-door collectors shorter routes to them. This measure would help reduce both the cost of household collection as well as the issues with secondary dumpsite, thus optimizing the meta-functions of aesthetics, public health and value creation. As mentioned in 3.3.3, increasing the number of trips to secondary dumpsites could significantly decrease costs for household collection. In the long run, secondary dumpsites could be transformed into transfer stations that make efficient use of available space and contain separation facilities, thus optimizing all four meta-functions.

4.3.2 Educating households

As public awareness and education in regard to waste are extremely low, educational programs and outreach could help solve several problems. First, households might be more inclined to pay their waste collection fees if they realize the benefit provided to them and the importance of waste systems. Second, waste dumping and the “only my backyard stays clean” mentality might fade away, making streets cleaner and the putting more pressure on A2Z to actually provide efficient services. Programs could include citizen groups, educational components in school, reward and incentive schemes, and awareness campaigns.
4.3.3 Mitigating between Balmiki and A2Z

As the Balmiki are trying to regain power in the system, it would be beneficial to mitigate between them and A2Z. Several solutions come to mind. A2Z could contract some of its primary collection services to independent Balmiki companies, therefore relying on local expertise and creating additional jobs for Balmiki. A2Z could hire more Balmiki into their own services, as they need additional staffing either way in order to fulfill their contractual obligations. The Balmiki could ask their private sweeper community members to solely dump their waste into secondary dumpsites and coordinate with A2Z, thus making sure that households do not double pay for waste services.

4.3.4 Introducing new technology

To improve door-to-door collector efficiency, different primary collection vehicles could be tested, such as tricycles with higher capacity, small motorized vehicles or even motorcycles. Another possibility is the introduction of small-scale neighborhood-based technology, such as local composting and biogas plants. Further, cell phone based technology could be introduced to optimize collection routes, increase accountability and provide better customer service.

4.3.5 Integrating ragpickers and Kabadiwalas into formal system

As Kabadiwalas and ragpickers currently act outside the formal system, it would be possible to integrate them through various business models. Ragpickers could receive exclusive access to secondary dumpsites in exchange for separation services, retaining their entrepreneurial roots while at the same time providing even more valuable services to the waste system as a whole, with two models coming to mind here.

Franchise based system: Start a local cooperative in Muzaffarnagar driven by A2Z and a local NGO. The cooperative would facilitate waste pickers joining up in franchises with 3-4 people. These franchises operate as an economic unit and are equipped with carts, bicycles. Central drop-off points are established. The wastepickers collect trash and recyclables. Their profit comes from selling recyclables to A2Z. Cell phones can be used to allow for route optimization and better household – rag picker communication. A system where households pay a contribution to order wastepickers to come pick up trash could be envisioned.

Household aided market system: Encourage source separation by households. Wastepickers will continue working independently or under the umbrella of a cooperative. A2Z will provide a transparent market place where wastepickers can sell their recyclables and trash. No fees are collected from households.
4.3.6 Re-negotiating the A2Z contract

The A2Z contract with the municipality is a major hindrance in the waste systems of Muzaffarnagar. It is poorly designed and even more poorly enforced. There are no independent entities making sure that the conditions of the contract are met, thereby letting both parties violate the contractual agreements freely. This vicious circle leads to A2Z to struggle financially, and the city to receive poor waste services for the money paid. A detailed list of issues and solutions for the A2Z contract can be found in appendix 5.

4.4 Implementing solutions

While solutions can readily be ideated and formulated in theory, implementing them in practice is a whole different matter. For this, the functional perspective once again falls back to the design thinking process. As mentioned in box 1, once solutions have been ideated, products can be prototyped and tested. In the case of a waste system within the functional perspective this means the design, testing and iteration of pilots.

