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Sorting it out

An analysis of waste management provisions and realities on Bali

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An analysis of waste management provisions and realities on Bali

By

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Declaration concerning the TU/e Code of Scientific Conduct for the Master's thesis

I have read the TU/e Code of Scientific Conduct[i].

I hereby declare that my Master's thesis has been carried out in accordance with the rules of the TU/e Code of Scientific Conduct
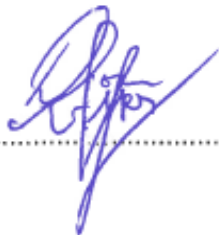
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Abstract

The importance of waste management in sustainability issues has been increasingly recognized in organizations and nations globally. In many countries, especially in the developing world, waste streams are inadequately managed, posing threats in public health, environmental issues and even economic domains. This situation is also evident in Indonesia, and more specifically in Bali. Despite of the policy framework that is in place regarding waste management, collection levels of waste are low, indiscriminate waste dumping and burning is prevalent and landfills are not adequately built or managed. Given that in Bali the GHG emission contribution from waste is estimated to be 87%, the importance of an improved waste management system cannot be underestimated. The aim of this research is to analyze the realizations from the Municipal Solid Waste management policy framework to the waste management situation in Bali, and to identify which factors influence these realizations. Therefore, a literature review and a study, based on qualitative empirical fieldwork, were conducted.

The literature review made clear that, while extensive research has been conducted focusing on the *provisions* regarding waste management, the actual enforcement of and *realizations* from a policy framework are often underexposed. Moreover, the literature review showed that the phases that the developed world went through in waste management can by no means serve as a roadmap for developing countries. This is due to the different state of knowledge in waste management as well as the different context in which developing countries have to set up their waste management systems. These results outline the need for local specific approaches in waste management.

During the qualitative empirical fieldwork, the main methods applied were: participant observation and semi-structured interviews. The empirical findings from the fieldwork indicated two important factors that influence the performance of the waste management system in Bali: a lack of policy framework enforcement and a tension between the degree in which the policy framework leans on people taking up their own responsibilities, and the current level of awareness and knowledge in Indonesia. The realization that these are not often discussed in existing literature has pointed out that it is important to study provisions as well as realizations simultaneously, because it is vital that the behaviour of the system users enable the system to function properly and to reach maximum results. In the case of Bali, it is not the policy framework itself that needs revision as much as it is the way that the framework is set up, executed and how the realizations are monitored.

A review of the premises, requirements and drawbacks of several sustainable energy technologies in the field of waste management has lead to the conclusion that while technology offers opportunities in the waste management sector, by no means it holds the premise to resolve the waste problem by itself. It is recognized that it is vital that the behaviour of the system's users enables these technologies to function properly and reach maximum results. Hereafter, a quantitative emission analysis has shown that improved waste management could significantly contribute to the reduction of the environmental impact. A simple trend model for a 15 year period, from 2010 to 2025, showed opportunities for a 2018 reduction of 90% in waste-to-landfill, that leads to an overall reduction of GHG emission from MSW management of 72% in Bali.

In conclusion, this research shows the relevance of using qualitative empirical research to inform policy framework design, to create a policy framework that is adequately secured, implemented and monitored, which can ensure a properly operating system.

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Acknowledgements

It is strange to be writing this chapter, the last part of my thesis. It marks an end point in my educational track, but the whole process of conducting my research and writing the thesis also proved to be starting points for many important things in my life. Starting points for knowledge and appreciation of the field of qualitative empirical research, insights I have gotten about myself by going through the process, experiences that I would have never had without this research, people I would have probably never met without the fieldwork. It is powerful to acknowledge the positive impact a sometimes seemingly random chain of events has on one's self.

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"The most fascinating aspect of ethnographic research, is what you don't expect to discover."
  (Crang & Cook, 2007)

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1. Introduction

The last decades have seen an increase in the recognition of waste as an environmental problem, with waste generation rate in on the rise globally in the last decades (World Bank, 2012). Due to increasing population levels, rising affluence and a change in community living standards, the rise in waste generation will continue for years to come (Z. Minghua, 2009). With the exception of high income countries, all other groups are projected to rise even further in per capita urban waste generation for 2025 (World Bank, 2012). In many countries waste streams are inadequately or inefficiently managed due to lacking regulations, utilities or enforcement. This poses threats, since a lack of waste collection and management leads to water, land and air pollution posing great health, environmental and economic risks (CWG, 2008). This has especially become a problem in rapidly growing countries in the developing world, as is the case in Indonesia. Rapid population growth and urban development have intensified the waste problem, and all over the nation much of all the waste is dumped, burned at street sides or discharged into rivers or oceans (Verstappen, et al., 2016).

Existing Municipal Solid Waste (MSW) systems in Indonesia include the collection of waste from households and the transport to a landfill. In Indonesia, the capacity of landfills is limited and new landfills are not adequately built or managed, therefore landfilling cannot be seen as a sustainable solution (Allen, 2001). The government has put the Indonesian law number 18 of 2008 regarding Waste Management (WM) in place aiming to reduce landfilled waste through the principle of the 3R concept of Reduce, Reuse, Recycle (Kerstens, Leusbrock, & Zeeman, 2015). The law furthermore requires all 504 regions of Indonesia to have integrated waste processing sites where collection, sorting, recycling, handling and final waste processing takes place (Ministry of Public Works, 2008). Other important provisions in the law regard funding schemes, shared responsibilities among authorities an disobedience penalization (Meidiana & Gamse, 2011). However, despite of the policy framework in place now, enforcement is still low, and several studies have shown that there is tension between current regulations and its enforcement (Meidiana & Gamse, 2010; MacRae & Rodic, 2015; Aprilia, Tezuka, & Spaargaren, 2013).

Another important facet to be surveyed that is often overlooked is the environmental sustainability of waste management. Different methods of waste management have a different impact on the environment. In almost all Southeast Asian countries, open uncontrolled landfilling is the most prevalent waste disposal method, because it is the cheapest disposal method with large capacity (Ngoc & Schnitzer, 2009). However, open and uncontrolled landfilling of waste is a huge contributor to global warming, through the release of methane by anaerobic decomposition of organic fractions of the waste. It is calculated that methane emissions from landfills is the largest anthropogenic source of atmospheric methane (Spokas, 2006). This suggests that improved waste management can greatly contribute to lowering Green House Gas (GHG) emissions. Looking at the emission profile of Bali specifically, it is noted that 87% of Bali's GHG emissions come from waste (mis-)management (World Resources Institute, 2016), highlighting the importance of an improved waste management system.

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Taking these factors into account and reviewing literature on the reality of waste management on Bali (Bruce & Storey, 2010; MacRae & Rodic, 2015), the notion arises that a tension might exist between the policy framework as it is provided and the realization on the ground. Therefore, by conducting an inductive research based on literature reviews and qualitative empirical fieldwork, I will answer the following research question:

 "What are the realizations from the Municipal Solid Waste management policy framework to the waste management situation in Bali, and which factors influence these realizations?"

Additionally, an important aspect is to measure and compare the environmental impact and energy aspects of the current system to that to a hypothetical improved situation. Next to the previously mentioned threats, mismanagement of waste also makes up for a large loss of materials that could be used as a resource.

In a study into the waste composition in Indonesia, *Aprilia et al.* (2013) show that over 78% of the MSW has the direct potential to be recycled, composted or reused. However, due to low level of awareness, householders dispose hazardous and toxic waste together with other household waste, largely delegitimizing the economic and environmental viability of recycling. Large quantities of recyclable material therefore end up in landfills, essentially losing their resource value. Choices for disposal or re-use of materials can greatly differ in the environmental impact and energy use that is related to the system of waste management. Recyclable materials such as paper, plastic, metals and glass can be directly recycled as raw materials. By eliminating the need to mine, create or import them, energy in terms of fuel for transport, mining or production processes can be saved (Rada, et al., 2014). The environmental opportunities of different MSW management systems will therefore be briefly reviewed. To properly address this aspect I will analyze the environmental impact of an improved waste management system in comparison to the current system in place.

The answers to these questions provide insight into the current waste management situation on Bali, and the potential contribution an improved system could offer in reducing environmental impact. These insights can be used to inform policy recommendations for Bali, and in general, for Indonesia as a whole. Moreover, given the similarities between waste management situations in developing countries, the resulting conclusions of this research can inform future research in this field of academic literature.

1.1 Thesis outline

The remainder of this report is structured as follows. Chapter 2 describes the methods that are applied to conduct this research. I will outline which methods are used, how they are used and why they are chosen as the most suitable methods for this research objective. The way of gathering as well as the way of analyzing the data collected will be discussed in length, as this forms the base of the research.

Chapter 3 provides the academic as well as the regional context that is relevant to understand the setting of this research. I will define the type of waste management that is addressed in this thesis, as well as outline its development and state-of-the-art in academic literature. Furthermore I will go into the specific field of waste management in developing countries, as this shows the prevalent barriers and opportunities that are present in the field. This chapter will end with an outline of the current waste situation on Bali, by analyzing the waste stream from generation to final disposal. Elaboration on these topics is necessary to understand the arguments made in the subsequent chapters.

In chapter 4 I will discuss one of the overarching aspect that I identified to create tension between the provisions and realizations in waste management in Bali: a lack of policy framework enforcement. This argument is elucidated by going into the Indonesian policy landscape changes and how they shaped certain characteristics of the policy framework and its functioning, which influence the realizations in waste management. Two factors will be elaborately discussed, as they proved to play a major role: the lack of accountability mechanisms and resource and capacity gaps in local governments.

The second overarching aspect that I found to effect the functioning of the waste management system in Bali will be the main topic of focus in chapter 5. Throughout the research, multiple interviewees stated that there is a gap between the degree in which the policy framework leans on people taking up their own responsibilities and the current level of awareness and knowledge in Indonesia. Therefore I will stress the importance of awareness and knowledge in pro-environmental behavior, as well as go into the specific situation regarding awareness and knowledge levels in Indonesia as a whole, and Bali specifically.

In chapter 6 I will go into methods for waste management improvement and the state of the art in sustainable energy as well as resource technology in the specific field of waste management. The current paradigm in waste management improvement will be discussed, to create a general understanding of the background in the field. Hereafter, several sustainable energy and resource technologies will be reviewed, as well as the promises and limitations for the field of waste management. Lastly, the viability for implementation of these technologies for Bali will be discussed, with the context-specific possibilities and limitations taken into account.

After covering the two main findings that I identified to hinder the functioning of the waste management system in Bali in chapter 4 and 5 as well as technology in the field to improve sustainability in chapter 6, chapter 7 will be used to show that progress in these two findings would lead to improved waste management, which would significantly reduce waste to landfill disposal and therefore subsequently reduce greenhouse gas emissions from waste management in Bali. Therefore, two scenarios will be contrasted through a simple quantitative impact analysis: a Business-as-usual scenario versus a hypothetical improved scenario. Furthermore, three topics in improving waste management that are relevant for the situation in Bali will be discussed, as the qualitative empirical evidence gathered showed the importance in this context.

In the final chapter all the insights from the previous chapters will be used to answer my research question: *"What are the realizations from the Municipal Solid Waste management policy framework to the waste management situation in Bali, and which factors influence these realizations?"*
This will be followed by a discussion on which implications this answer has for waste management research as well as recommendations for the policy framework on Bali.

2. Methodology

The thesis research is aimed at uncovering the main factors that influence the realizations on the ground from the provisions in the MSW management policy framework. It is focused on a qualitative research of the situation in the field. Given that the aim of the study can be reached by understanding people's interaction with and perception of several parts of the waste management system, qualitative research resulted to be a suitable approach. The qualitative research methods applied in this thesis can be used *"to understand social phenomena from the perspectives of those involved and to frame individual behaviors in the context and community that surrounds them"* (Glesne & Peshkin, 1992). The qualitative research approach is also suitable because of the richness of information that can result, the benefits of first-hand experiences and the ability to quickly adapt methods or planning, and still effectively collect information.

In short, the main methods that I have used are qualitative empirical data collection during in-depth semi-structured interviews held with diverse stakeholders (Hammet, Twyman, & Graham, 2014), participant observations, field visits and as well as a thorough literature review. In this chapter I will provide an overview of the methodology I used to gather and analyze the data.

2.1 Gathering empirical data

The approach of this research was aimed at gathering in-depth information and perspectives from people with direct experience and knowledge on waste management on Bali. Therefore it was chosen to conduct semi-structured interviews, as they enable dialogue and fairly deep engagement, while retaining focus on a topic (Smith & Leith, 2015). In conducting the interviews, the goal was to make the conversation flow in a natural way, and to be open for topic suggestions by the interviewee, while keeping an eye on the topics discussed and the depth in which topics were discussed. Hereby, the semi-structured interview provides the flexibility to follow up on interesting or unexpected topics that arose. In order to obtain the data in the most convenient and complete way, these interviews were audio recorded if possible, as well as a written account of them. To ensure covering all topics and as a guide to follow up during the interviews, an interview structure was created.

One of the most important aspects to take into account when setting up semi-structured interviews is to decide who to interview in order to obtain relevant , complete and trustworthy data. In their book on *Doing Ethnographies*, *Crang & Cook* outline that *"this approach involves gaining selective access to appropriate groups of people who may be concerned with, and/or involved in living through, the research problem and encouraging them to teach the researcher about it from their various perspectives."* (Crang & Cook, 2007, p. 14). Therefore, it was of vital importance to create and contact a group of people from a wide variety of backgrounds, in order to construct a broad understanding of the viewpoints held on the waste management situation on Bali. Eventually I had the chance to conduct in-depth interviews with 12 experts in the field, complemented by over 30 shorter 'informal' interviews or meetings, which greatly contributed to data collection alongside the set of formal interviews. This provided me with a wide variety of information and viewpoints, since the interviewees almost all came from a different background and were related to different parts of the waste system on Bali. I included the viewpoints of environmental engineers, municipality officials, regency landfill administrators and NGO leaders as well as landfill scavengers, informal sector middlemen and system users. Information on the in-depth interviews and the background of the interviewees can be found in appendix 2.

It is noteworthy to state here that in some of the interviews a language barrier existed between interviewer and interviewee. Therefore I was accompanied by a translator throughout these interviews. Acknowledging that the quality of information that is collected can be negatively affected by bias, lack of accuracy in interpretation, or lack of understanding of the research goals (Smith & Leith, 2015), the translator was closely involved in the research process and was always up to date on the backgrounds, state of research as well as the objective of a visit or an interview.

To obtain these insights from people directly I was fortunate to be able to access the network of *Eco Mantra*, a local consultancy firm that offers sustainability consultation and project implementation in the field of energy, water and waste. Having worked with them before in my internship, I gained access to the vast and varied network in the local waste management sector, which proved to be invaluable for the research. Additionally, working with Mantra added an opportunity to work in the waste management sector myself.

This led to the encompassment of participant observation in my fieldwork, which aided to construct a thorough understanding of the context of MSW management on Bali. Participant observation involves, as *Hammett et al.* put it *"the recording of interactions, thoughts, reflections, (un)certainties, (mis-)behaviors, (in)actions and other symbolic or ephemeral phenomena to build up a picture of everyday life"* (Hammet, Twyman, & Graham, 2014, p. 9). Participant observation is helpful in building up an understanding of daily life and tacit knowledge about the context of the research. In my research, this was done mostly by cooperating in a material management pilot project that I had worked with before, *Merah Putih Hijau*[1] . It added an immersion aspect to the research as well, which contributed in getting first-hand experience as well as creating a deeper understanding of the context. My activities within MPH ranged from working in the facility to doing waste pickup rounds, and from participating in strategic meetings to sourcing resources from informal sector middlemen.

Performing a solid literature review is always an important part of qualitative research, as it serves to learn about the various contexts regarding the study, the state-of-the-art knowledge as well as to understand the similarities and differences between studies performed (Crang & Cook, 2007). In this study it was specifically important to develop an understanding of the regional context culture, as well as to learn the tensions and commonalities between different perspectives on waste management in general and in developing countries. This literature review serves to reach a point that *Crang & Cook* (2007, p. 15) call *"theoretical adequacy"*, ensuring that the concepts and insights presented are based on a theoretical background that is supported by literature.

Given the nature of the chosen research methods, spending time in Bali was a key part of the study. The fieldwork conducted to support this research was split into two periods. It was chosen to stay on Bali for at least 4 weeks, which allowed sufficient time to plan the visits and interviews and keep a contingency in terms of planning. The first fieldwork term was exploratory, and was based on theoretical insights gained through the literature review. The results and findings of the first fieldwork term were then analyzed back at university, and discussed with supervisors. The outcome of this analysis was subsequently used in the iterative process to accurately see where an additional literature research was necessary, as well as where the emphasis for the second, more in-depth fieldwork term should lie to complete the thesis research (Crang & Cook, 2007).

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[1]A group that supports Bali villages to build, maintain & benefit from their own WM system- www.mph-bali.org

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In pursuance of a detailed recollection of research findings, I kept a daily research diary during the fieldwork terms. This was used to register all events, encounters, interesting observations and other relevant notices. Next to that there I accounted every interview, site visit and immersion activity. Together with pictures, videos and supporting datasheets (brochures, flyers, booklets etc.) these formed a detailed account of the context as well as the content of the research parts.

Throughout the research there were instances were parts of the waste system were not open for guided visits, or that the staff was not willing, allowed or able to participate in semi-structured interviews. Reasons vary, with examples such as distance to the community, practical reasons and non-confirmation to laws.

Where this was the case, an understanding of the system part was still constructed through observation and site visits, even if this only entailed walking around the premises where the system operates. This was especially the case in the informal sector. The informal sector is often a 'grey area' in MSW management, with little data on inputs, outputs and practicalities. Observational visits to middlemen stations and informal waste recycling enterprises did however provide an understanding of the waste streams and daily business in this part of the system.