4.5. Designing a pilot for improved household collection in Muzaffarnagar

Based on the proposed solutions in 4.3, this section formulates a pilot for improved household collection in Muzaffarnagar, in several steps:

1. Establishing a baseline and identifying one ward each from low-, middle- and high-income neighborhoods suitable for pilot
2. Improved household service collections in the three pilot wards. Effect on household behavior will be examined.
3. Improvement of secondary dumpsites at the three pilot wards by optimizing location and demarcation
4. Continuous measuring
5. Further pilots, including transfer stations, integrations of informal sector, outsourcing primary collection to Balmiki, etc.

The pilot was designed for the city of Muzaffarnagar and A2Z to approve. Roughly 600 households will be involved in the pilot over the time period of 9 - 12 months, 200 each in low-, middle- and high-income areas. Identifying suitable wards and establishing a data baseline in these wards would be the first step in the pilot, as to allow comparative data analysis over the time of the pilot and measure effectiveness of measures. Once baseline data has been collected, the second step would be to improve the collection system in the determined wards with incremental, small changes. At the same time, secondary dumpsite throughout the city will be analysed as proposed in 4.3.1. In the third step, the pilot wards would see new, optimally placed secondary dumpsites. Continuously measuring and evaluating the progress of the pilot would be the fourth step, underlying all three previous ones. Once initial
results become available after approximately three to four months, the next pilot tasks can be planned in more detail, according to step 5.

4.5.1 Establishing a baseline

Ward selections
The wards would be selected based on the current fee collection rate. The fee payment rate seems to be closely related to the collection rate (number of households collected from). It is likely that ward fee correlates with other socioeconomic factors, especially income. Our goal is to determine whether the collection and the collection rate would increase in each of the selected wards. Wards would be selected in joint decision by the municipality and A2Z.

Household selection
In each ward, 200 households would be selected for the pilot. The only requirement is that these households are located next to each other, making it easy for one waste collector to collect waste from 200 households. Initially, the waste collector may collect waste from 10 households to as many as 110 households. Over the pilot, the goal is for the number of households a waste collector is collecting from to increase to the full 200 households.

Once pilot wards have been identified, all participating households will be surveyed on a questionnaire. The questions are designed to establish a baseline against which progress can be measured twice every month. After the baseline has been established in each ward, collection improvement will commence. Data collected will be fed into Excel spreadsheet by project manager and uploaded to a cloud database, visible for all stakeholders.

4.5.2 Improving household services

Improvements for household services will come incrementally. A2Z and the municipality will have to cooperate on making sure that the aims of this stage are accomplished. The use of external parties and pilot managers as observers of progress would make sense in this case.

Inform Households of Service Update

A waste collector and a fee collector will visit the households that they serve in each ward, explain that they are participating in a new version of the A2Z service with regular waste and fee collection and give the household a copy of a waste information leaflet. The leaflet will contain all necessary information on the Muzaffarnagar waste system, as well as containing the mobile phone numbers of community waste workers. The goal is to establish a relationship with households so that households know both the manager and the waste collector. The second goal is to set expectations on behalf of the households.
**Initiate Regular Waste and Fee Collection**

During the pilot, the waste collector would collect waste on a daily basis; if he cannot collect the waste, another waste collector would be called in to substitute. The role of the pilot supervisor is to answer the customer helpline and respond accordingly. The fee collector would regularly collect the household fees on a regular and pre-notified basis.

**Launch a Customer Support Line**

Currently the customer support line is routed through the municipality. Through the pilot, one the pilot supervisor would run a customer support line. The customer support line would document customer feedback, along with the survey throughout the pilot. The pilot supervisor would answer phone calls, document the response, and respond accordingly.

**Aim**

The aim of these initiatives is to test for changes in household behavior. Are they more likely to pay fees? Does their attitude towards waste change (as measured by surveys). Are they happier with the provided services? Might a better cooperation and acknowledgement of A2Z work in the ward result in higher worker efficiency?

**4.5.3 Improving secondary collection sites**

The next step would be to improve secondary collection sites in the pilot wards. For this purpose, first the current secondary dumpsites will be analyzed. Based on the routes of door-to-door collectors in pilot wards, the waste output, and the fit into secondary collection, new secondary dumpsites can be proposed. These dumpsites will have to be properly demarcated and fenced off.