2.2 Analysis

Given the iterative nature of the research, the empirical data that I had collected was analyzed in several stages throughout my research. The selected method to analyze the data was a coding process. Coding is the process of sorting and defining pieces of all sorts of collected data that are relevant to the research question, and by putting like-minded pieces together, you start to create a framework (Glesne & Peshkin, 1992, p. 152). Going through the data with substantive coding, I worked with the data directly, sorting and labeling it, initially through open coding for the emergence of a core category and related concepts. Thereafter, I continued with selective coding of data to theoretically saturate the core and related concepts. Additionally, I cross-checked the empirical insights with the outcome of the literature review, to see how they were related as well as to see where I had insights that were not discussed in the literature and were therefore interesting to expand upon. These rounds of analysis led to the insights that will be discussed in chapters four, five and six, as well as the identification of opportunities and policy recommendations that I will present in chapter seven.

A challenging point in doing qualitative empirical research is to be able to evaluate when a research part in a certain context can be considered adequate and therefore when to move on, either into analysis or to research in a different context. In this research, it is chosen to check whether I have reached the point that *Crang & Cook* (2007) call *theoretical saturation*: the accounts that are told begin to have the same ring to them, and the same concepts and range of stories within a community resurface. Whenever this point was felt, a close look was taken into the sampling for the interviewees as well as the places to visit, and from that it was decided whether to move to a different group or to adjust the research methods, to gain different insights from the same group.
In the analysis process, theoretical saturation is achieved through constant comparison of indicators in the data to elicit the properties and dimensions of each category. This constant comparison of incidents continues until the process yields the interchangeability of indicators, meaning that no new properties or dimensions are emerging from continued coding and comparison. At this point, the concepts have achieved theoretical saturation.

An important note on the research methods is that these chosen methods did not form a set structure throughout the process. Given the high possibility of unforeseen events (for instance, interviews that were cancelled last-minute, site visits where access was denied, a language barrier that could not be overcome) it was necessary to be flexible in the process. As *Marshall & Rossman* (2016) point out, flexibility is a key characteristic of the research design in qualitative research, both before and throughout the actual research. Therefore, research plans were adjusted several times throughout the course of the research, in an attempt to optimize the time, available resources and opportunities to create as much input for the study.

In this chapter, I discussed the research methods that I have applied in the fieldwork on Bali. The selected methods were partly based on the possibilities I had in that specific place, as the research methods that can be applied are dependent on variables such as distances to travel, time available, local culture and languages. The combination of several qualitative empirical research methods resulted in a suited strategy to be flexible in the research process while increasing knowledge and understanding about the waste management situation and people's perception of in, in the specific context of Bali. In the next chapter, I will describe the context wherein my research was conducted.

3. Context description

The aim of this chapter is to provide the information that is necessary to understand the context in which this research is placed and to show that the development of waste management in developed countries can by no means be used as a roadmap for successful waste management in Indonesia. To support this argument, I will first go into the type of waste management I regarded, to define the boundary of this research. Secondly, the development as well as the state-of-the-art of waste management in literature will be characterized. By constructing an understanding of these it is possible to explain the barriers and opportunities that are prevalent in the field. Given that the research has been conducted in Indonesia, which in this context is considered a developing country, specific attention will be paid to the differences between waste management in developed countries versus developing countries. I will elucidate on the region-specific context, by covering general information on Indonesia and Bali. Moreover, I will provide an outline of the current waste situation on Bali, by analyzing the waste stream from generation to final disposal, highlighting the stark regional characteristics that proof the need for a regional approach. Hereby, I will expand on relevant information regarding geography, demography and economy.

Municipal Solid Waste

To understand the boundary of what type of waste management is reviewed in this research, it is important here to elaborate on the used definition, as there are many different types of waste that are generated and need management. In this thesis, I discuss the collection, treatment and disposal of Municipal Solid Waste (MSW). However, in international waste policy there is a lack of a standard definition and classification on what is included and what is excluded in this definition. The definition of MSW varies widely between organizations and countries. This is highlighted by three examples of leading international organizations, as it can be seen in figure 1. It is noticeable that while the OECD focuses on the collecting body, the PAHO looks to the generation location and the IPCC lists every group separately. This difference in approach makes up for a widely varying definition between organizations.

The Organization for Economic Co-operation and Development (OECD) refers to the collecting body as a qualifying method ("MSW is collected and treated by, or for municipalities").

The Pan American Health Organization (PAHO) looks to the location of generation ("Solid or semi-solid waste generated in population centers, as well as small-scale industries and institutions")

The Intergovernmental Panel on Climate Change (IPCC) lists all groups that they include in their definition of MSW ("The IPCC includes the following: food waste, garden and park waste, paper and cardboard, ...")

Figure 1: Different definitions for MSW in use (Hoornweg & Bhada-Tata, 2012)

Even though the definition of MSW often varies in literature, household wastes and waste from small businesses or industry that can be present in residential areas, are always included. Therefore, it is chosen here to adhere to the definition that covers these elements that are always present in the definitions used by leading organizations in the field: MSW comes from households, but also includes wastes from offices, hotels, shopping complexes/shops, schools, institutions, and from municipal services such as street cleaning and maintenance of recreational areas.

There are several reasons why it is important to study MSW management as a separate field of the general waste management research. Although MSW comprises only a part of the total waste flows, it is considered important, considering the large amounts, the public cost and the links to social norms (Zurbrügg C. , 2013). MSW forms about a quarter of the total generated waste in countries belonging to the Organization for Economic Co-operation and Development (OECD), and this is estimated to form even more when considered globally (UNEP, 2015). Additionally, MSW management has a large impact on important factors such as public health, climate change, resource security and economies (Marshall & Farahbakhsh, 2013). These factors will all be taken into account in the next section, where I will cover the importance of waste management as well as its development through recent years, informed by academic literature.

3.1 Waste management: development & state-of-the-art

There is a general global consensus on the importance of ensuring good MSW management nowadays. This is best outlined by the role in the United Nations Sustainable Development Goals (SDG's). This is a set of 17 "Global Goals" set up by the United Nations (UN), the largest cooperation on global development. Although waste management is not specified as a separate goal, environmentally sound waste management is seen as a key mechanism in achieving almost all of the 17 goals (WasteaidUK, 2016). The relevance of waste management in achieving the agreement is outlined by the following statement out of the UNEP Global Waste Management Outlook 2015: *"Environmental sustainability is the core issue that will need to be addressed for development to focus on human well-being and yet stay within the limitations of planet's capacity. Environmentally sound waste management is one of the key elements for sustainable development."* (UNDP, 2015). Given that the SDG's are signed by the UN's 193 Member States, the resolution is a broad intergovernmental agreement that confirms the supported opinion that sustainable development cannot be achieved without effective waste management. This notion has been developing progressively over the last decades, as I will show in the following section.

Given the large impact of MSW management on society, this sector has been developing ever since humans started living in settlements. This development is depicted in figure 2. This representation is by no means meant as a roadmap, but is used here solely as a schematic and linear description of the focus of MSW management throughout the years, for simplification and analytical reasons. It is noteworthy to mention that MSW management in developing countries nowadays is complex given this development: while developed countries gradually improved both their knowledge on and execution of waste management, developing countries have to take all these gained insights into consideration when setting up their MSW management systems. An example hereof is the focus on environmental threats, which was not an integral driver for waste management historically, but it is considered a vital goal of a MSW management system in today's context (Konteh, 2009) and therefore has to be met.

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Historically, resource scarcity as well as public health were the main drivers for waste management (Wilson, 2007). However, focus was mostly on regaining the economic value of waste materials or getting the waste out of streets. Public health concerns and legislation led to the emergence of formalized waste collection systems since 1900, however, little attention was paid to final disposal. Waste was commonly disposed either by dumping on land or by burning. From the 1960's onwards, with the emergence of environmental protection as a driver for waste management in the developed world, the methods of waste disposal gained more attention (UNEP, 2015). In this 'control' phase, efforts were made to control unwanted side-effects of uncontrolled disposal, followed by the systematic increase of technical and environmental standards. The control phase was followed by an emphasis on developing better technologies to address waste management ('technical fix'), which in a sense still continues today given the constant technological progression.
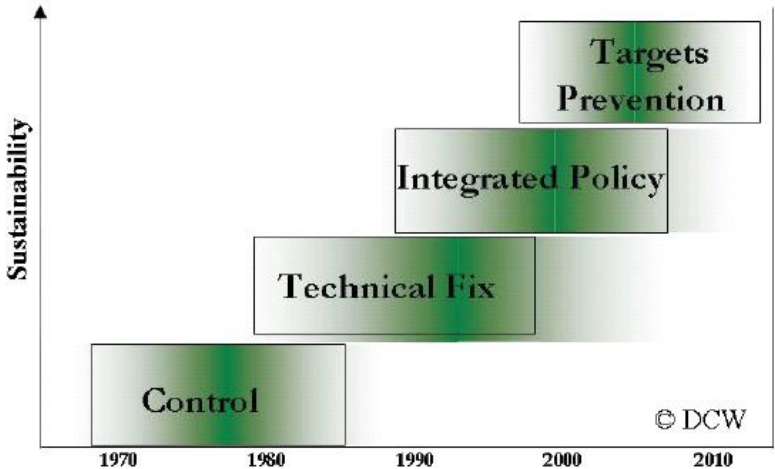
Figure 2: Phases in the development of modern waste management policy (Wilson, 1999)

However, from the 1990's onwards, the realization came that a single strategy focused on technology is not enough, and that technology by itself cannot fulfill the desired needs if not supported by political, institutional, social, economic and financial aspects (Wilson, 2007). This lead to the concept of 'integrated policy'. The central aspect of integrated policy is that it must address all technical and governance aspects to allow a well-functioning system that works sustainable over the long term. The Integrated Sustainable Waste Management (ISWM) framework, introduced by *Van de Klundert & Anschütz* (2001) describes the waste management system's components as integrated across three dimensions: all the elements of the waste hierarchy, all the stakeholders involved, and all the aspects of the 'enabling environment' (political, institutional, social, financial, economic and technical).

Nowadays, in literature, terms as 'sustainable waste management', 'environmentally sound waste management', 'integrated solid waste management' and 'integrated sustainable waste management' have become synonyms and refer to the same paradigm: the Integrated Sustainable Waste Management (ISWM) thematic use. Leading organizations in the field such as the United Nations Environment Program (UNEP) and the World Bank take the ISWM framework as a reference for how a waste management system should be designed and how it should function (World Bank, 2012; UNEP, 2015).

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In recent years, an addition to the ISWM framework can be observed in literature regarding MSW management: a shift is being made towards 'targeting prevention' and closing the loop, since over the last decade critique has risen towards regulatory, end of pipe approaches in WM (Graci, 2012). These approaches do not see waste as a resource, and often do not deliver satisfactory environmental outcomes (Silva, 2016). Therefore, attention is paid to move away from creating waste in the first place by considering the product that hypothetically ends up discarded as waste, from the very beginning of its design (Wilson, 2007). Additionally, in closing the loop one of the prevalent views is that all outputs that would previously be discarded can be valuable inputs for different processes, thereby seen as resources and materials rather than waste (Nguyen Ngoc, 2009). The *UNEP* (2001, p. 101) even states that *"The increasing volumes of waste being generated would not be a problem if waste was viewed as a resource and managed properly"*.

It is notable to outline another important shift perceived in the MSW management literature, parallel to the development as was depicted in figure 2. This concerns a shift further away from technology as a source of solutions. In the *Global Waste Management Outlook* (UNDP, 2015, p. 30) it is stated that: "*As previous publications have tended to have a more technical focus, the GWMO has chosen to focus primarily on issues of governance and finance"*. *Scheinberg et al.* (2010, p. 5) remark that technologies work "*[..] because of the far less visible institutional, governance, policy and participative frameworks that are highly varied and complex, and directly related to local conditions."*, stressing the importance of the enabling environment over the sole characteristics of a technology.

These views of field leaders show that nowadays, in MSW management, there is a strong call for the improvement of parts of the MSW management system other than technology. Empirical evidence obtained during my fieldwork supports this argument, as I will elaborate on later in chapter 6. Recent studies emphasize that the success of a MSW management system not only depends on technical innovation or the policy it is built upon, but is also significantly influenced by social and psychological factors, such as public participation and public attitude and behavior (Wilson, Velis, & Rodic, 2013; Ma & Hipel, 2016). Therefore, strategies aimed at the improvement of sustainable behavior are considered the most promising in any sustainable development strategy (Jackson, 2005).

As I have shown, waste management on a global perspective has developed starkly over the last 50 years, moving from 'controlling' unwanted side-effects, to looking for a 'technical fix', to 'integrated policy' and now 'targeting prevention'. However, these phases cannot be copied as a road map since they provide both barriers and opportunities that are prevalent in the field of developing countries. Understanding the development of waste management in the developed world is important, because this adds criteria to developing countries systems, as they have to take all these gained insights into consideration when setting up their MSW management systems, and cannot build up the system in these phases. In the next section I will therefore elaborate on WM specifically in developing countries.

3.2 Waste management in developing countries
A rough distinction in current waste management can be seen between developed countries on one hand, and developing countries on the other. Poor waste management, associated with public health and environmental implications, remains problematic for many developing countries (Scheinberg, Wilson, & Rodic, 2010). However, it is notable to state that similarities exist between the historical SWM development trajectories of industrialized countries and the current trajectories of developing countries (Marshall & Farahbakhsh, 2013).

This is rooted in the fact that solid waste is linked to urbanization and economic development (Hoornweg & Bhada-Tata, 2012). As countries develop, their economic wealth increases. As standards of living and disposable incomes increase, consumption of goods and services increases, which results in a corresponding increase in the amount of waste generated and changes in composition.

The drivers of waste management systems in developing countries are similar to drivers in developed countries some decades ago. In developed countries, health benefits from improved waste management is nowadays seen as a prerequisite, which is only becoming a major driver in developing countries (Marshall & Farahbakhsh, 2013). Final waste disposal control is still low on the list of priorities, but is gaining in importance fast, driven by fears for climate change and the strive for environmental protection (Wilson, 2007). The resource value of waste is an important driver in developing countries, since scavenging valuables from waste provides a livelihood for poor people (Bruce & Storey, 2010). This 'informal sector' resource recovery will be discussed later in this chapter.

Despite the similarities in the development of waste management systems, one should not think that these pave the way for a 'one fits all' approach. The broader contexts in which developing countries are situated are fundamentally different from the historical contexts of developed countries. As *Chaturvedi* aptly phrases it in *Scheinberg et al.* (2010, p. 1) : *"Just as it is amusing to picture a cycle rickshaw collecting waste in Adelaide, it's ridiculous to send a giant compactor into the lanes of the old city in Dhaka, Bangladesh."*. Differences in economy, urbanization, climate, geography, culture, and policy, all shape what can be considered a locally appropriate approach in WM (Coffey & Coad, 2010).

Stressing the differences between MSW management in developing countries and in developed countries, it is important to look into specific literature on the topic. Many researchers that cover the challenges of waste management in developing countries predominantly focus on urban areas and cities, rather than rural areas or smaller towns. There are limited journals on rural areas (Ren, 2014; Vidanaarachchi, 2006; Wang, 2014). The dynamics of MSW management however differ greatly between big cities and small towns. In small towns the economies of scale necessary for market-based solutions is not present, nor do they have the financial resources, and often the technical expertise and institutional capacities, needed for high-investment or high-tech approaches (MacRae R. , 2015; Graci, 2012).

Most of the research that is conducted on WM in the developing world focuses on direct factors such as technical, management and financial related aspects that influence MSW management (Troschinetz & Mihelcic, 2009). Studies focus on the technical aspects of MSW management (Kerstens, Leusbrock, & Zeeman, 2015), practical aspects of pilot projects (Zurbrügg et al., 2012) or they review projects that were successful in a later stage (Graci, 2012). Evidence from projects conducted in several countries shows how financing aspects associated with the MSW management system play a role when it comes to performance and sustainability. Many journals address the cost of MSW management in developing countries. Most notably at this point, *Kerstens et al.* (2015) compared the costs of landfilling with a centralized and a decentralized waste management facility for Indonesia. *Zurbrügg et al.* (2012) investigated a sustainable waste management project from an economic view. The importance of sustainable financing for MSW systems has been agreed upon in international literature. However, these studies almost always assess these systems from the perspective of an outside investor, where focus is laid mostly to investment cost and return on investment period, therefore disregarding crucial social or environmental aspects.

Since policy is inevitably of great influence in any kind of public service system, this is an extensively researched part of MSW management. However, it is significant to notice that while extensive research has been conducted into the *provisions* regarding waste management in Indonesia (Meidiana & Gamse, 2010) (MacRae R. , 2015; Bruce & Storey, 2010), not much research has been done in the *realizations* from the MSW policy framework, despite the fact that many of the researchers concluded that the waste management system in Indonesia was not functioning according to those provisions. The realization of waste management is therefore one of the main focal points of my research, rather than the institutional provisions.

Next to policy in waste management, it is recognized that social elements such as user mobilization, participation and acceptance can be drivers for success or failure in MSW management in developing countries (Zurbrügg et al., 2012). Difficulties in integrating stakeholders and ensure public involvement remain (Morrissey & Browne, 2004) in large part due to the fact that citizens did not help shape the MSW systems they depend upon. Effective waste management must be fully embraced by local governments as well as local users in order to be effective (Henry, Yongsheng, & Jun, 2006). This subsequently means that the functioning of the management system is reliant on behavioral patterns and underlying attitudes of the users (Marshall & Farahbakhsh, 2013), that are shaped by the local cultural and social context (Schübeler, 1996). Even though the importance of public awareness and attitudes towards waste is widely acknowledged, only few studies have been focused on the implementation of qualitative empirical informed in the design stage of MSW management systems. Given the acknowledged key role of public participation and empowerment, decision transparency, networking, co-operation and collective action, communication and accessibility of information (Carabias, Winistoerfer, & Stuecheli, 1999; Zarate, Slotnick, & Ramos, 2008), qualitative research can provide valuable insight in user's perspective on waste and how a system should be set up. Awareness and knowledge levels seem to play an important role (Jackson, 2005), but have only scarcely been studied.