**4.5.4 Continuous Measurement of Pilot Results**

**Conduct ongoing surveys**

The surveyor will conduct monthly surveys with households to measure their satisfaction with A2Z services and the regularity of waste and fee collection.

**Measure changes in waste and fee collection and process**

The pilot manager would work with both the waste and fee collectors to document changes in the collection process. The waste collector would measure whether a house did not receive service on any given day and the amount of waste collected (as determined by the number of stops to the secondary collection site and estimating the amount of waste with the appropriate markings on the side of the cart). The fee collector would share an updated report about how many fees were collected and experiences with households (positive or negative). The project manager would collect the reports from both the fee and the waste collector.

**Share monthly findings with A2Z and relevant municipal officers**

At the end of each month, the surveyor would develop a report of his/her findings. The report would include an analysis of the surveys to date and any changes that
they notice. The project manager and the fee collectors would report their findings to A2Z and relevant municipal officers. Both would compare the findings to the goals set forth in the pilot.

**Financial costs**

The financial costs of pilots are not high enough to be prohibitive. The proposed pilot will come to around Rs. 432,700 for 6 months.

<table>
<thead>
<tr>
<th>Table 17: Pilot costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Required investment</td>
</tr>
<tr>
<td>Monthly re-occurring costs</td>
</tr>
<tr>
<td>Total cost 3 months</td>
</tr>
<tr>
<td>Total cost 6 months</td>
</tr>
</tbody>
</table>

4.5.5 Further pilots and iteration

The results from the pilot cannot be foreseen. Only after the pilot has been implemented will it be possible to see what elements work and which ones don’t. These insights can then be used for future pilot variations and new pilots. Further pilot ideas include

- Outsourcing collection to Balmiki
- Transfer stations
- Integration of rag pickers into system
- Segregation of household waste
- Collection of recylables

4.6 Pilot summary

While conducting single pilots is a time-consuming and possibly undertaking, the resulting insights can help transform entire waste systems. In Muzaffarnagar, the proposed pilots were presented to all stakeholders with decision power in the system (A2Z, municipality, Balmiki) and received positive feedback. The stakeholders are motivated to change the system as everyone is unhappy with its current state. Using pilots and incremental improvements is a way to foster collaboration between stakeholders in baby steps and to introduce some much needed accountability.

Ultimately, the pilot concludes the first loop in the functional perspective to Muzaffarnagar. With its completion, further loops can be triggered, incrementally improving the waste system as time goes by.
Conclusion

This thesis led its reader through the formulation of the functional perspective to applying it in the case of Muzaffarnagar. It introduced the practical application of first four steps of the functional perspective (analyzing institutional structure, inferring meta-functions, defining problems, and formulating and designing solutions) and the tools from design thinking in waste problems.

The functional perspective emphasizes the two most important elements in waste management: context and systemic planning. Waste management systems need to be adapted for local context and need to be considered in their systemic implications. It provides a framework that allows analyzing both tangible and intangible factors in waste systems, leading to the formulation of better contextual solutions through iterative processes. While ISWM is similar in some analytical elements, the functional perspective is more practicable in its emphasis on dynamics in waste systems and the underlying, changing processes. Incorporating elements of design thinking into the functional perspective and waste management additionally gives a very modern and flexible toolbox into the hands of decision makers in waste management.

Both the practical tools and the theoretical considerations of the functional perspective provided a very good guideline for the research of our group in Muzaffarnagar. We successfully used design thinking to analyze the institutional structure of the Muzaffarnagar waste system and used ideation processes to design solutions. Through the process of going through these steps alone, acting as independent entity in the Muzaffarnagar waste ecosystem, we were able to foster a sense of collaboration among relevant stakeholders.

The emphasis of the functional perspective on inclusivity and the tools for informal sector analysis made the other stakeholders realize the important role that the marginalized groups of ragpickers and Kabadiwalas play in the waste system of Muzaffarnagar. While the first iterations of the pilot do not aim at improving the livelihoods of these groups, future ones will.

While the functional perspective was well applied in Muzaffarnagar, some elements still remain untested. As pilots can only show results over longer periods of time, iterating solutions was unfortunately not within the scope of this thesis. Future research can be directed at incorporating case studies of longer term research and the application of the functional perspective. Nevertheless, by combining a theoretical framework and practical tool, the functional perspective proved a useful tool for decision makers in waste management.
Bibliography


Appendix
Appendix 1: Ragpicker questionnaire

Waste Picker Questions Round I

1. Name?
2. What is your age?
3. How many years of experience do you have working with waste?
4. How did you begin working with waste?

On average...
5. How many days a week do you work?
6. What time do you start work?
7. What time do you end work?

8. Do you rent or own your cart?
9. What did it cost to buy it?
10. Is it fully paid for? How do you finance it?

11. Which materials do you collect?
12. Which is the most valuable?
13. What are the values of the materials (per kilo)?
14. On average, how much material do you collect during one day?

16. Do you know other waste pickers in the city? How many?

17. Who do you sell your material to? Where are they located?
18. How often do you sell your material?

19. Do you store your material anywhere?
Waste Picker Questions Round 2

Personal Questions

1. What is your education level?
   a. Can you read and/or write?
2. How many siblings do you have?
3. Are you married?
4. Do you have children?
   a. Are your children in school?
5. Does your mother or sister work with waste?
   a. What do they do?
6. Are you fulfilled and/or happy with your work?
   a. If not, what other kinds of jobs would you like to have?
   b. What are barriers to you changing jobs?
7. Where do you live? How?
   a. Condition of the home
8. Do you use any government schemes?
9. Are you interested in joining a union?
   a. How do you think you would benefit from being in a union?

Business Questions

1. Where do you work?
2. How do you decide where to work?
3. Which dumpsites have the best material?
4. Do you borrow money from a kabadiwala?
   a. Does the kabadiwala pay you market price for the waste or a lower price?
   b. Who or where else could you borrow money from?
5. Why do you only sell to one kabadiwala?
6. How is your relationship with the city officials?
7. How is your relationship with the police?
8. What would improve your work or make it easier?
## Appendix 2: Kabadiwala Questionnaire

**Kabadiwala Profiles** -

<table>
<thead>
<tr>
<th>1st Round Information</th>
<th>Date Collected</th>
<th>Location (GPS):</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Category</th>
<th>Data</th>
<th>Units</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>years</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Work experience</td>
<td>years</td>
<td></td>
<td></td>
</tr>
<tr>
<td>How entered biz</td>
<td>--</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start time</td>
<td>am</td>
<td></td>
<td></td>
</tr>
<tr>
<td>End time</td>
<td>pm</td>
<td></td>
<td></td>
</tr>
<tr>
<td># days worked</td>
<td>days</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Income</td>
<td>Rs/day</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Income (avg)</td>
<td>Rs/mo</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Most valuable material</td>
<td>--</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amount of material</td>
<td>kg/day</td>
<td></td>
<td></td>
</tr>
<tr>
<td># employees</td>
<td>people</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contact #</td>
<td>--</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Material</th>
<th>Buy Price (Rs/kg)</th>
<th>Sell Price (Rs/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(circle materials that are collected)
# Kabadiwala Profiles -

1st Round Information  Date Collected:  Location (GPS):

<table>
<thead>
<tr>
<th>Category</th>
<th>Data</th>
<th>Units</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>years</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Work experience</td>
<td>years</td>
<td></td>
<td></td>
</tr>
<tr>
<td>How entered biz</td>
<td></td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>Start time</td>
<td></td>
<td>am</td>
<td></td>
</tr>
<tr>
<td>End time</td>
<td></td>
<td>pm</td>
<td></td>
</tr>
<tr>
<td># days worked</td>
<td></td>
<td>days</td>
<td></td>
</tr>
<tr>
<td>Income</td>
<td></td>
<td>Rs/day</td>
<td></td>
</tr>
<tr>
<td>Income (avg)</td>
<td></td>
<td>Rs/mo</td>
<td></td>
</tr>
<tr>
<td>Most valuable material</td>
<td></td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>Amount of material</td>
<td></td>
<td>kg/day</td>
<td></td>
</tr>
<tr>
<td># employees</td>
<td></td>
<td>people</td>
<td></td>
</tr>
<tr>
<td>Contact #</td>
<td></td>
<td>--</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Material</th>
<th>Buy Price (Rs/kg)</th>
<th>Sell Price (Rs/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(circle materials that are collected)
Appendix 3: Sample household survey