Another important aspect to consider is the geographical or demographical scale of local-specific solutions. Most of times, a system is designed and planned on a national level. However, sufficient attention must be paid to regional differences. For instance, Bali is unique in its conceptions on waste and has a " [..] *distinctively Balinese cultural disinclination to get too closely involved with rubbish, originating in Hindu conceptions about pollution, combined with a status-based social hierarchy.*" (MacRae R. , 2015, p. 313). This is a feature that has not been discussed much in literature, and therefore it was an important starting point for my research on Bali. Understanding these local conceptions and overcoming them might be the first step in setting up a system, as it is vital that these aspects are taken into the design in order to set up a socially accepted system, therefore creating the need for dynamic, location-based strategies (Graci, 2012).

As I have shown in this section, the barriers and opportunities in WM in developing countries strongly differ from these in developed countries. Difference in for instance economy, urbanization or climate create a need for locally appropriate approaches. Most research on MSW management covers direct factors such as technical, management and financial related aspects, mostly aimed at the scale of large cities. However, while *provisions* are often studied, *realizations* from MSW management frameworks as well as awareness and knowledge levels of system users is often disregarded. Given the importance of the regional context of Bali, especially given the specific cultural inclination of the Balinese, I will elaborate on this in the next section.

3.3 Regional context

Despite progress in solid waste management in the last decades, fundamental institutional, financial, social, and environmental problems still exist. As stated before, since each country has its own site-specific situation (Hoornweg & Bhada-Tata, 2012), it is important to understand the regional context in which this research has been conducted: Bali, Indonesia.

The Republic of Indonesia (Indonesia) is a sovereign state located in Southeast Asia (see figure 3). It is the world's 14th largest country in terms of land area, and the 4th most populous country in the world, with over 261 million inhabitants (CIA, 2018). Indonesia's republican form of government includes an elected parliament and president. The government is politically subdivided into 5 levels; National, Provincial, Regency and Cities, Districts and Municipality level. Each of these have their own legislature.

Figure 3: The location of Bali within Indonesia (Quora, 2017)

Indonesia is divided into 34 provinces. Given the scope of this thesis and the vastness of the country as a whole, it is chosen to focus on one specific province: Bali. Given the nature of Bali´s demography, economy, it represent a concentrated case of barriers in MSW management prevalent in many developing countries (MacRae R. , 2015). The province of Bali neighbors Java to the east and Lombok to the west, and consists of the main island (Bali) and three smaller islands to its south. It holds a population close to 3.9 million inhabitants, of which 60% lives in urban areas (BPS Indonesia, 2010). Bali's economic strategy is focused on the tourism industry, with a contribution of 48% to the overall economy, generating 68% of tax income and taking up 42% of new labor (Gapura Bali, 2017).

Institutionally, Bali is subdivided into eight regencies and one city: the provincial capital of Denpasar. Following the implementation of decentralization that set out in 2001, regencies and municipalities have become the key administrative units responsible for providing most government services. This will be elaborately discussed in chapter 4.

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Waste management in Bali

To understand the systemic context of this research, I will elaborate on different parts of the current waste management system. Firstly, I will discuss current waste generation, projected growth and composition. I will then review collection methods and the role of the informal sector herein. Lastly, the different treatment and disposal methods will be considered. Throughout the chapter, the stakeholders which have a role in the system will also come forward, as well as the system's costs and affordability for users.

There are a number of academic reports on waste generation in Indonesia. These reports provide values of waste generation quantities in Indonesia, however, results are inconsistent. Average Municipal Solid Waste generation rates of 0,52 kg/capita/day (Hoornweg & Bhada-Tata, 2012), 0,76 kg/capita/day (Ngoc & Schnitzer, 2009) and 0,9 kg/capita/day (Guerrero, Maas, & Hogland, 2013), can all be found in published academic literature . From my own experiences on Bali, the expected value is closer to the high end of the reported numbers. There are good indications to assume that Bali will show a vast annual waste growth in the next few years, which will put pressure on the existing waste management systems. This is driven by three major indicators: population growth, tourism growth and GDP growth.

With a rise in population, a surge in waste generation can be expected as well. Bali is one of the fastest growing regions of Indonesia. With a population of approximately 2.5 million in 1980, 30 years of rapid growth lead to a number of 3.9 million inhabitants counted in the 2010 Indonesian census (BPS Indonesia, 2010). This number is estimated to increase even further, given the fact that the growth rate was recorded to be 2.15% in the period between 2000 and 2010. Extrapolations using this growth rate show that the current number of inhabitants would be approximately 4.5 million in 2017.

Another important contributor to waste quantities is the tourism industry. High numbers of tourist heighten the waste generation rate, since tourist are reported to have a higher per capita and per day waste output (UNEP, 2015). Being one of the most popular tourist destinations in the world, Bali accommodates a huge number of tourists per year. In 2016, 8.6 million domestic and 4.9 million foreign visitors stayed on the island (Bali Government Tourism Office, 2017). Waste from tourism is scheduled to grow: for the year 2018, the expected foreign tourist arrival number is an estimated 7 million.

Thirdly, waste production is firmly related to GDP (Hoornweg & Bhada-Tata, 2012). Even though Indonesian GDP growth rate has somehow stagnated in the last decade, there is still an annual growth rate of 5% over the last years (Indonesia Investments, 2018). Generally speaking, a rise in GDP causes an often equal rise in waste generation, and alters the waste composition towards more inorganic contents, which thus can be expected for Indonesia as well.

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Waste composition greatly influences the subsequent collection and treatment methods that are suitable and efficient for these waste streams. One of recent years largest studies into MSW in developing countries worldwide, performed by the *World Bank*, collected information on waste characterization and composition in Indonesia (Hoornweg & Bhada-Tata, 2012). Comparing these figures to other sources results in an indication of the waste composition as can be seen in table 1.

Table 2: Waste composition in Indonesia according to multiple sources

Waste fraction	% (Trisyanti & Helmy, 2015)	% (Hoornweg & Bhada-Tata, 2012)	% (Meidiana & Gamse, 2010)
Organic	65%	62%	62%
Paper	10%	6%	9%
Plastic	11%	10%	14%
Glass	2%	9%	2%
Metal	2%	8%	2%
Other	10%	4%	11%

Looking at the average waste composition, it becomes clear that there are large opportunities for material recovery. The average composition of waste is similar to that of many other developing countries, generally showing high organic waste fractions (50 – 70%) (Hoornweg & Bhada-Tata, 2012). The organic fraction can be composted, and thereby reused as fertilizer. Large fractions of the paper, plastic, glass and metal contents can also be reused, recovered or recycled. Amongst others, *Aprilia et al.* (2013) showed that of the average composition of household waste in Jakarta almost 80% has the potential to be recycled.

Waste collection has been, and still continues to be, a point of concern for much of the Indonesian archipelago (IV12, 2017). While there are no recent studies providing a trustworthy number for the fraction of households that are served by a waste collection operator in Indonesia, this is generally considered low, between 40 and 60% (Meidiana & Gamse, 2010).

Since there are many differences between the areas of Bali in terms of population density, affluence, and spatial planning, there is no single strategy that is used for the collection of waste. Rather, as in many developing countries, a system in which the formal and informal sector operate side by side has been developed. The informal sector can be characterized by "small-scale, labor-intensive, largely unregulated and unregistered, low-technology manufacturing or provision of services" (Wilson, Velis, & Cheeseman, 2006). Informal sector involvement results in the extraction of recyclable and reusable materials from mixed waste, thereby influencing waste quantities, composition and value throughout the systems chain.

In Bali the waste collection industry is basically a free market for operators, largely unregulated by the government. The most common setup is a person or a company with trucks and staff, that collect the waste from the households and bring it to one of the landfill sites. These kind of operators have been around since decades, and they typically service most villages and cities. Either the village council, the users, or a combination of both pay for this service, which provides the income to cover costs for vehicle maintenance, diesel, staff, landfill tipping cost and profits. When the system is set up as user-pays, in general businesses have to pay a quite high fee, whereby the households are kept free of charge. The prevalent method that can be observed in MSW collection all over Bali is collect-transport-dispose, as schematized in figure 4.
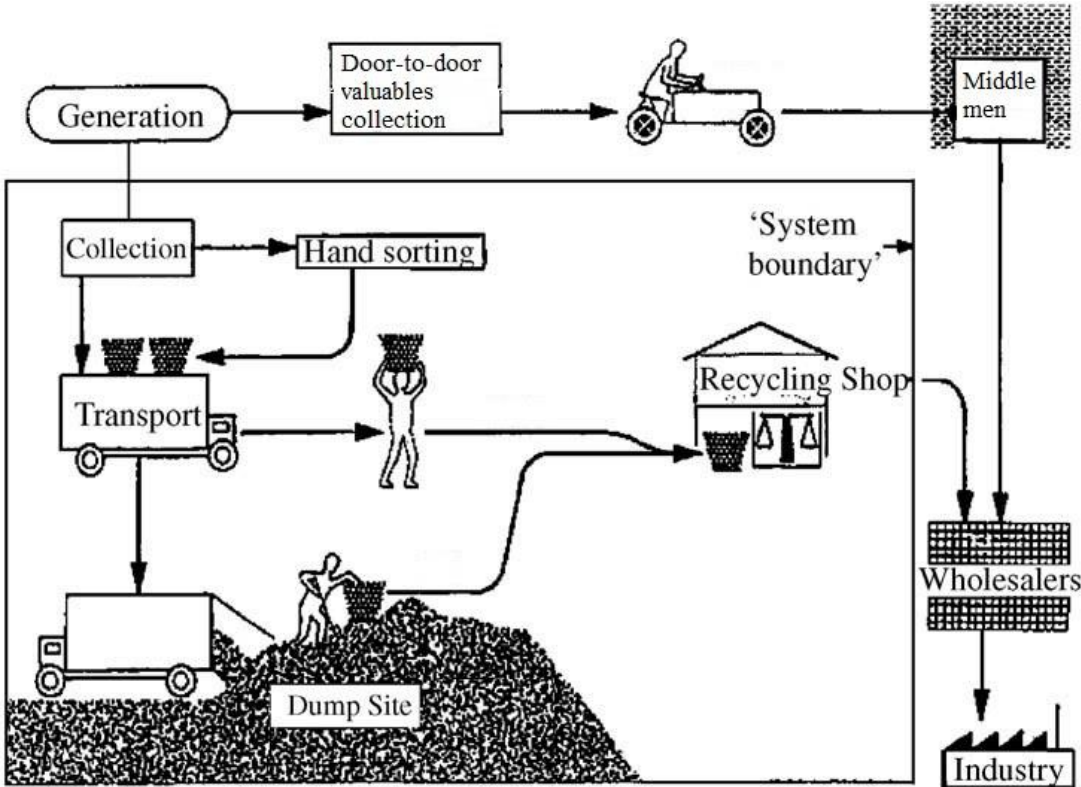
Figure 4: A schematic representation of MSW collection in Bali (reproduced and adapted from (Wilson, Whiteman, & Tormin, 2001))

Households collect all of their waste and perform some segregation tasks on it themselves in order to collect and store the most valuable materials for sale directly to the informal recycling sector, either by door-to-door collection of the scavengers (*pemulung)* or by going to middlemen (*pengumpul)*. The remaining materials are disposed of by putting it to the side of the street. This is then collected by the municipalities Cleanliness Department or through a third party hired by them. Depending on the spatial planning of the area, the waste is either picked up by handcart or by truck. When it is picked up by handcart it is brought to a transfer station, where multiple handcarts are emptied and trucks are filled. These handcarts are often operated by informal waste handlers, who rely on the income by the resale of valuable material received throughout the pickup. When the waste is loaded onto the trucks, the employees on the truck often scan through the materials to check if there are still some non-organic components of the dumped waste that have market value for resale, without needing much effort to segregate these quantities. The waste trucks then go to the dump site.

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In these sites, the waste is often scavenged again; even though there are little valuable materials left in the waste, heavily marginalized individuals can still earn a slight amount of money by collecting and selling leftover valuable materials that were economically unappealing to other waste pickers throughout the waste system.

Scavenging at waste disposal sites occurs in cities throughout the developing world, and it is often associated with communities living on or near the site in poor conditions (Wilson, Velis, & Cheeseman, 2006). As depicted in figure 4, the 'system boundary' is seen as the boundary between the formal and informal sector. However, there is a grey area in which formal and informal tasks and task executers often overlap. It is often a matter of whether the informal sector is allowed by the municipality to operate within the waste system. Since the segregation of market valuable materials degrades the overall value of waste streams, this can lead to revenue losses for larger commercial formal waste providers. In formal recycling systems, the resale value of valuables is often necessary for public or private service providers to partially pay back the cost of the service provision. In such cases, the scavenging of materials throughout the waste stream is considered as disruptive and economically weakening the provider's position, and it can therefore be banned by a municipality or neighborhood.

Treatment and disposal

The prevalent method for waste disposal in Bali, as in the rest of Indonesia, is disposal in a landfill. Unfortunately, exact numbers on waste treatment and disposal methods are not available, as it was the case with waste generation rates and composition. However, there is a broad consensus on and acceptation of the fact that transport to landfill amounts for about 70% of waste disposal (Meidiana & Gamse, 2010; Damanhuri, Handoko, & Padmi, 2014). Figure 5 shows the shares of different treatment and disposal methods for the whole Indonesia, according to the Indonesian Ministry of Environment (MoE) in 2008.
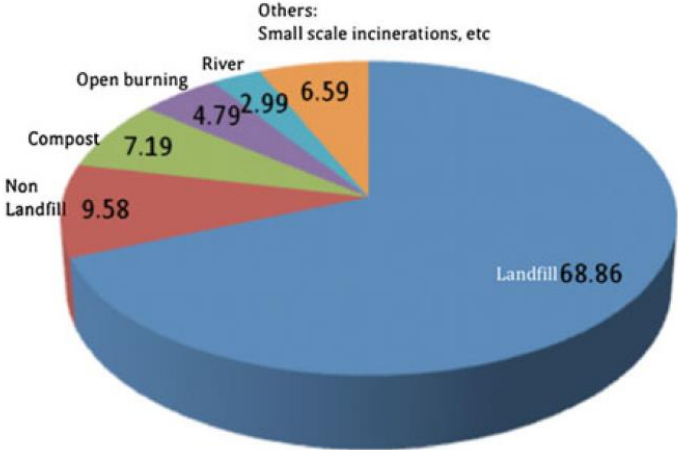
Figure 5: *Treatment and disposal methods in Indonesia* **(M.O.E., 2008)**

A category that is not specifically recognized by the MoE is recycling. Exact figures for recycling rates are difficult to quantify, since recycling is done mainly by the informal private sector. Recycling rates in literature vary from 8% to 15% of all waste generated (Damanhuri, Wayhu, & Ramang, 2009; Pasang, More, & Sitorus, 2007). However, Bali has a lack of local solutions in terms of recycling and closing the loop in MSW management, since there are no factories that provide these services (IV2, 2017). The local technical field of Bali is shaped by the fact that it is located to Indonesia's main island, Java.

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Throughout history Bali never had to develop (middle-) heavy industry because that was developed and built on Java. This lack of local recycling options makes recycling less cost effective given the necessity for transport to Java and therefore lowers recycling rates. Additionally, the scarcity of parts and knowledge for those kind of technologies further drive up recycling cost (IV1, 2017).

Landfilling is therefore the largest method of waste disposal. The Indonesian Waste Act of 2008 commissioned the build and use of sanitary landfills only by the year 2015. However, out of observational visits to 4 out of 7 legal sites it can be concluded that this is not the case yet. The biggest landfill in Bali, Suwung, has only been partially equipped with technologies to make it sanitary. At most, Suwung can be considered a controlled landfill, in which controllers designate areas where waste should be dumped to avoid landslides and other dangerous situations. However, since the amount of waste that is brought into Suwung is a lot higher than the controlled landfill can take and Suwung raises a tipping fee for every truck, several illegal uncontrolled dumpsites have been formed around the legal one. Out of the observations and interviews, it can be concluded that currently only three sanitary landfills exist in Bali. Hereby, it is noteworthy that one of these was still being built during the course of this study, and was not in use yet. An interview with the executive staff of Temesi (Gianyar regency), the best performing landfill from an environmental perspective, showed that even though they are equipped as a sanitary landfill and go to lengths to recycle waste as much as possible, the amount of waste brought into Temesi is far higher than the amount that the facility can process. This has led to dumping in an uncontrolled landfill next to the facility (IV1, 2017).

In conclusion
As shown in this chapter, MSW management is of great importance for a society and therefore has experienced strong development in the last century, especially in developed countries. However, the phases that the developed world went through in waste management can by no means serve as a roadmap for developing countries, given the different state of knowledge in waste management as well as the recognition that the enabling environment in a local context is of vital importance for the success or failure of a system. Currently, there is a consensus in academic literature that the success of a MSW management system not only depends on technical innovation or the policy it is built upon, but is also significantly influenced by social and psychological factors, such as public participation and public attitude and behavior, which is therefore an important focal point of this research.

Additionally, I have argued that while extensive research has been conducted into the *provisions* regarding waste management in Indonesia, not much research has been done in the *realizations* from the MSW policy framework. Out of the literature review as well as observational visits to the waste management system in Bali, it seems that the realizations from MSW management in Bali do not correspond to the provisions in the policy framework. This is clearly indicated by low levels of collection, indiscriminate waste dumping and burning, and uncontrolled landfills. The tension between the reality on the ground and the institutional provisions in the policy framework is therefore one of the main focal points of my research.
Moved by the needs emphasized in this chapter, the next two chapters present the empirical evidence found during my research on Bali. The explanation of this evidence is made through the analysis of factors that arise repetitively throughout the review of the literature as well as insights gained from the qualitative empirical study. As I have concluded, one of the main reasons this tension exists is the lack of policy framework enforcement. I will extensively elaborate on this argument in the next chapter.

4. The lack of policy framework enforcement

In this chapter I will discuss the lack of enforcement of the policy framework in Bali, which represents one of the overarching aspects that makes up for the tension between the provisions in the Municipal Solid Waste management policy framework and the reality on the ground. I will argue that while there is a framework in place, there are multiple deficiencies in its implementation and enforcement that altogether result in a very weak execution.

The deficiencies that I identified that led up to this argument will structure this chapter. In the first section, I will elaborate on how the current policy framework formed, through a brief analysis of the history of the Indonesian political landscape changes. I will explore the setup and the goals, and contrast this with some critique. In my research I find that the lack of accountability mechanisms and resource and capacity gaps in local governments play a major role in the lack of policy framework enforcement. These two factors will therefore be elucidated. Finally, I will elaborate how they influence the implementation and practice of the system.

4.1 Indonesian policy landscape changes

Before 1999, the legislative situation in waste management in Indonesia was overly complex, with several departments and ministries sharing responsibilities for legislation and execution. The involvement of many different institutions with overlapping responsibilities created bureaucracy and inertia, and consequently weak implementation of the system (IV2, 2017). Since then there have been two major changes in the legislative framework concerning waste management and environmental protection: the decentralization in 1999, and the introduction of a new Waste Management Law (WML) in 2008.

The decentralization of the Indonesian government structure in 1999 was prepared under escalating pressure of disintegration, and in the midst of a severe economic crisis (Firman, 2009). In contrast to many developing and transitioning countries, it was not primarily carried out in order to enhance civil participation or improved delivery of public services. It was an overall reform that consequently effected all policy domains.

The Indonesian Parliament passed law 22/1999 and 25/1999 regarding regional autonomy and fiscal decentralization in May 1999. This resulted in a huge shift of tasks and responsibilities from central government directly to regencies and municipalities. The provinces were bypassed, to prevent secessionist movements within the republic (Nasution, 2016). This change in the governmental system also had consequences in policy and execution of waste management. Responsibility for the execution of waste management was put in the hands of the local governments; the national government only issued the law and acted as a regulator. In the field of waste management the responsibilities for city cleaning, MSW collection and treatment were divided between the provincial, the regency and village governments (Meidiana & Gamse, 2010). Similar institutional structure can be observed in different countries (Ma & Hipel, 2016).

This greater autonomy and responsibility for provincial and local government has created opportunities. Experts believe that a decentralized system is ultimately an appropriate approach. In support, most point to the same decentralized approach being in use in developed countries, where it has proven its value. Concrete advantages that have been ushered are the appropriateness of local solutions *"Because Indonesia is an archipelago, whatever is feasible in Java might not be applicable somewhere else."* (IV2, 2017) and cuts on necessary transport times and cost, *"since then only the residue would have to be transported to the centralized landfill"* (IV5, 2017).

However, it is argued that given the political and social pressure with which the decentralization was persevered, it was crafted without well-developed transition or implementation plans (Nasution, 2016). The decentralization has therefore led to weaknesses related to amongst others accountability mechanisms, local government capacity and resource availability and allocation (Bruce & Storey, 2010). I will elaborate on these aspects later in this chapter.

The second major change in the Indonesian legislative framework concerning MSW management was the introduction of waste management law no.18 in 2008. The law came into force in May 2008 and was the first national law on solid waste management (Meidiana & Gamse, 2010). The law covers issues of environmentally sound waste management, public service principles, incentives and discouragement mechanisms, funding schemes, responsibilities with waste authorities, private sector participation, waste management commercial licensing and fines for disobedience (Ministry of Public Works, 2008). The law states the roles and responsibilities in waste management, whereby the focus is on increasing the authority of the local government levels (Meidiana & Gamse, 2011). The primary approach set out by the 2008 WML focuses on two aspects of the waste management system the reduction of waste generation through the promotion of the 3R-principle (Reduce – Reuse – Recycle), and the environmentally sound final disposal of waste. This exemplifies the observation from the previous chapter, in which I have outlined that developing countries have to take all the gained insights into consideration, such as the importance of waste prevention, when setting up their MSW management systems. The aim was to replace the end of pipe paradigm of collect-transport-dispose with a more resource-conscious paradigm, wherein less waste is produced, less materials seen as waste and the waste is disposed of in an environmentally responsible way (Damanhuri, Handoko, & Padmi, 2014).

Regarding the current legal framework, experts put forward that the law itself is *"designed well,[…] with the right regulations (e.g. take-back principles) as well as delegation of processes, […] it is probably based on a developed country's MSW law"* (IV1, 2017). The head of a waste management NGO, that has been active in MSW management since 2006, stated about the concepts and aims that *"It is clear in terms of what the government stands for and how the concept of 3R should help manage waste in a more sustainable way"* (IV2, 2017).

Even though the waste law is generally seen as well-designed and was published in 2008 already, the situation in Bali has not drastically improved (Zurbrügg et al., 2012; Bruce S. , 2010; IV3, 2017). As I will argue in the next section, two main drivers were found that are major hindrances in the functioning of the system: a lack of accountability mechanisms, and resource and capacity gaps in local governments. Even though these institutional aspects are often discussed in existing literature on the Indonesian waste management situation (Wilson, Velis, & Rodic, 2013; Chang, Pires, & Martinho, 2011) the focus is often on the institutional provisions rather than the actual practice, thereby disregarding the tension between the aspired outcomes in the framework and the reality on the ground.

4.2 Lack of accountability mechanisms

In this section, I will argue that the lack of accountability mechanisms in the waste management policy framework majorly contributes to the difference between the policy aims and the reality. Before presenting this aspect, I need to elaborate on the meaning of accountability mechanisms. It is noted that there is a huge body of literature on accountability mechanisms, but for the restriction to this thesis research it is chosen to elaborate on it through the definition of the *World Bank*. Accountability mechanisms are governance tools that seek to regulate answerability between different stakeholders in a system, and are an essential part of a healthy law enforcement framework (World Bank, 2011). Accountability in the context of service provision, as this representation is suitable and relevant in this research, can be unbundled into five key accountability relationships, as can be seen in figure 6 (adaptation *World Bank*, 2011).
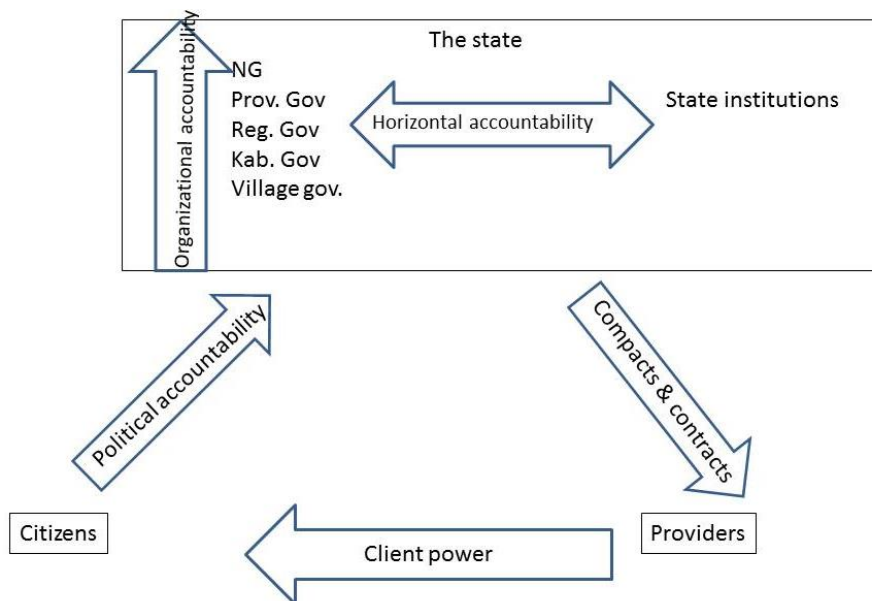
Figure 6: The key accountability relationships in the context of service provision (adaptation of (World Bank, 2011)

There are five types of accountability mechanisms in this representation. *Political accountability* is the process whereby citizens hold state officials accountable for their behavior and performance, for instance through elections or communications between citizens and politicians beyond the electoral process (Aucoin & Heintzman, 2000). Within the state body, *organizational accountability* constitutes the accountability relationships from local government all the way up to the national government. Additionally, *horizontal accountability* is the capacity of state institutions to check abuses by other public agencies and branches of government, or the requirement for agencies to report sideways. Between government and public service providers, the mechanism consists of compacts (within-government) or contracts (external, private provider). Furthermore, there is a certain degree of direct *client power*, stating to which extent citizens can directly exert influence on service providers to ensure efficient delivery of public services (World Bank, 2011), for example by choosing between different providers or refusing payment with unsatisfying service provision.

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Defining accountability relations, rules and their enforcement can establish strong regulatory mechanisms for collective systems, and are seen as an important aspect in developing a society's ability to manage its affairs (UNDP, 2006). In my research I identified a number of problems regarding the accountability mechanisms in Bali. First of all, the formulation of accountability mechanisms in a policy framework have to be based on a division of roles and responsibilities, which are not strongly set in the policy framework. Secondly, clear mechanisms of political accountability as well as horizontal accountability are absent. Thirdly, social ties of municipal administrators create a social barrier for law enforcement on a village scale. I will now discuss these deficiencies in this order.

An important point set out by the interviewees regarding the functioning of accountability mechanisms is the ambiguous definition of roles and responsibilities within the law: there will not be a functioning waste management system without a clear division of roles and responsibilities in the setup and execution of the WML. The law sets out to achieve a system in which the lower levels of institutions are responsible for waste management. The exact way in which these roles and responsibilities are defined, however, leads to a lot of critique among the interviewees. Roles and responsibilities are unclearly and insufficiently defined. There is a statement that people, companies and everybody else are responsible for their own waste; *"Chapter 2, Obligation, Article12: (1) Everybody in the management of household waste and household-like waste oblige to reduce and handle waste based on environmentally sound management"* (Ministry of Public Works, 2008). However, while it states that everybody should oblige, it does not further expand into the concept, keeping the statements rather vague, as outlined by interviews. *"There is no clear definition of what the roles are, which actor holds which responsibilities, nor who is accountable when the system fails. From the law, it is not clear who has the power to do so and who has the responsibility to enforce it, or fine violation of it"* (IV2, 2017). This lack of clear definitions on responsibility is supported by literature, for instance with *Aprilia et al.* (Aprilia, Tezuka, & Spaargaren, 2013, p. 646) declaring that *"[...]it is stated that the sorting of waste is conducted by the provision of facilities [...], however it is not clearly stated regarding the actors that should be responsible for providing such facilities."*.

While a lack of clearly outlined responsibilities makes up for ambiguity on who should perform tasks as described in the law, the absence of clear mechanisms of political accountability further impede an appropriate law enforcement. According to (Bird & Smart, 2002) local governments, receiving transfers of responsibility and authority, should be held accountable for the results both to their citizens and to a higher level of government. However, these accountabilities are still not in place, after the decentralization program, as observed by (Shah & Thompson, 2004): the Indonesian program implemented so far has failed to address accountability of local governments to resident-citizens. *Nasution* (2016) argues that the political system needs to be improved to make elected governors, mayors, and heads of districts truly accountable to the community through regular elections, and not to their political parties, since a potential candidate has to pay the political party to get nominated in the local election. Other evidence of constraints to political accountability exists: citizens have little opportunity to trace how a parliament representative acts, since decisions are made by consensus (Ziegenhain, 2015, p. 100), transcripts from committee sessions are not produced systematically and if they are, they are not public (Sherlock, 2010). It is outside the scope of this thesis to go deep into this topic, but it is clear that certain elements of the Indonesian institutional setup severely hinder the extent to which citizens can exert political accountability.

Another important accountability mechanism is organizational accountability. Organizational accountability refers to an accountability mechanism between central and local levels of a political system, for instance through auditing or frequent reporting. However, in Indonesia these means are underdeveloped, stemming from a lacking capability of the central government to monitor the implementation of the government functions transferred to the subnational level and to monitor subnational governments' spending patterns and efforts (Nasution, 2016). In infrastructure development, the probability of a higher government audit visit to verify expenses is only 4%, and it is stated that even with an audit, abominations are hard to expose (Olken, 2007). This was underlined in several interviews throughout the field study: managers of the landfills that were visited clearly stated that they never got audits or field visits from government officials. This essentially created a playing field in which they were free to act as they wanted, since they were not held accountable, nor by higher government levels as by government branches sideways. It is noteworthy to say that this did not always result in inadequate service execution; one of the landfill managers stated to "[..] *request government visits on a regular base, because there is a need for more funding as we are striving for better environmental performance in waste management. But no one from the government visits.*" (IV6, 2017). This shows that there is either a lack of priority or capacity to visit service providers from the government levels, even if it is requested to construct better public service delivery.

Social barriers to execute law enforcement
An interesting aspect in the execution of the policy framework on a village level is the effect of social ties between local law enforcers and inhabitants of their legislative area. This aspect has not been discussed in literature, but multiple interviewees stressed the importance of social bonds between law enforcers, such as government administrators or members of a police force, and their area. On a village level there is a social barrier to execute law enforcement "..*because they feel that enforcing the law on the people in their village, their own people, might lead to personal problems, and therefore they avoid enforcement to avoid conflict*" (IV5, 2017). This is illustrated by an account of the change in WM policy in a Balinese village, in 2008. The cleanliness administrator was tasked with waste management according to the new guidelines. There was an existing private business executing waste management (collection and landfill disposal) in the village when the 2008 Waste act was issued. This business was operated by a woman from the village itself, as this is mostly the case in small villages in Bali. The cleanliness administrator noted that "*In this situation I had a dilemma to deal with the existing 'service', because they accept all mixed waste, there is no need to sort, the villagers just put it in front of their houses. I did not want to interfere with that business, as they were in operation even before the village council become responsible.*" (IV7, 2017). Therefore, they now hired them as a private party and allowed them to execute the collection on the village scale, as used to be the situation before. This shows that social ties between law enforcers and inhabitants of their legislative area greatly affect the readiness and willingness of enforcers to adapt the policy framework provisions.

In this section I have presented the deficiencies in accountability mechanisms that are identified as barriers to policy framework enforcement. Most important are the lack of clear roles and responsibilities, the lack of political and organizational accountability mechanisms as well as social ties of law enforcers. In the next section I will now cover a second barrier that has been recognized: the existence of capacity and resource gaps in local government.

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4.3 Capacity and resource gaps in local governments

Throughout most of the interviews and field visits, the concept of 'capacity gaps' always surfaced. It was often stated that there was a lack of capacities within local governments: "...*most regency level governments do not have the capacities to take up responsibility for enacting the law*" (IV3, 2017). A 'capacity' in this field can be considered an asset, whether a skill, knowledge, network or an executing power, that can reside in individual as well as collective actors (Bebbington, Dharmawan, Fahmi, & Guggenheim, 2006). Capacity in the context of waste management can be seen as the knowledge, skills and executive capabilities that are necessary to perform tasks. Additionally to capacities there is a need for resources. These constitute necessary inputs in a system to reach a desired goal, and can be everything from human resources (e.g. workforce size) to financial (e.g. available budget) and physical resources (e.g. equipment). As I will argue in this section, there are considerable gaps in both capacity as well as resources within local government levels.

Because of the long history of centralization in Indonesia, local governments had not built capacities in public service provision. Before the reform, subnational governments had mainly functioned as implementing agencies of policies and programs set up by the central government. This was the case in the field of waste management as well. Given that local governments had never been in charge of MSW management before 1999, they did not have the knowledge nor the resources to start executing waste management in a decent manner after the decentralization and then again after the implementation of the 2008 WML. In the Asean Development Bank research on Indonesia's decentralization, *Nasution* (2016) states that the decentralization of government functions was not followed up with equipping subnational governments with the capacity to produce public goods and provide other services, as it was the case in the field of waste management as well.

Given the lack of waste management experience in local governments, there was a strong need for clear and practical guidelines in national waste policy. However, experts in the waste management field state that this practical guidance is one of the main deficiencies in the 2008 waste management law (IV2, 2017; IV3, 2017).

After the decentralization in 1999, local governments had to provide public services autonomously, while under the former centralized system the minimum standards for public services were set by the central government. This had resulted in a lack of national policy in different public service areas, including waste management, and accordingly in a huge variation in the quality of public service delivery across the nation. The waste management law was mainly introduced to provide an overall framework in this field. The role of the central government is to establish national waste policy, and that of local governments is to determine waste policies at the lower level, based on national waste policy (Meidiana & Gamse, 2011). The need to support capacity and resources in local government is by now recognized at policy level as well, with government officials specifically naming these in their approaches (Sidik, Oct. 2010). The Ministry of Public Works is redefining its role in national SWM to focus on providing technical advice and support, and creating national standards. (Indonesia Infrastructure Initiative, 2013).

The need for increased capacity building in local governments was outlined in the interviews as well. In an interview with the head of the cleanliness division of a village council, the civil servant expressed that he *"did not get more than a single training on MSW management from the regency, even though I formerly had no responsibility in MSW management and therefore no knowledge"* (IV7, 2017). Despite the civil servant's willingness to adopt the new policy framework in his area, he felt that he only got a goal to work towards, without getting practical instructions on how to reach these goals.

In addition to the lack of practical guidance in the WML, the realistic setting and attainability of the aims are often disputed. One of the interviewees, with over 20 years of experience as NGO lead in the waste management field in Indonesia stated that *"the law is too much future oriented, it describes a state of waste management that Indonesia would like to achieve, but is out of reach for the time being. The infrastructure provisions, the current level of awareness and participation are not yet at a level to work in the prescribed way in the 2008 waste law"* (IV1, 2017). This opinion on the future-orientation of the law is supported by executives in the Indonesian National Government as well. In an OECD Global Forum presentation on Sustainable Material Management, the Deputy Director for Product and Packaging Ministry of Environment and Forestry stated that *"Indonesia has just started to implement a proper waste management, therefore in Sustainable Material Management policy we are still in the end of life perspective. It is far away to implement Sustainable Material Management"* (Sidik, Oct. 2010). This endorses the view that the 2008 WML was too much future orientated, without considering current capacities and resources.