Survey Schedule

General Information
Date: ______________________

1. Location & Area Information
   a. Ward No.: ______________________
   b. Mohalla: ______________________
   c. Address: ______________________

2. Type of Physical Connection/Communication (Attach Photograph)
   a. Alley (narrow passageway urban context) 
   b. Lane (narrow passageway rural context) 
   c. Street (Road between houses) 
   d. Road (Motorised Movement) 

3. Availability of Drainage (Attach Photographs)
   a. No. 
   b. Yes. 
   i. Width: ______________________
   ii. Condition: ______________________

4. Condition of House (Attach Photographs)
   a. Katcha (Flimsy, Poor Hinge) 
   b. Pucca (Solid) 
   c. Zopadpatti (Squatter settlements) 

5. Existence of Attached toilet & Bathing Facilities
   a. Yes. 
   b. No. 

6. Land Area of House
   a. 300 - 600 Sq. Ft (LIG) 
   b. 600 - 1200 Sq. Ft (MIG) 
   c. 1200 - 2400 Sq. Ft (HIG) 
   d. Above 2400 Sq. Ft 

Family Information

1. Religion & Cast:
   a. Hindu: 
   b. Muslim: 
   c. Sikh: 
   d. Jain: 
   e. Other (specify) 

2. Head of Family
   a. Male: ____________
      i. Education:
         1. Illiterate: 
         2. Can read and write: 
         3. High School: 
         4. Intermediate: 
         5. Graduate: 
         6. Post Graduate: 
   b. Female: ____________
      i. Education:
         1. Illiterate: 
         2. Can read and write: 
         3. High School: 
         4. Intermediate: 

Scanned by CamScanner
3. Family Size
   a. Below 15 Yrs. of Age
   b. Between 15-25 Yrs. of Age
   c. Between 25-60 Yrs. of Age
   d. Above 60

4. Earning Members
   a. Earning Member 1
      Profession:
      i. Agriculture
      ii. Service
      iii. Business
      iv. Labour Work
      v. Other (specify)
   b. Earning Member 2
      Profession:
      i. Agriculture
      ii. Service
      iii. Business
      iv. Labour Work
      v. Other (specify)
   c. Family Income:
      i. Lower Income Group (up to 1.5 Lac)
      ii. Lower Middle Income Group (between 1.5 to 3.5 Lac)
      iii. Upper Middle Income Group (between 3.5 to 8 Lac)
      iv. Higher Income Group (above 8 Lac)

Dispose of Garbage

1. Approx. quantity of Daily Garbage
   a. Up to 1 Kg
   b. Between 1-3 Kg
   c. Between 3-5 Kg
   d. Above 5 Kg

2. Medium of Collecting Garbage (Within House) (Attach Photographs)
   a. Dustbin
   b. Any Corner allocated
   c. Any Other (Specify)

3. Medium of Disposing Garbage
   a. Through Waste Picker (if Yes)
      i. Type of Waste Picker
         1. Government
         2. A to Z (Private)
         3. Any Other (Private)
         4. Any other (specify)
      ii. Fee Charged per month (in Rupees)
         1. 0-25
         2. 25-50
         3. 50-100
         4. Above 100
   b. Through Waste Picker (if No, Specify the reason)
      i. Service Problem
      ii. Money Problem
      iii. Lack of Awareness
iv. Any other (specify)

c. In Dumping Ground (if Yes)
   i. Location of Dumping Ground (Attach Photograph)
   ii. Distance
      1. 0-100 metres
      2. 100-500 meters
      3. Above 500 meters

d. Along Drain

4. Your idea for garbage collection
   a. From door to door
   b. Dustbin along the street
   c. Any other (specify)

5. Whether separation/segregation of garbage is carried out? (Yes/No)
   a. If yes
      i. Organic/In-organic
      ii. Biodegradable/Non-biodegradable
      iii. Any other (specify)