A claim that was often made during the interviews was that there was a lack of budget to properly set up a waste management system according to the WML. This was stated both by members of government organizations as well as NGOs (IV7, 2017; IV1, 2017). There are multiple causes for a lack of financial resources. Firstly, it can be an actual lack of budget available for a local government. Secondly, it happens that local governments are unaware of opportunities to apply for and utilize the available funds of central governments. Thirdly, the budget that would be available for waste management is often used for different spending, given the low priority to budget allocation for waste collection and handling in local governments. These three causes will be discussed in the section below, after a brief explanation of local governments' revenue sources.

Local governments' budget sources
There are several main sources of income for local governments: local governments' own source of revenue (e.g. local retribution, revenue from privatization and lease), tax and revenue sharing (from income, corporate tax, and tax on natural resources) and transfers from the central government. The budget allocation of local governments mostly consist of the transfers from the central government. In these, there are three forms. The first is an allocation named the 'General Allocation Fund' (*Dana Alokasi Umum* [DAU]), the second is an 'Equalization Grant' (*Dana Bagi Hasil* [DBH]).

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The availability for funds in the field of waste management mostly lie in the third transfer, which is not a guaranteed transfer, but one that has to be requested from the local governments. The 'Special Allocation Funds' (*Dana Alokasi Khusus* [DAK]) provided to finance central government initiatives implemented by the region, particularly in remote and less developed areas. This is a special purpose grant similar to a capital-financing program. The block grant can only be used for development purposes, with a primary focus on infrastructure.

Regarding local governments budgets, a few shortfalls have been recognized and will be discussed here. It concerns general low infrastructure spending, budget provision for capital expenditures only, a lack of knowledge in local governments on how to absorb funds and administrative overspending in government levels. I will briefly elaborate on each of these.

Funding for waste management therefore mainly come from the governments available funds in infrastructure spending. However, this class of investment in Indonesia only amounts to around 4 percent of GDP in recent years (McKinsey Global Institute, 2012), which is considerably lower than that of for instance China, Thailand and Vietnam, where infrastructure investment accounts to around 7 percent (World Bank, 2011). This underinvestment has led to a major infrastructure deficit, which carries substantial economic and social costs (Ray & Yan Ing, 2016). I observed that this infrastructure deficit affects the waste management sector as well, with low investment directly (e.g. in landfill capacity and control, transfer stations, treatment & recycling industry) as well as indirect effects (e.g. low road maintenance creates long travel times to landfill).

Even when infrastructure investment is low, the National Government does provide possibilities for sponsoring to waste management operators: facilities that need to be built can be sponsored, trucks and other amenities can be requested. The problem hereby lies in the fact that these subsidies are only available for capital expenditures; operational costs do not qualify for fund requests. Multiple interviewees emphasized that this is a big barrier to sustainable waste management on Bali (IV2, 2017; IV1, 2017; IV5, 2017), since budgetary problems mostly arise in operation, not in the acquisition and setup phase. This is a common problem in MSW in developing countries, as International Financial Institutions approach MSW investments the same way, focusing on the acquisition and building of infrastructure, not on its operation (Marshall & Farahbakhsh, 2013).

Given the low income opportunities within the current system (IV2, 2017), there is a gap between revenue and operational expenditures, where there is no National Government fund available. Since formal waste management responsibilities are now with local governments, funding for waste management operational costs should come from local government budgets. However, expenditures such as roads or ports, which have a more obvious link to economic growth, are typically favored over MSW investments, thereby leaving little of their budget to MSW management (Indonesia Infrastructure Initiative, 2013). Other examples show a common budget for sewage and wastewater treatment and MSW management, in which the latter receives only a small share of the available funds (Shekdar, 2008).

Another mechanism that leads to low budget opportunities for waste management is the lack of knowledge and know-how in local governments as to the availability of funds from the National Government. For example, the transfers of funds from the central to local government is largely unutilized in government bonds and Bank Indonesia (central bank) certificates, amounting to more than US $10 billion; this shows the low capacity of local government to absorb and utilize available funds from the National Government (Firman, 2009). In the interviews with local government officials, it was noticeable that not all ways of obtaining National Government's funds were known and applied (IV7, 2017; IV6, 2017). Problems also occur due to ambiguity in the legal framework. In many cases, local governments hesitate to spend money for public service delivery because they doubt the legality of their actions, since there are numerous cases wherein local leaders have been convicted of illegal spending of public money, though sometimes they acted unintentionally (Ziegenhain, 2015). Furthermore, it is stated that the absence of public service standards and the lack of knowledge in the new administration of public funds has contributed to corruption and delays in the disbursement of government budget expenditure (Nasution, 2016).

Throughout almost all the interviews that were held for this research, the persistent existence of administrative overspending as well as corruption was also outlined, together with the barriers that they create in public services delivery. Corruption and administrative overspending in the Indonesian system attribute to budget allocation diversion and therefore lower spending on actual public service delivery. While corruption is defined as an illegal abuse of entrusted power for private gain (Transparancy International, 2018), administrative overspending is a variant, wherein public funds are directed away from the public to benefit bureaucrats. This is often less visible, in non-illegal ways, and less directly benefitting the officials, however, "*the general public is harmed equally*" (Sjahrir, Kis-Katos, & Schulze, 2014, p. 168). As a global organization that exposes and fights corruption, *Transparency International* ranks Indonesia 96th out of 180 countries for freedom for corruption in its 2017 Corruption Perceptions Index, with only 37 out of 100 points (Transparency International, 2017). Even though recent years' anti-corruption efforts have led to a slight improvement (from 32 points in 2012), *Transparency International* states that Indonesia has a long way to go in the fight against corruption (Transparency International, 2017). This exorbitance in corruption and administrative overspending uses up large portions of money intended for public service delivery. This was outlined by an anonymous interviewee, with over 20 years of experience in the local waste management field: "*A project for us is an activity to realize something. A "project in Indonesia" means there is money involved and someone is going to have some gains in that.*" (Interview anonymous, 2017).

These findings are supported by literature. Compared to international standards, administrative expenditures of Indonesian districts are extremely high. On average, districts spend around one third of their budget on staff and not on public services (Sjahrir, Kis-Katos, & Schulze, 2014), which severely affects infrastructure development projects. Even though it was hoped that corruption in public service delivery would diminish through the decentralization, corruption at the local level has risen enormously (Ziegenhain, 2015).

As I have shown in this section there is a lack of capacity and resources within local governments to enforce the policy framework in waste management. The low level of experience in public service delivery leads to a capacity gap that does not match with the low level of practical guidance in the 2008 WM law. Additionally, the budget for waste management is generally low, either through low budget availability, provision for capital expenditures only, a lack of capacity in local governments to absorb funds and administrative overspending.

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In conclusion

In this chapter I have outlined that there were two recent major changes in the Indonesian legislative framework concerning waste management: the decentralization in 1999 and the introduction of a new waste management law (WML) in 2008. The 1999 decentralization was prepared for different reasons than improved delivery of public services, but greatly influenced the waste management sector nonetheless. The introduction of waste management law no.18 in 2008 resulted in a huge shift of waste management tasks from the central government directly to regencies and municipalities, which has created both opportunities as well as hindrances.

I have argued here that there are two major hindrances in the functioning of the policy framework: a lack of accountability mechanisms, and resource and capacity gaps in local governments.

The lack of accountability mechanisms in the waste management policy framework majorly contributes to the difference between the policy aims and reality. There is a lack of clear roles and responsibilities in the policy framework, as well as an absence of political and organizational accountability. Additionally, an important aspect that has not been discussed in literature, but that had serious effect, was related to the social barriers to execute law enforcement on a village scale.

I have also shown that there are considerable gaps in both capacity as well as resources within local government levels. Because of the long history of centralization in Indonesia, local governments had not built capacities in public service provision. This lack of capacity is subsequently amplified by the lack of practical guidance in the WML, a lack of local governments to absorb or utilize available budgets, and administrative overspending and corruption.

5. Environmental awareness and knowledge

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In addition to the poor top-down enforcement of the framework, I will reason that a second important limit for the waste management is the lack of awareness and knowledge among the inhabitants of Bali. This results in a low willingness from users to adopt waste management as the legislative framework foresees. To support this argument I will elucidate the importance of awareness and knowledge in pro-environmental policy implementation, as well as how these are crucial for the Indonesian policy framework to function accordingly. Hereafter, I will show that these aspects are not sufficiently present among inhabitants of Bali, and on a larger scale in Indonesia as a whole. There is a tension between the degree in which the policy framework leans on people taking up their own responsibilities and the current level of awareness and knowledge in Indonesia (appendix 1.9). This tension creates problems in various aspects of system adoption and performance, amongst others user participation, system ownership and private company operation. I will also elaborate on another important aspect: the low social value that is attributed to waste management and all its related tasks, which causes an inherent disinclination to handle waste or work in waste management.

The importance of awareness and knowledge in pro-environmental behavior
The *Cambridge Dictionary* defines awareness as *"knowledge that something exists, or understanding of a situation or subject at the present time based on information or experience"* (Cambridge Dictionary, 2018). Intuitively, a person cannot consciously act to diminish a problem when he/she is not aware of the problem in the first place. Within an environmental management context, awareness is described as the first phase of the learning process towards pro-environmental behavior and is highly influenced by various internal and external factors (Zsoka et al. 2013). This shows the importance of awareness in waste management policy adoption.

However, awareness alone does not necessary result in pro-environmental behavior (*Steg* et al. 2014). In addition to awareness, a person should also have a basic understanding of the environment and its problems, as well as skills to be able to participate in environmental improvement programs (*Kamaruddin*, 2015). This comes down to a certain level of environmental knowledge. Environmental knowledge can be defined as one's ability to identify a number of symbols, concepts and behavior patterns related to environmental protection (*Laroche* et al., 2001). There is a large number of studies that indicate that environmental knowledge has a strong correlation with environmental behavior (Ramayah, Lee, & Lim, 2012; Ezebilo, 2013; Zen, Noor, & Yusuf, 2014). Knowledge of environmental issues, and in this case specifically waste management, has been recognized as one of the most important factors influencing household recycling behavior (Nixon & Saphores, 2009).
These studies also outline variables that influenced sorting behavior as an case study of participation in waste management, whereby the level of knowledge on environmental issues proved to be of great influence (Dhokhikah, Trihadiningrum, & Sunaryo, 2015; Ma & Hipel, 2016). In a case study regarding the factors that influence recycling in developing countries, the low extent of household education was seen as a barrier in 69% of cases (Troschinetz & Mihelcic, 2009), further highlighting the importance of environmental knowledge for pro-environmental behavior and policy adoption.

Tension between provisions in the law and policy implementation

As a complement to top-down policy making, bottom-up policy adoption is of vital importance to reach a functioning waste management system. In Indonesia, a clear gap between policy making and adoption can be observed, as it was strongly stated by multiple interviewees (IV3, 2017; IV2, 2017; IV1, 2017) as well as observed first hand. Even though the policy framework has been in place for over ten years, a lot of the policy provisions are still not taken up in the waste management routines of people in Indonesia.

As I have shown in chapter 3, nowadays there is a large consensus that for a policy framework in waste management in order to reach the desired outcome, it is necessary to look beyond the scope of mere policy or technology (Zurbrügg C. , 2013). The success of a MSW management system not only depends on technical innovation or the policy it is built upon, but is also significantly influenced by social and psychological factors, such as public participation and public attitude and behavior (Wilson, Velis, & Rodic, 2013; Ma & Hipel, 2016). Literature on the topic emphasizes that for governments it is necessary to evaluate the suitability of the proposed policies within the local environmental and social context (Ma & Hipel, 2016). This requires the active involvement of all stakeholders, including product manufacturers, institutions, private businesses and households.

Experts in the field of waste management on Bali emphasized that the policy framework is heavily dependent on the awareness and knowledge of environmental issues regarding waste in individuals (IV1, 2017), however these are exactly the elements that often lack (IV3, 2017). As discussed in the previous chapter, this dependency can be seen in policy provisions in the 2008 WML. Most notably, on the roles and responsibilities of households, in Chapter 2, Article12, (1), it is written that *"Everybody in the management of household waste and household-like waste oblige to reduce and handle waste based on environmentally sound management"* (Ministry of Public Works, 2008). However, even though the policy framework hereby states that household members have an obligation in waste management, this obligation is not taken up by the mass of people in Indonesia. Given the previously discussed importance of awareness and environmental knowledge for pro-environmental behavior and policy adoption, it can be stated that the degree in which the policy framework leans on people taking up their own responsibilities does not match the current level of awareness and knowledge in Indonesia.

Low level of environmental knowledge in Indonesia

In this research I have identified two main contributions as to why the current level of environmental knowledge in Indonesia is too low to conform to the level required by the 2008 WML. These will structure the next section. First of all, there is a lack of environmental education in the Indonesian school system. Secondly, there is a lack of (access to) information on the current waste management situation. Thereafter I will illustrate how this lack of environmental knowledge influences waste management practices, from the perspective of a user as well as in policy making.

The literature regarding the role of education in pro-environmental behavior show a consensus on the positive correlation between education and high levels of environmental concern and behavior (Vicente-Molina, 2012), and on the fact that knowledge transfer in the form of environmental education has the promise to improve MSW management (Valaencia-Vazquez et al., 2014). The importance of environmental education is undisputed amongst all the interviewees as well – some of them even stated it to be the most important aspect (IV5, 2017; IV6, 2017). However, environmental education has not yet been a set part of the curriculum of Indonesian schools.

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Only recently, it was decided that environmental education will be included in the Indonesian national curriculum in the near future, through a memorandum of understanding between the Ministry of Education and the Coordinating Ministry for Maritime Affairs (Indonesia Waste Platform, 2017). The lack of environmental education was also underlined by an interview I conducted with a school teacher in Medewi (Interview teacher, 2017). She confirmed that she did not have any environment related topics in the curriculum at all. Moreover, she stated that she had very little knowledge on the theme herself, whereby she expressed that she felt she did not have the skills or resources to educate the schoolchildren on the topic. The lack of education is endorsed in literature as well. In a study on community participation in waste management in Surabaya, half of the respondents noted that they had never had any form of educational training or program at all (Dhokhikah, Trihadiningrum, & Sunaryo, 2015).

The lack of formal education is further reinforced by a lack of (access to) information on the current waste situation in Indonesia. The importance of access to information about MSW handling and reduction is extensively proven in other researches. Multiple studies outline the effectiveness of communication efforts in improving awareness of recycling attitudes to contribute to recycling behavior (Sidique, Lupi, & Joshi, 2010; Nixon & Saphores, 2009). In their survey into community participation in MSW handling, *Dhokhikah et al.* (2015) concluded that an increase of information through mass media on this topic would be one of the most effective strategies to increase households' participation in waste management. *Lim-Wavde* et al. (2017) showed public education through information distribution related to household hazardous waste to have increased the amount of household hazardous waste collected.

The information deficit is rooted in two important causes. First of all, there is a lack of insight in waste management statistics throughout the country. Secondly, there are certain barriers to reaching local communities on environmental issues.

The Indonesian government also recognizes the importance of providing information on the current waste management situation in the country. In the 2008 WML, it is formulated that *"Everyone has the right to: [...] get accurate, correct and prompt information on the implementation of waste management."* (Ministry of Public Works, 2008). However, I have found that there is a lack of reliable information and numbers regarding waste generation, composition or collection. The latest government publication on the topic stems from 2008, when the Indonesian Ministry of Environment conducted the Domestic Solid Waste Statistics (State Ministry of Environment, 2008). This is a publication on Indonesian waste conditions, based on a survey conducted among region functionaries. However, this report has some limitations. First of all, only 33% of regions participated in the survey, which can be considered too low to provide an accurate average over the country as a whole. Secondly, there was no validation of the data from the survey, and there was no indication that the region functionaries were actually aware of the waste situation in their area. Moreover, there is a lot of ambiguity in the terms and classifications used in the survey. Most notably, in waste composition, 58% of the waste is classified as 'garbage', without any elucidation of what is meant by this term. The accuracy as well as the trustworthiness of the data can therefore be heavily debated.

Accordingly, the 2008 Indonesian Domestic Solid Waste Statistics do not offer a reliable and encompassing comprehension of the waste situation in the country. Given the fact that this is the main source from which the Indonesian government draws information, it shows that the government has little insight in the waste situation in the country.

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An additional barrier in information and knowledge transfer in Indonesia is the difficulty in which local communities are reached by information on the issue. In an interview on this matter with an Indonesian working in Communication of environmentally conscious businesses, she confirmed this observation by stating that it is very hard to reach the local communities on these matters, since local governments do not focus on these topics, and there is little to no budget in local governments for these kind of awareness campaigns (IV8, 2017) .There are some initiatives that promote sustainability and aim to educate people in issues such as waste management and people's role in environmental degradation. However, despite the high number of initiatives, there is a low community outreach for these kind of awareness campaigns and educational events. The information that can be obtained about MSW handling through mass media is limited. In the study on community participation in waste management in Surabaya, only 61% of the respondents stated that they ever obtained information through a mass media campaign (Dhokhikah, Trihadiningrum, & Sunaryo, 2015). During my fieldwork studies in Bali I went to a number of educational events (e.g. the *Ubud Sustainable Design Festival*) and what I observed was that these events are mostly visited by foreigners, both tourists and expats. Very few Indonesians visit these events, and the ones that do visit are the ones who are already aware of the situation, thereby having little effective outreach in local communities.

Low value to waste management

As I have discussed so far, awareness, knowledge and access to information are important factors that contribute in shaping people's behavior in waste management. Another important element herein is the norms and values people hold to waste management. There is a lot of research that covers the role of attitudes and values in environmental issues, however, given the scope of this study I do not go into broader debates but focus on the parts relevant for my findings.