6. Willingness to pay if some system is applied for waste collection (Yes/No)
   a. If yes (How much)
      i. 0-25
      ii. 25-50
      iii. 50-100
      iv. Above 100

7. What problem you face due to not disposing the waste at right place? Suggestion for Cleaning/Waste disposal for your locality.

8. Do you give your waste to "Kabriwalas"? Yes No
   a. What kind of waste it consists of

   b. What prices did the Kabriwalas charge (per kg)
      i. Paper Waste
      ii. Plastic Bottles
      iii. Glass Bottles
      iv. Metal scrap
      v. Others (mention)

9. Is the community ready to contribute & treat/manage waste on their own level? Yes No
   a. Alternatives that can be adopted for the same
   b. Interested to convert the waste into the compost (manure)? Yes No

10. Any other observation

Scanned by CamScanner
Appendix 4

<table>
<thead>
<tr>
<th>Variables</th>
<th>Explanation</th>
<th>Assumption</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General</strong></td>
<td>Waste generated per household</td>
<td>Kg of waste generated by each household</td>
</tr>
<tr>
<td></td>
<td>Number of households</td>
<td>65,000</td>
</tr>
<tr>
<td></td>
<td>Households covered by A2Z collection</td>
<td>Percentage that A2Z covers every month in Muzaffarnagar</td>
</tr>
</tbody>
</table>

| **Primary Collection** | Collector salary | Salary of door-to-door collectors | 5,200 Rs. / month |
| | Trips to secondary dumpsite per day | How many trips waste collectors did to the secondary dumpsites per day, emptying their tricycle | 4 / day |
| | Tricycle capacity | Capacity of individual tricycle | 70 kg |
| | Collectors per supervisor | How many collectors would be under one supervisor | 15 |
| | Supervisor salary | Salary of door-to-door supervisors | 15,000 Rs. / month |

| **Secondary Collection** | Dumper capacity | How much each dumper can carry | 8,000 Rs. / month |
| | Secondary Dumpsites | How many secondary dumpsites exist in the city | 45 |
| | % waste from households in secondary dumpsite | How much waste in each dumpsite originates from households | 60% |
| | Daily trips to processing per dumper team | How many trips each dumper can make to processing site per day | 3 |
| | Driver salary | | 7,000 Rs./month |
| | Diesel cost per kg of waste | | 0.12 |
| | Transport helper salary | | 5,200 Rs. / month |
| | Frontloader maintenance | Monthly maintenance for each frontloader | 20,000 Rs./month |
| | Dumper maintenance | Monthly maintenance for each dumper | 10,000 Rs./month |

| **Processing** | | | |

85
### Appendix 5

<table>
<thead>
<tr>
<th>Problems</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-payment of obligations</td>
<td>~75 lakh rupees</td>
</tr>
<tr>
<td>Unclear household fee structure</td>
<td>Why does A2Z not get the money?</td>
</tr>
<tr>
<td>Equipment usage and maintenance</td>
<td>A2Z does not maintain</td>
</tr>
<tr>
<td>Tipping fee increase</td>
<td>Should have been increased</td>
</tr>
<tr>
<td>Road to A2Z plant</td>
<td>Not maintained for 4 years</td>
</tr>
<tr>
<td>Contract length</td>
<td>10 years, time horizon?</td>
</tr>
<tr>
<td>Unclear division of tasks and mistiming</td>
<td>At dumpsites; municipal &amp; A2Z</td>
</tr>
<tr>
<td>Complaint hotline</td>
<td>Still handled by city</td>
</tr>
<tr>
<td>Fee payment structure invites corruption</td>
<td>No direct accounting desk</td>
</tr>
<tr>
<td>Waste processing and landfilling process</td>
<td>Unclear how to be done</td>
</tr>
<tr>
<td>Lack of awareness surrounding A2Z role</td>
<td>Citizens don’t know</td>
</tr>
<tr>
<td>Secondary dumping site maintenance and usage</td>
<td>Who pays for what?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Staff salary</th>
<th>Salary of staff at plant</th>
<th>~N (200,000, 20,000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Security salary</td>
<td>Salary of plant security</td>
<td>75,000</td>
</tr>
<tr>
<td>Irregular staff salary</td>
<td>Plant expenses such as diesel or electricity</td>
<td>~N (10,000, 1,000)</td>
</tr>
<tr>
<td>Plant expenses</td>
<td>~N (330,000, 30,000)</td>
<td></td>
</tr>
<tr>
<td>Repairs</td>
<td>Maintenance charges for machinery</td>
<td>50,000</td>
</tr>
<tr>
<td>Others</td>
<td>Other processing related expenses</td>
<td>~N (200,000, 10,000)</td>
</tr>
<tr>
<td>Solutions</td>
<td>Priority</td>
<td></td>
</tr>
<tr>
<td>----------------------------------------------------------------------------</td>
<td>----------</td>
<td></td>
</tr>
<tr>
<td>Joint coordination office between A2Z collection and municipal sweepers</td>
<td>! !</td>
<td></td>
</tr>
<tr>
<td>Make contractual work public</td>
<td>! !</td>
<td></td>
</tr>
<tr>
<td>Consideration of other stakeholder interests</td>
<td>! !</td>
<td></td>
</tr>
<tr>
<td>A2Z ward supervisor responsible for handling complaints</td>
<td>! !</td>
<td></td>
</tr>
<tr>
<td>Obligatory minimum fund for equipment maintenance by A2Z</td>
<td>! !</td>
<td></td>
</tr>
<tr>
<td>Include bulk generators in contractual work</td>
<td>! !</td>
<td></td>
</tr>
<tr>
<td>Ward-wise civil boards with ward officer, A2Z supervisor and citizens. Meet every two weeks to discuss situations and produce report every 3 months</td>
<td>! !</td>
<td></td>
</tr>
<tr>
<td>Allowing outsourcing</td>
<td>! !</td>
<td></td>
</tr>
<tr>
<td>----------------------------------------------------------------------------</td>
<td>----------</td>
<td></td>
</tr>
<tr>
<td>Adjustment of tipping fee according to varying factors</td>
<td>! ! !</td>
<td></td>
</tr>
<tr>
<td>Independent audit firm to evaluate A2Z and city transactions twice per year, costs are borne equally by both parties</td>
<td>! ! !</td>
<td></td>
</tr>
<tr>
<td>Clear establishment of A2Z account handling party on city side</td>
<td>! ! !</td>
<td></td>
</tr>
<tr>
<td>A2Z has obligation for brand recognition, proper uniforms and use of logo</td>
<td>! ! !</td>
<td></td>
</tr>
<tr>
<td>A2Z has obligation for proper accounting structures</td>
<td>! ! !</td>
<td></td>
</tr>
<tr>
<td>Household fees go directly to A2Z; otherwise tipping fee increase if tax</td>
<td>! ! !</td>
<td></td>
</tr>
<tr>
<td>Duty for worker contracts, health insurance, timely wages, etc.</td>
<td>! ! !</td>
<td></td>
</tr>
<tr>
<td>Maintenance of road to A2Z by city, checked yearly</td>
<td>! ! !</td>
<td></td>
</tr>
<tr>
<td>Extension possibilities and length adjustable</td>
<td>! ! !</td>
<td></td>
</tr>
<tr>
<td>Usage &amp; maintenance of secondary dumpsites regulation</td>
<td>! ! !</td>
<td></td>
</tr>
</tbody>
</table>