A useful way to think about values is suggested by *Schwartz* (1992) : 'desirable goals, varying in importance, that serve as guiding principles in people's lives'. *Fuhrer et al.* (1995) hypothesized that a person's values are most influenced by the immediate social network: family, neighbors, peer-groups, etc. Values are attributed to affect a wide array of beliefs, attitudes, norms, intentions and behaviors (Steg 2014), and thereby responsible for shaping much of a person's intrinsic motivation.

The social value to waste management therefore greatly affects a person's behavior in waste management. This is confirmed in specific research on the topic. Psychologic variables related to social norm and peer pressure are found to be influencers of recycling behavior (Nixon & Saphores, 2009). *Ramayah et al.* (2012) found that social norms and values have a great impact on recycling behavior, congruent with earlier findings from studies by *Do Valle et al.* (2004), *Shaw* (2008) and *Wadehra et al.* (2018). *Shekdar* (2008) concluded that in many Asian countries the social status of solid waste management is low, resulting in an apathy towards it. Throughout my research, multiple interviewees confirmed the importance of social value to waste management as well, and expressed their concern over the current low value. The general opinion held that institutional aspects will not be successful if they are not supported and enforced by social aspects (IV7, 2017; IV1, 2017). As I will elucidate now, this is further emphasized by a specific characteristic present in Balinese culture.

Balinese culture is unique in its conceptions on waste and has a "*[...] distinctively Balinese cultural disinclination to get too closely involved with rubbish, originating in Hindu conceptions about pollution, combined with a status-based social hierarchy.*" (MacRae R. , 2015, p. 313). This disinclination to handle waste is further enhanced by the stigma that handling waste holds, as it is strongly associated with poor and marginalized people with low social status (IV2, 2017). This was clearly observable during my fieldwork time in Bali, most notably in a pilot project I was working in. Given the local setup of the waste management service, all the workers were from the village itself, and were Balinese. After a few weeks of operation, the community manager in the project refused to go out and collect waste. In an interview with him, he declared that "*[...] the work is dirty, it is too hot to perform these kind of tasks, and it is not something I want to do. Why can't we get people from the other race to do the waste collection and sorting?*" (Interview P. Krishna, 2017).

This division of labor according to background was visible throughout all aspects of the waste management system. In observational visits to several villages to characterize the waste management system in place I asked for the demographics of the work force. The landfill operators confirmed that both the scavengers as well as the workers that do the pickup rounds with the waste truck are mostly Javanese and Sundanese (IV1, 2017; IV6, 2017). Further through the waste management system, the same can be observed: in multiple conversations with pemulung (the door-to-door valuable collectors) as well as pengumpul (the informal recycling sector middlemen) they confirmed their background as non-Balinese.

Low intrinsic motivation for environmental behavior

As I have argued, the low level of awareness, education and social value to waste management in Indonesia does not match the provisions in the 2008 WML. Additionally, these factors also have effect on public participation in a different way: it makes up for a low intrinsic motivation for users to perform according to environmental standards.

Intrinsic motivations aim to satisfy psychological needs directly in terms of relationships, autonomy, competence, self-acceptance, affiliation, and a sense of community or health. *De Young* (1986) has argued that intrinsic motivation to act is an important predictor of environmental and waste management behavior.

Another psychological variable that is important with regard to intrinsic motivation in waste management behavior is the degree to which the waste problem is perceived to be a threat to personal well-being. *Graci et al. (*2012*)* stated that " *[...] when a system is reflective of stakeholders' concerns, those individuals are more likely to provide support by participating in desired behavior*". The importance of the role of public acceptance in influencing the effectiveness of a MSW management scheme and its smooth operation is further supported by literature (Ma, 2015). Given the current level of development in Indonesia (UNDP, 2016), waste management might not be seen as an important direct threat to one's environment and therefore not prioritized in actions and behavior.

This low prioritization of waste management together with low levels of awareness, knowledge and information in people result in low intrinsic motivation to perform according to environmental standards. This consequently leads to less willingness to act according to the 2008 WML. Practically, this lack of willingness shows in forms of e.g. lacking waste collection, indiscriminate waste dumping, waste burning and hindrances for waste service operators. In the next section, I will elaborate on some of the barriers that waste service operators have to overcome, which were expressed frequently during interviews.

Hindrance for waste service operators

The low social value that is given to positions in waste handling subsequently creates problems in staffing for MSW management logistics positions. As one interviewee, who was the operating manager of one of the largest NGO's on waste management in Bali, expressed: *"We have had several people that had to quit [their job in MSW logistics] because Mum and Dad were not happy"* (IV2, 2017). The low social value that is given to waste, combined with a low intrinsic motivation to tackle waste related issues, leads to an unwillingness of skilled people to work in the waste management sector. In the pilot project I cooperated in, I observed the same issue, when there was a vacancy for a facility manager. Multiple applications led to interviews, but most of the applicants withdrew after a site visit wherein they saw that they would be working in the facility itself. The reasons they stated mostly were that they did not want to work between the waste, and that they felt the job had too little status for their level of education. This hindrance in fulfilling human resource positions is endorsed in literature as well (Shekdar, 2008). In the case study on barriers for sustainable MSW management in developing countries, the extent of trained laborers and skilled professionals in MSW management positions was stated to be of great importance, but proved to be a barrier in 83% of cases (Troschinetz & Mihelcic, 2009).

The difficulties in the value chain of a sustainable waste operator are very much linked to the willingness of users to pay for a certain service. As mentioned before, the level of education and awareness on sustainability issues in Indonesia is very low. System users often do not have an intrinsic motivation to participate in a sustainable waste management system. This leaves external motivation as drivers whereupon to choose a waste disposal method. Important external motivations are the convenience of working with a certain service and the cost of one. Participating in a sustainable system is often much less convenient (for instance, users might have to separate waste in their households) but is also often more expensive, due to the added steps for sustainable disposal. Subsequently, people are not willing to pay the higher fee for services that comply to the Indonesia's 2008 waste act and these operators have problems in creating a viable financial model. As an NGO-leader in waste management (IV2, 2017) stated: *"The problem is not that people are not paying, the problem is that they are not willing to pay enough"*, outlining the disinclination for people to pay a higher price for a sustainable service operator.

In conclusion

In this chapter, I have reasoned that the degree in which the waste management policy leans on certain levels of awareness and knowledge does not match the actual level among inhabitants of Bali.

I have outlined the importance of awareness and knowledge in pro-environmental behavior, and more specifically in participation in waste management. However, the degree in which the policy framework leans on people taking up their own responsibilities does not match the current level of awareness and knowledge in Indonesia. This is mainly due to a lack of environmental education and lack of (access to) information on waste management. Another significant hindrance to the adoption of sound waste management in Bali is the low value that is given to the topic, recognizing that the social value attributed to waste management greatly affects a person's behavior in waste management. Bali is unique in its conceptions on waste and has a distinctively Balinese cultural disinclination to get too closely involved with it. This disinclination to handle waste is further enhanced by the stigma that handling waste holds, as it is strongly associated with poor and marginalized people with low social status.

These factors also have effect on public participation in different ways: it makes up for a low intrinsic motivation for users to perform according to environmental standards, a lack of willingness to pay for waste management services, as well as causing human resource gaps in the waste management operator field.

In the two last chapters I have shown that there is a large gap between the provisions and the realizations for waste management on Bali. From the insights gained from the qualitative empirical study, I concluded that these aspects are mostly consequences of a lack of policy framework enforcement and an insufficient environmental awareness and knowledge, where the policy framework starkly leans on. The next chapter discusses the sustainable technologies that are available to reach improved waste management, as well as how they could contribute to improve the local-specific waste management system of Bali and, in a greater perspective, of Indonesia as a whole.

6. Sustainable energy technology in waste management

This chapter covers methods for waste management improvement and the state of the art in sustainable energy as well as resource technology in the specific field of waste management. I will briefly discuss the current paradigm in waste management improvement first, to create a general understanding of the background in the field. Hereafter, several sustainable energy and resource technologies will be discussed. As it is outside the scope of this thesis to go into depth in all the technologies, I will only briefly discuss the method and the promises and limitations for the field. Lastly, the viability for implementation of these technologies for Bali will be discussed, with the context-specific possibilities and limitations taken into account.

Waste management improvement: the current paradigm

There are diverse options for a system to increase sustainability in waste management. In the context of MSW management as discussed in this thesis, sustainability refers to *"the assessment of environmental, economic, and social impacts of available waste treatment options"* (Soltani, Sadiq, & Hewage, 2016, p. 388). In the current waste management paradigm, the preference of options to address these impacts is viewed by the widely used waste hierarchy, as depicted in figure 7, which is an updated version of the original hierarchy (CEC, 1977). Proper management consists firstly of waste prevention at source, followed by reuse, recycling and composting, other recovery (e.g. energy recovery) and as least desirable option, the disposal of the product or material. This hierarchy follows the finding on studies stating that recycling of energy and materials versus disposal through landfilling leads to a reduction of energy and resource use, less environmental impact and ultimately, lower economic costs (Eriksson et al., 2005).
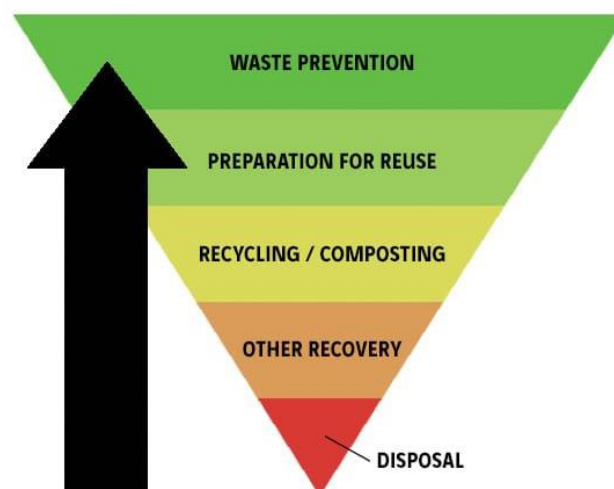
Figure 7: An updated version of the waste hierarchy (Letsrecycle, 2014)

Taking the waste hierarchy into account, the waste industry can offer significant improvement potential through a range of strategies. In the context of the environmental impact of the industry, I distinguish three significant strategies where technology enhances the sustainability: direct reduction of GHG emissions, avoidance of GHG generation and avoidance of waste generation in general.

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The first one is aimed at direct reduction of environmental impacts of landfills. This can be done through landfill methane recovery and utilization and by optimizing methane oxidation in landfill cover soils. The second strategy is to aim for avoidance of greenhouse gas generation compared to landfilling through Waste-to-Energy (WTE) processes or Mechanical and biological treatment (MBT). Thirdly, and given the waste hierarchy this option is preferable, the aim can be to avoid waste generation, through the 3R principle: Reduce, Re-use, Recycle. Waste avoidance leads to a reduction of virgin materials to be used leading to resource as well as energy conservation and fossil fuel offsets.

It is outside of the scope of this thesis to go into depth in all of the existing methods mentioned. However, I will discuss these topics briefly, and will go into their relevance for the situation specifically in Bali thereafter.

Direct reduction of GHG emissions from landfills

The main contributor to GHG emissions from improper waste management is CH4 emitted by landfills (Cherubini, Bargigli, & Ulgiati, 2008), estimated to be in the range of 20-40 million tons globally per year. Final disposal through (uncontrolled) landfilling is the prevalent method of waste disposal on Bali, and therefore has large impact on its emission profile. In order to cut back on these emissions and many other hazards that uncontrolled waste dumping represents, the Indonesian government issued the built and use of sanitary landfills only (Ministry of Public Works, 2008). Besides the environmental impact, landfills also represent hygiene and safety risk due to the compound's nature. Sanitary landfills are equipped with systems that prevent secondary pollution problems, such as the infiltration of leachate through the use of liners or to capture GHG emissions to the atmosphere with gas capturing methods. A system for landfill gas capturing can be implemented in order to lower environmental pollution impact. These type of systems generally consist of vertical wells or horizontal collectors in order to absorb the landfill gas production, as can be seen in figure 8.
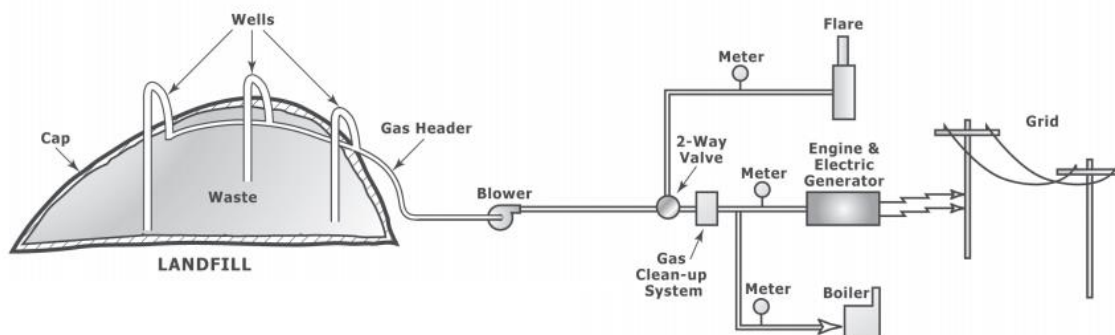
Figure 8: Typical landfill gas recovery and use project diagram (Global Methane Initiative, 2018)

After processing in a gas clean-up system, this gas can be used to generate heat or electricity and as a substitute of natural gas. A major drawback of these kind of systems is that the costs increase significantly with each protective measurement, such as gas capturing, liners, leachate collection and gas removal systems (Cheng & Hu, 2010).

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Waste-to-energy processes

Waste To Energy (WTE) is important to discuss given the current national discussion of the role of this technology in waste management in Indonesia (The Jakarta Post, 2017). Despite the general focus on waste prevention, there will always be residual waste that needs to be disposed of. In this case, WTE processes offer a way to dispose of the (sometimes hazardous) waste, while regaining some value out of it. Methods like incineration (Brunner & Rechberger, 2015), gasification (Arena, 2012) and pyrolysis (Malkow, 2004) allow the recapture of part of the energetic value of waste, that cannot be reused or recycled, by generating heat or electricity, together with offering a large reduction of the disposable waste volume. One of the main advantages of this method is the applicability for all mixed waste streams. With today's available technologies, emissions of modern WTE processes comply to the most stringent of air pollution standards (Brunner & Rechberger, 2015). However, for successful clean air management it is crucial to allocate the different waste streams to suited combustion processes with adequate air pollution control. Additionally, by using energy produced with this type of technology, the need for fossil fuels is reduced, which decreases the emission of GHG to the atmosphere. Therefore, WTE represents itself a technically promising solution. When compared to nonrenewable energy sources, the CO_2 emission can decrease from 26 to 63% per MWh produced, depending on the nonrenewable energy source (Wilson, Velis, & Cheeseman, 2006). These premises have led the Indonesian government to issue a presidential regulation to speed up the development of WTE power plants as an attempt to resolve acute garbage problems (The Jakarta Post, 2016).

Mechanical and Biological treatment (MBT)

An MBT system is a type of waste processing system that combines strict sorting with a form of biological treatment. Mechanical treatment refers to the sorting of inorganic materials into several components that can be treated accordingly (through re-use, recycling or in a WTE process). Biological treatment can be used as a way to recover the energy and resources in the organic waste. Concerning biological treatment, there are two main options to treat biological waste: composting and anaerobic digestion. The first is the decomposition and stabilization of the organic fraction of organic waste in aerobic conditions, by diverse microorganisms (Vergara & Tchobanoglous, 2012). The resulting product can be used in agriculture, horticulture, soil stabilization and soil improvement. According to *Friedrich* (2013), a reduction of 85% in greenhouse emissions (in the organic fraction) can be done solely by implementing composting methods in the waste management systems. This study shows that one ton of garden waste dumped in a landfill emits up to 1298 kg CO2e, but if the same amount of waste is composted, the emission is reduced to an average of 178 kg CO2e. In Indonesia only, the organic fraction of municipal waste represents approximately 60 to 65% of the total production (Kerstens, Leusbrock, & Zeeman, 2015). Therefore, if the volume of organic waste that ends up in landfills is reduced, the overall quantity will experience a considerable cutback, which will be reflected in the total emission count and therefore greatly contributes to the GHG emission cuts from waste management. There are some drawbacks to composting treatments as well, mainly regarding the relatively large space that is necessary for composting and the degree of labor that is needed for separation and processing of the organic waste (Cheng & Hu, 2010).

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Recycling and re-use

Recycling and material recovery was highlighted by multiple interviewees (IV6, 2017; IV4, 2017; IV3, 2017) given the attainability and potential it holds on Bali,. As an important part of waste management, the main purpose of recycling is to restore the value of certain waste materials by transforming them into new products. To recycle directly reduces the amount of waste in landfills, therefore the emissions involved in waste management are also reduced. Indirectly, by recycling, the need for raw materials is decreased, lessening the need for natural resource exploitation (Vergara & Tchobanoglous, 2012). This especially holds for the recycling of glass, plastic and metals, where respectively 34%, 93% and 93% of CO_2 emissions can be reduced (EAWAG, 2017). The only exception is the recycling of paper, that due to larger energy inputs and large residues in the recycling process, leads to an increase of CO_2 emission of 361% (EAWAG, 2017).

Implementation of sustainable energy and resource technologies in the context of Bali

As I have outlined, several readily available technologies exist that offer significant improvement in the sustainability of waste management. However, in the specific context of Bali, certain things should be taken into account when reviewing the possibility for implementation in this context. First of all, many of these technologies rely on very strict process norms, require constant maintenance and responsible and ethical operation. The repercussions of a deteriorated operation of these type of systems could end in a project that would actually end up in a net increase in environmental impact. Additionally, deteriorated operation could result in a non-economically-feasible operation, lowering the chance of successful use. There is one landfill in Bali that is theoretically equipped with a WTE technology (based on methane capturing technology) but its yield has always been questioned, even though large amounts of subsidiary money was used to construct and implement the technology (BaliFokus, 2016). Therefore, a general opposition to this technology type has been growing in Bali, showing that this technology might not be suited to be implemented in this context. Firstly, the use of WTE could lower the incentive to reduce, reuse and recycle (IV2, 2017). Next to that, WTE technologies require a high degree of monitoring capacity, knowledge and training in the field to ensure proper operation (IV4, 2017). As multiple interviewees argued, discussed in chapter 4, these are factors that are often lacking in Bali. Additionally, spare parts are not readily available in Bali, which increases the overall cost and further risks improper operation (IV1, 2017). Whereas a maintenance manager in a developed country may be able to obtain a spare part within hours, the process of acquiring spare parts can take more than six months in a developing country, because of restrictions on foreign currency, bureaucracy and customs procedures (Coffey & Coad, 2010). Throughout the fieldwork I have visited multiple facilities that were equipped with sustainable technologies such as methane capturing methods (Appendix 1.10), but none of the systems were operational at the time of visit. In an interview the manager of one of these sites (IV6 I. , 2017) confirmed that the technology had been installed, but when the system was not performing to standard and they did not have the parts and knowledge to fix it, they ceased operation altogether.

Another drawback of most of the technologies discussed is the degree in which they rely on the input that comes from the waste generator: such systems often only work on a specific waste stream that has to be separated from the mixed waste stream. Given that waste generators in Bali currently do not separate their waste streams, the economic viability of such technologies is low. This was one of the points that most experts thought was vital in the search for appropriate MSW management technologies: if the waste generators would not behave in the system in a certain way to facilitate a MSW management method, the method would almost certainly fail (IV1, 2017; IV2, 2017; IV3, 2017; IV4, 2017). Most of the waste management experts claimed that for Bali it would be better to invest in low cost, low tech and low risk methods, wherein MBT with the use of manual labor would have a central role. The main requirement to the success of this strategy is the degree in which waste generators would comply to the separation criteria, which would lean starkly on the level of knowledge and awareness on waste related issues (IV1, 2017; IV4, 2017; IV5, 2017; IV8, 2017)

In conclusion
In this chapter I have briefly discussed the main sustainable energy as well as resource technologies in the field of waste management. Three strategies have been reviewed: direct reduction of GHG emissions from landfills, avoidance of greenhouse gas generation compared to landfilling through Waste-to-Energy (WTE) processes or Mechanical and biological treatment (MBT) and the avoidance of waste generation through the 3R principle: Reduce, Re-use, Recycle. While all of the methods can have a significant impact on the sustainability of waste management, it has to be noted that for all of them to function properly and deliver the desired benefits, strict input as well as process norms should be adhered to. This leads to the conclusion that while technology offers opportunities in the waste management sector, by no means it holds the premise to resolve the waste problem by itself. From the description of the discussed methods and the opposition to WTE technology in Bali it is noticeable that for these strategies to work and to reach the desired results, it is vital that the behaviour of the system's users enables these technologies to function properly and reach maximum results. The lack of awareness and education as well as the lack of policy framework enforcement therefore have to be addressed hand in hand when implementing a more technological solution.

The next chapter discusses the sustainability opportunities of an improved waste management, in order to construct an understanding of the implications and impact of the failing waste management system on the environmental performance of Bali and, in a greater perspective, of Indonesia as a whole. Taken the conclusion from this chapter into account, the improved waste management system consists of waste generators that collect and separate all of their waste, where after this waste is processed through MBT including recycling of inorganics and composting of organics, and 10% residual waste being transported to a sanitary landfill.

7. Sustainability opportunities of improved waste management

In the previous chapters I covered two findings that I identified to hinder the functioning of the waste management system in Bali: policy framework enforcement and awareness and knowledge levels. Hereafter, I discussed the premises that technology can hold in the field of waste management, if used in conjunction with improved waste generators' behavior. In this chapter, I will show that progress in these two fields in combination with adequate waste processing technology would lead to improved waste management, which would significantly contribute to the reduction of the environmental impact of Bali, specifically focusing on greenhouse gas (GHG) emissions. To support this argument, this chapter will compare and contrast the GHG emissions resulting from the current waste situation to the hypothetical situation in which waste management is established and fully operational. Given the demography and economy of Bali, especially with its role in the Indonesian tourism industry, Bali is a concentrated case study of problems prevalent all over Indonesia (MacRae R. , 2015). Problems in waste management have even lead to the declaration of a state of '*garbage emergency*' on the island (Saragih, 2018). Improvement of the waste management situation in Bali and the resulting contribution to the reduction of environmental impact can therefore serve as an example for the whole of Indonesia.

In the first section, I will elucidate on the environmental goals and commitments set by the Indonesian government wherein waste management is of great importance. Hereafter, an improved scenario will be outlined, after which the assumptions for improvement will inform a quantitative impact analysis of the Business As Usual (BAU) scenario in contrast to the hypothetical improved scenario. Recognizing that it is a simple impact model and acknowledging the lack of reliable data as discussed in chapter 5, the outcome of this quantitative analysis merely serves as a relative indicator of the sustainability opportunities for improved waste management. Lastly, regarding the possibilities to improve waste management, I will discuss three main topics that are relevant for the situation in Bali: recycling and material recovery, Waste To Energy (WTE), and final disposal through landfilling.

Indonesian engagements in waste reduction

As discussed in chapter 4, one of the main causes for the current inadequate waste management situation identified through this research was a lack of policy framework enforcement from the government, despite the fact that the government has set goals and targets in fields where waste management is of great importance. To elucidate on these, I will stress the relevant engagements of the Indonesian government that regard waste management.

The most notable direct engagement towards reducing waste consists mainly in the 2008 Waste Management Law, already discussed in chapter 4. Additionally, the government made different efforts to reduce waste. For example, in 2010 the government of Indonesia committed itself to reduce GHG emission by 26% in 2020 from the 2010 BAU level with its own efforts and reaching 41% reduction if it would secure international support (Ge, Chrysolite, Utami, Wijaya, & Friedrich, 2016). Furthermore, there are numerous local initiatives in improving waste management throughout the country, often in collaboration with local and national governments (The Jakarta Post, 2014), as part of the efforts to lower the amount of waste produced in the country.

Indirectly, proper waste management is also linked to international agreements that the Indonesian government has regarding environmental impacts. For example, every official effort from the Indonesian government to reduce climate change (e.g. the Paris Agreement, 2015) is linked with proper waste management, since GHG emissions from waste contribute to around 3% of total GHG emission (ClimateWatch, 2014). For 5 of the 34 provinces, including Bali, waste is even the biggest contribution. The emission profile for Bali specifically (see figure 9) shows that in 2010 the complete waste sector contributed to 87% of total GHG emission with an emission of 42.92 $MtCO_2e$ on a total of 49,33 $MtCO_2e$ (World Resources Institute, 2016). It has to be noted that these values did not inform the quantitative analysis, as this is the fraction of the total waste sector, which includes all forms of waste such as MSW, construction waste and industrial waste.
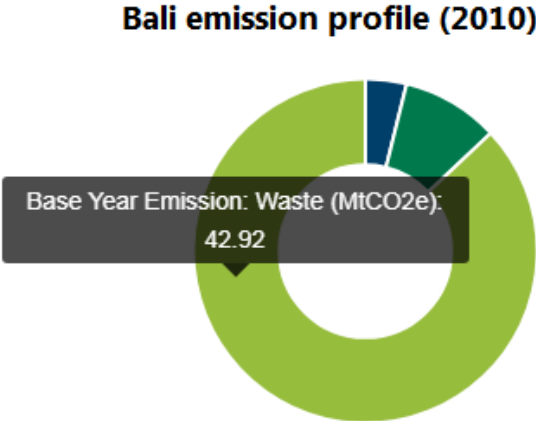
Bali emission profile (2010)

Base Year Emission: Waste (MtCO2e):
42.92

Figure 9: The share of GHG emissions from the waste management sector for Bali (World Resources Institute, 2016)

7.1 Business As Usual against improved MSW management

In this section, I will compare the Business-as-Usual (BAU) in Bali to the potential implementation of an effectively improved waste management system on the island. Given Indonesia's ratification of the Paris Agreement and the focus herein on GHG emissions, I will compare the two scenarios in terms of resulting GHG emissions. Both cases were considered for a 15 year period; from 2010 to 2025. This time span allowed to take the volume of waste disposed from 2010 to 2017 and subsequently make a projection from 2018 to 2025. These projections are based on the past disposal rate from both locals and tourists (international and domestic) in Bali. Given the ambiguity in data on MSW management, as discussed in chapter 5, this analysis is not meant as an absolute value projection, but more to show the trends in both scenarios.

The improved scenario is based on literature findings as well as experts' view. As stated before, *Aprilia et al.* (2013) have shown that over 78% of the MSW has the direct potential to be recycled, composted or reused. Moreover, most of the experts that I have interviewed believed that by improving the policy framework enforcement and overcoming the lack of awareness, education and social value to the waste management sector, waste ending up in landfills could be further reduced to 10% of the waste in BAU (IV4, 2017; IV2, 2017; IV5, 2017; IV1, 2017) with a slight change in the residue waste composition. The common vision was that the enforcement of the policy framework should be strengthened while resources should be dedicated to increase system infrastructure provisions as well as users' knowledge on improved waste management behavior.

Subsequently, this would lead to a waste management system wherein:

- All users collect and separate their waste
- Illegal dumping and burning of waste are banned by apt law enforcement
- All waste gets transported to material management centers
- All materials that can be reused or recycled or treated accordingly
- All organic material would be composted
- Hazardous household waste is treated and disposed in an environmentally conscious manner
- The materials that cannot be reused, recycled or composted are sent to sanitary landfills only
- Landfills are equipped with state-of-the-art waste management techniques to ensure as little environmental impact as possible.

Given the changes, resources and the time that is needed for the situation to improve in such a significant way, it is assumed that the improvement is progressively accomplished in equal steps for 5 years. For more detailed information regarding the computations of the quantitative analysis, see appendix 3. The results of the analysis are shown in figure 10 and figure 11.
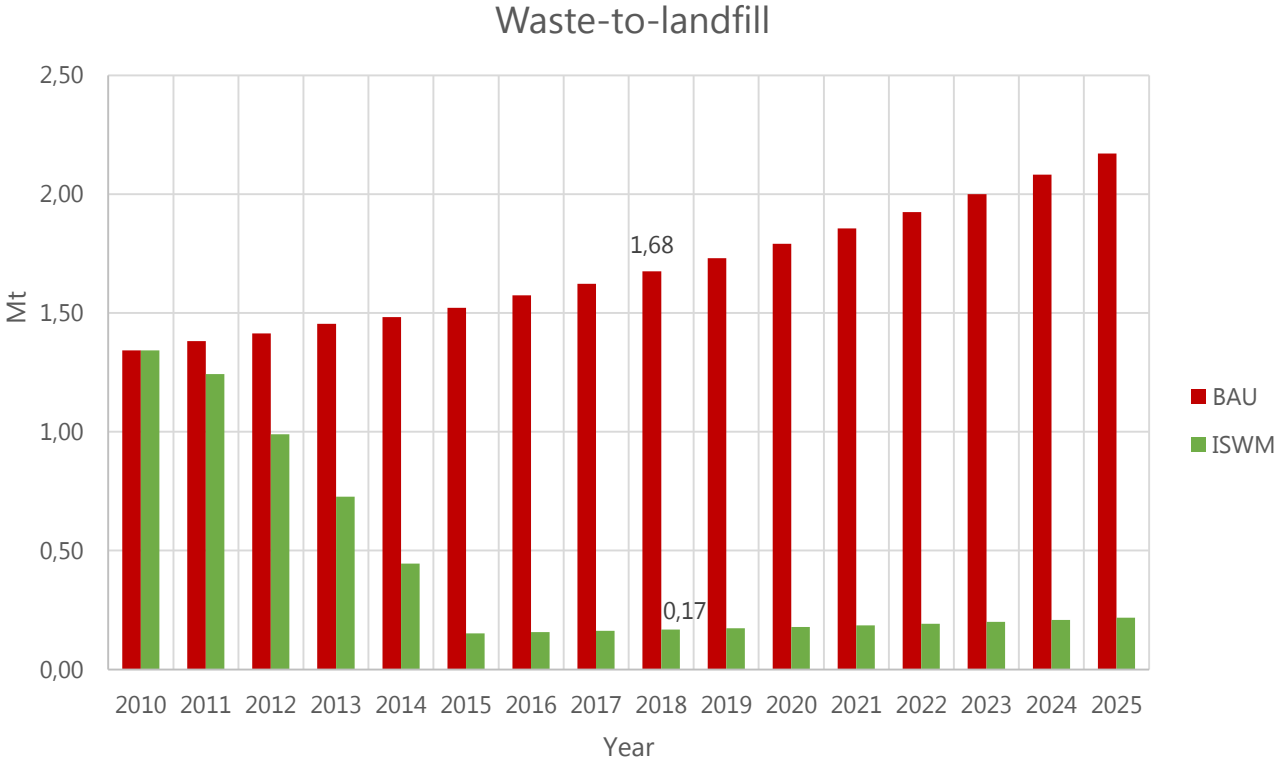
Figure 10: Waste-to-landfill (2010-2025) for the two scenarios: Business-as-Usual (BAU) and improved system waste management (ISWM).

As can be seen in figure 10, the difference between the amount of waste that goes to the landfill in the two scenarios is significant. In particular, in 2018 the values are 1,68 Mt in the BAU scenario versus 0,17 Mt in the improved scenario. Most of the materials that are disposed of as waste in the BAU scenario are then either used anew, as resources to create new raw materials, or are treated to regain their resource or energetic value, according to the current paradigm of 'closing the loop' as discussed in section 3.1.

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Taking these changes in waste-to-landfill as well as a slight difference in waste composition into account for the GHG emissions, the analysis provides the outcome presented in figure 11. Once again, this analysis does not offer absolute value results, but it is meant to outline trends, and therefore opportunities, to cut back on GHG emissions from waste.

GHG emission from MSW Management
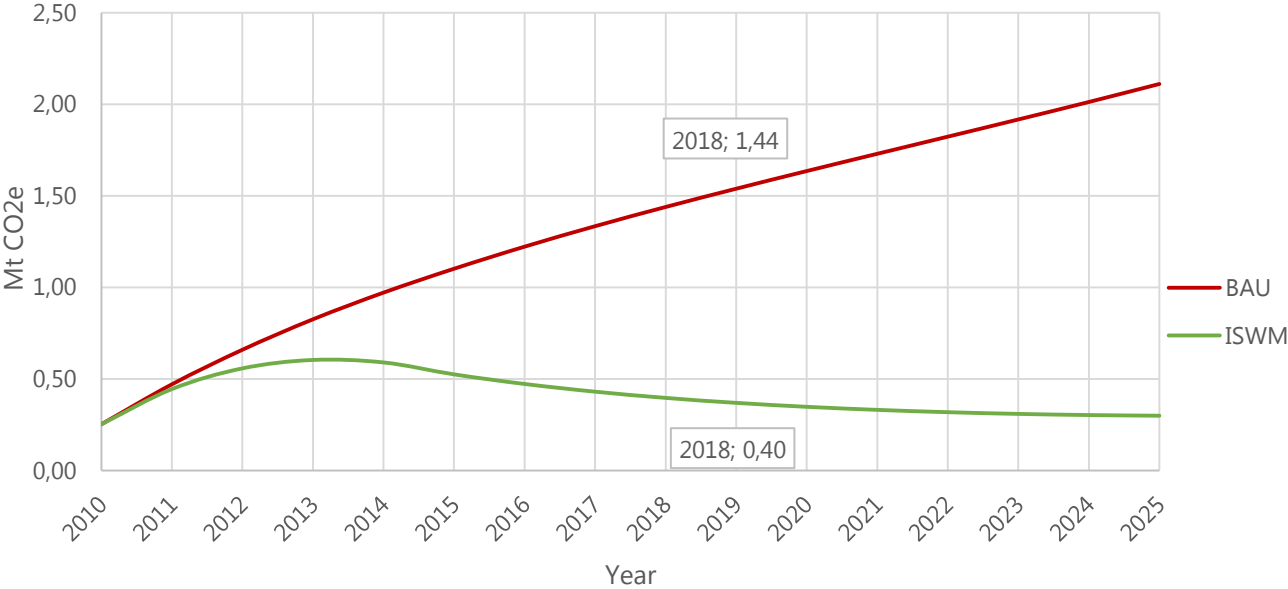
Figure 11: GHG emission from MSW management (2010-2025) for the two scenarios

In 2018 the GHG emissions are 1,44 $MtCO_2e$ for the BAU scenario, and 0,40 $MtCO_2e$ for the improved scenario. The main contributions to this reduction are the reduction in the amount of waste that gets transported to the landfill, as well as the improvement of landfills to perform according to the lines of sanitary landfills as described in the 2008 WML (Ministry of Public Works, 2008).

This implies that, if the improvements in the MSW management sector had been implemented in 2010, it would have resulted in a 2018 GHG emission level that is only 28% of the projected current situation. This outlines the importance for improvements in MSW management and the sustainability opportunities that these hold. It also shows that not only GHG emission from waste management decreases, but the growth rate decreases as well. This implies that it is possible to stabilize the emission from waste in the case of Bali, and eventually to bring it down. Moreover, illegal but commonly seen practices such as waste burning were not taken into account due to the lack of data hereof. These computations were subsequently done under the assumption that all of the generated waste goes to legal landfills. The difference between the BAU and the improved scenario might therefore be even greater than foreseen in this section.

In conclusion

In this chapter the importance of waste management for Indonesia to meet its emission cut goals were outlined, by comparing the GHG emission resulting from the current waste situation to a hypothetical improved situation through a quantitative impact analysis. Given the magnitude of the contribution of the waste sector in these emissions, improvements in this sector are vital in Indonesian engagement in several efforts to reduce GHG emission. For Bali specifically, I have shown that 87% of GHG emission comes from the waste sector. The quantitative impact analysis subsequently showed that with a 5-year commitment towards an improved waste management situation in which only 10% of waste goes to landfill, GHG emissions in this sector could have been reduced by 72% for 2018. Additionally, the analysis showed that by doing so the growth of emission from the waste sector could be stabilized and reversed.

Regarding the methods of improvement in MSW management, three important factors that are relevant for the situation in Bali were discussed. I have argued that recycling and composting can make up for major cuts on emissions, which also holds for improved final disposal sites in the form of sanitary landfills with GHG emission capture systems. However, as was the case with WTE technology, it is emphasized that, while technology offers opportunities in the waste management sector, by no means it holds the premise to resolve the waste problem itself. In all these improvement strategies, it is vital that the behaviour of the system's users enables these technologies to function properly and reach maximum results.

8. Conclusions & recommendations

In this final chapter I will combine the insights presented throughout this thesis and through these I will answer my research question: *"What are the realizations from the Municipal Solid Waste management policy framework to the waste management situation in Bali, and which factors influence these realizations?"*
I will also discuss which implications the generated insights hold for MSW management research as well as recommendations for the policy framework on Bali.

8.1 Conclusions

Through an analysis of literature I presented an overview regarding the aspects held on waste management in a global perspective and in developing countries. This analysis showed that, over the last few decades, there has been a shift towards a more holistic view of the sector. The current consensus is that the success of a MSW management system, not only depends on technical innovation or the policy framework it is built upon, but it is also significantly influenced by social and psychological factors, such as public participation and public attitude and behavior. Another important conclusion of the literature review is that the phases that the developed world went through in waste management can by no means serve as a roadmap for developing countries. The different state of knowledge in waste management as well as the recognition that the enabling environment in a local context show to be of vital importance for the success or failure of a system.

Focusing on Indonesia, I have argued that while extensive research has been conducted into the *provisions* regarding waste management, not much research has been done into the *realizations* from the MSW policy framework. When it comes to the context of Bali, the literature review, as well as observational visits to parts of the local waste management system, show that the realizations on Bali are not corresponding to the provisions in the policy framework. This is clearly indicated by low levels of collection, indiscriminate waste dumping and burning, and uncontrolled landfills.

Findings from literature and empirical evidence from fieldwork resulted in the recognition of two main barriers to the performance of the waste management system in Bali: a lack of policy framework enforcement and a mismatch between the degree in which the policy framework leans on people taking up their own responsibilities and the current level of awareness and knowledge in Indonesia. It has to be stressed that these are themselves results of a complex combination of factors present in Indonesian culture, society and institutions. A general conclusion from this research is therefore that there is no single reason to identify that shapes the current waste management situation in Bali, and therefore no single method to improve.

An important theoretical contribution comes from the observed tension between institutional provisions in a policy framework and the reality on the ground. While institutional provisions are often well studied and documented in current literature, few researchers focus on the actual enforcement of a policy framework, even though this is probably a more decisive factor in system performance. This research shows that a framework itself of course has to be set up in a matter that provides the policy base on which waste management can be conducted, but a policy framework that is inadequately secured, implemented and monitored will not lead to a properly operating system.

The lack of policy framework enforcement is mainly a result of two major changes in the legislative framework concerning waste management: the decentralization in 1999 and the introduction of a new waste management law (WML) in 2008. Given that the decentralization was not conducted in order to enhance public service delivery, no measures were taken to ensure the capacities in, and monitoring of local governments in this new decentralized institutional setup. This has led to two major hindrances in the functioning of the policy framework, being a lack of accountability mechanisms and resource and capacity gaps in local governments. Defining accountability relations, rules and their enforcement, as discussed in chapter 4, is not often described in literature, but has shown to be of great importance to establish strong regulatory mechanisms for collective systems such as waste management. A specific accountability relation that showed to be significant according to the interviewees were the social bonds between law enforcers, such as government administrators or members of a police force, and their area. This creates a social barrier to execute law enforcement on a village level and is an important reason why law enforcement on a local level is often absent.

Taking into account these conclusions from the review of top-down enforcement, it is evident that it is not the policy framework itself that needs revision as much as it is the way that the framework is executed and how the realizations are monitored. Multiple interviewees stated that the 2008 WML in itself was set up properly and would not need to be altered. However, they stressed that measures would need to be taken to make sure that the law would start going into effect, by holding people throughout the system accountable for their responsibilities according to the law. Since this is a matter that transcends the field of waste management, and goes into Indonesian national political system, it will not be easy to achieve.

Next to the lack of accountability mechanisms in local governments, the concept of 'capacity gaps' always surfaced both in literature and in the empirical qualitative analysis. Given that local governments had never been in charge of MSW management before 1999, they did not have the knowledge, nor the resources, to start executing waste management in a decent manner after the decentralization, and then again after the implementation of the 2008 WML. This lack of capacity is subsequently amplified by the lack of practical guidance in the WML, the inability of local governments to absorb or utilize available budgets, and the administrative overspending and corruption. An important conclusion from this part of my analysis is that this is probably the part of the policy framework that has the most potential to be improved without deeply rooted changes in the Indonesian national political system. With the right amount of resources made available, efforts can be put into strengthening local governments capacities, improve on practical guidance and monitoring of them, and altering procedures between national and local governments to make funds and support from the national government more available and more attainable for local governments. This by itself would hold the potential for large improvements in the WM field on Bali, which is emphasized by the interviewed local government officials that stated that they wished to perform better, but did not have the means, funds or support to realize this wish.

On the other side, on top of to the poor top-down enforcement of the framework, I have shown that a second important barrier is the mismatch between the degree in which the policy framework leans on people taking up their own responsibilities and the current level of awareness and knowledge in Indonesia. Combining all the relevant data I analyzed on this topic, I conclude that the 2008 WML is modelled after a developed nation's waste management policy, without accounting for Indonesian households' perceptions, knowledge, awareness levels and daily routines. This leaves two routes for the framework to match the necessary Indonesian household characteristics: changing the WML or improving awareness and knowledge levels among users.

In general, there is a lack of awareness and knowledge in important issues regarding waste management among inhabitants of Bali, mainly due to a lack of environmental education and lack of (access to) information on waste management. This results in a low willingness from the bottom-up to adopt waste management as the legislative framework foresees. Low level of awareness makes householders lead to a lack of willingness to pay for waste management services as well as the behavior to dispose of waste unseparated, thereby largely delegitimizing the economic and environmental viability of recycling. Large quantities of recyclable material end up in landfills, losing the resource value of the materials. Households' choices for disposal or re-use of materials can greatly differ in material recovery and the energy use that is related to the system of waste management.

Another significant hindrance to the adoption of sound waste management, that is specific for Bali, is the low value that is given to the topic, recognizing that the social value to waste management greatly affects a person's behavior in waste management. Bali is unique in its conceptions on waste and has a distinctively Balinese cultural disinclination to get involved with it. This disinclination to handle waste is further enhanced by the stigma that handling waste holds, as it is strongly associated with poor and marginalized people with low social status. I recognize this is a delicate subject in this research, as it is both identified as an important issue to address in designing a policy framework for Bali specifically, as it is a unique cultural characteristic that is inherited from centuries of social structures.

In chapter 6 several sustainable energy as well as resource technologies were reviewed. While all of the methods can have a significant impact on the sustainability of waste management, it was concluded that for all of them to function properly and deliver the desired benefits, strict input as well as process norms should be adhered to. This leads to the conclusion that while technology offers opportunities in the waste management sector, by no means it holds the premise to resolve the waste problem by itself. For technology in waste management to work and to reach the desired results, it is vital that the behaviour of the system's users enables these technologies to function properly and reach maximum results. Therefore, and maybe most importantly, I will stress the importance of viewing the field of waste management from a social perspective over a technical one.

Having identified certain barriers and thereby opportunities for waste management in Bali, a comparison was made between the Business As Usual scenario and that of an improved WM scenario in terms of environmental impact. In chapter 6 the quantitative emission analysis has shown that improved waste management can significantly contribute to the reduction of the environmental impact. A simple trend model for a 15 year period, from 2010 to 2025, showed opportunities for a 2018 reduction of 90% in waste-to-landfill, that subsequently leads to an overall reduction of GHG emission from MSW management of 72% in Bali. Plus, this would make up for a higher recycling rate that also lowers the need for raw materials as well as transport, resulting in a further reduction of energy and resource use as well as GHG emissions. Given the large contribution of waste management to the total GHG emission profile of Bali, it can be concluded that improvements in this sector are of vital importance to the reduction commitments in Indonesia.

8.2 Recommendations for future research

The recommendations for future research are mainly outlined from the point of view of qualitative research, complemented by a not on the importance of quantitative research. Qualitative studies are needed to increase the understanding of households' behavior in MSW management in a specific context. Such studies have the potential to provide a better picture of behaviors in waste management, such as separation at source, recycling and waste prevention, which I have argued to be of vital importance in improving the MSW management sector. This can lead to improved insights in how a waste management system should be set up to fit households' perceptions, knowledge and awareness levels and daily routines. This could subsequently minimize the mismatch between the degree in which the policy framework leans on people's own responsibilities and the level of awareness and knowledge, and make up for a better execution of the waste management policy framework as a whole.

Another recommendation stems from the lack of a standard definition and classification on what is included and what is excluded in the definition of Municipal Solid Waste. This results in a widely varying definition of MSW between organizations and countries, and subsequently in a lack of alignment in waste management research as well as in policy recommendations. It also makes up for difficulties in the quantification of the MSW sector, creating ambiguity in waste management data. Therefore, it is recommended that thorough qualitative research is conducted aimed at creating consensus on waste definitions and practices, which would result in a more useful quantification of waste management data. If this consensus is reached, the current lack of data availability can be tackled by conduction quantitative research aimed at generating insight in the numbers regarding waste management in Indonesia.

Furthermore, given the observed tension between institutional provisions in a policy framework and the reality on the ground, it is recommended that future research should focus more on the actual enforcement of a policy framework, instead of reviewing the framework itself. The framework itself of course has to be set up in a matter that provides the policy base on which waste management can be conducted, but a policy framework that is not secured with suited possibilities of monitoring and accountability keeping will not lead to a properly operating system.

8.3 Policy recommendations

This last future research recommendation also serves as a policy recommendation: next to the setup of the framework, policy makers should focus on the mechanisms that secure the correct functioning of the framework. As previously mentioned, this is a matter that partially transcends the field of waste management and goes into Indonesian national political system. It would need strengthening of horizontal and organizational accountability within the government, as well as reinforcement of political accountability. One way to achieve this is to follow a similar path as is currently done in Indonesia in fighting corruption. For this sole goal an independent Corruption Eradication Commission (*KPK)* was set up which duties include investigating and prosecuting corruption cases and monitoring the governance of the state. A similar independent commission could be set up to monitor the accountability in the public service sector. However, given the magnitude of such an endeavor, this would be a plan to implement over the course of the next decade or so.

On a municipal level of government, I do see more near-future achievable changes in policy that could result in a higher enforcement of the 2008 WML. This concerns the mentioned social barrier for law enforcement of the police force. If police officers would be switched between areas and would not be put on duty in their own social area, this measure would lower these social barrier because of the lower social bonds they have in another area.

Regarding the creation of awareness and knowledge among inhabitants of Bali, the implementation of large and small scale education programs is necessary. These steps can relate to mass and social media campaigns, offering waste system training in communities, shifting the recycling strategy to be easier for citizens, or phasing out labor- or knowledge-intensive approaches to separation and collection.

My last recommendation is to make funds available for the build and operation of local material recovery centers in Bali, as it is described in the 2008 WML (the 3R centers). Providing both capital expenditures and operational expenditures (see chapter 4) will make the recycling centers more efficient, with more materials getting into the recycling loop and better separation of materials, subsequently leading to higher buying rates since transportation and processing costs will be considerably reduced. Less transportation will also mean a reduction in atmospheric emissions. The high organic fraction of the waste stream (around 65%) offers options for material recovery as well. The energy and material value of this fraction can be recovered through composting. Provisions should be made to ensure a level playing field for the sale of compost by the material recovery centers, providing income that can lead to financially self-sustainable facilities.

On a final note, the conclusions from this thesis research outline the importance of waste management on regional and national levels as well as the complexity of ensuring a system that functions according to the framework it is set up to. There are many challenges to address, ranging from the performance of national institutional provisions to region specific characteristics to take into account. It is important in this field to recognize that there is no easy path to follow to a functioning system but that results are created through an accumulation of enabling factors in a country's institutional, economic, environmental and social domains.

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Appendix 1.1: Waste burning as a disposal method is prevalent all over Bali and Indonesia
(Photo: DJJ Visser)

Appendix 1.2: Uncontrolled landfilling in Bali (Photo: DJJ Visser)

Appendix 1.3: Scavengers looking for valuables in the waste stream in a temporary waste transfer station (Photo: DJJ Visser)

Appendix 1.4: Indiscriminate dumping of waste in the natural environment (Photo: DJJ Visser)

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Appendix 1.5: The vehicle with which the *pemulung* go door-by-door to collect valuables, in this case cardboard (Photo: DJJ Visser)

Appendix 1.6: A *pengumpul* station, where waste is collected and prepared for recycling
(Photo: DJJ Visser)

Appendix 1.7: Scavengers look for valuables in the waste at a landfill site (Photo: DJJ Visser)

Appendix 1.8: The newly build (10/2017) sanitary landfill of Lingasana (Photo: DJJ Visser)

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Appendix 1.9: Regency government sign dismissing the rubbish along the beach as a "natural phenomena"

Appendix 1.10: A non-operational methane gas capturing technology as visited in the fieldwork (Photo: DJJ Visser)

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Appendix 2
Overview of interviewees and semi structured interview topic list

It has to be noted that this list only includes the interviewees that the researcher was able to conduct a lengthy, thorough, semi structured interview with. It does not include the people that the researcher had short 'informal' meetings and conversations with, even though these contributed greatly to the data collection alongside the set of semi structured interviews.

Place (all in Bali)	Date	Acronym	Occupation/background
Ubud	5/10/2017	IV1	Landfill project lead / Development specialist
Tibubeneng	18/5/2017	IV2	Waste management NGO lead
Sanur	12/5/2017	IV3	Waste management NGO lead
Pererenan	6/10/2017	IV4	Sustainability engineer
Pererenan	16/5/2017	IV5	Local environmental NGO lead
Kerambitan	28/9/2017	IV6	Head of Landfill Technical Implementing Unit
Pererenan	19/5/2017	IV7	Village cleanliness administrator
Pererenan	10/10/2017	IV8	Environmental communication expert
Medewi	23/10/2016	IV9	Middle school teacher
Kertalangu	9/5/2017	IV10	Material transfer station manager
Lingasana	9/5/2017	IV11	Landfill manager
Legian	11/5/2017	IV12	Waste management NGO lead

General take on the status of MSW management in Bali

- General take

Institutional

- Government focus on MSW management
- Decentralization of MSW policies
- Institutional deficiencies and political frameworks
- Governmental education on MSW

Financial

- Availability and sorts of funds
- Participatory finances (user pays, earns, works, neutral)
- Community finances (pay, sponsor, help)

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- Viability of resale of materials
- Financial barriers for MSW management actors
- Infrastructure provision
- Ideal financial situation according to the interviewee

Social

- Community participation
- Existence of different services (Free choice for users?)
- Awareness in community
- Educational activities
- Physical location of WM in community
- Social value to waste management
- Capacity problems

Environmental aspects

- Main disposal methods
- Awareness of (Renewable) energy systems
- Added ecological value (techniques lowering impact)
- GHG emission awareness

Appendix 3
Quantitative trend analysis input data

Figures 8 and 9 in chapter 6 were created using calculations based on the waste generation of the local population as well as tourists that stay on Bali. This data was used in a calculation sheet made by *Temesi recycling*, an institution which monitors the emissions from the Gianyar landfill. This was done for the BAU scenario and then considered for the improved WM scenario with a 90% reduction of waste after 5 years of implementation.

The year 2010 was taken as the baseline year, since it was chosen by the Indonesian provinces as their baseline year for the "*Monitoring, Evaluation and Reporting*" program's goals. In the last official census in 2010, the population in Bali accounted for 3.9 million (BPS Indonesia, 2010). With a population growth averaging 2.15% per year, the population in 2017 is projected at 4.5 million, and approximately 5.3 million people in 2025. As outlined in Chapter 3 the average waste generation per capita in Bali is approximately 0.9 kg/day. This will account for 1.2 million tons of waste per year in 2010, projected to increase to 1.7 million tons in 2025 if no significant changes are made in the waste industry, from local communities alone.

As previously mentioned, Bali relies heavily on the tourism industry. In order to compute waste generation by the tourism industry, I took into account both domestic and foreign tourism, as well as the projected growth. Domestic tourism accounts for more than half of total tourists entering Bali each year, with an average increase of 15% each year, while foreign tourist numbers have showed an average yearly increase of 13% (Bali Government Tourism Office, 2017). According to several researchers (Sanaa & Hassan, 2014; Bashir & Goswami, 2016; Saito, 2013) waste generation per capita by tourists averages 1.03 kg per tourist per day; 100 grams more than locals. In addition, the average length of stay for tourists in Bali is 8.66 days (IndoSurfLife, 2015), varying from 5 to 9.28 days. Accordingly, the amount of waste produced by tourist per year was estimated to be 64.1 thousand tons in 2010, 140.3 thousand tons in 2017 and projected to be 413.4 thousand tons in 2025 in the BAU scenario. This adds up to a total production of 1.3 million tons for 2010, increasing to 1.6 million in 2017 and reaching 2.2 million in 2025, considering a steady growth.

In order to compute the following calculations, the data sheet from *Temesi Recycling* in Bali was used. These calculations provided insight regarding the methane emissions (in tCO2e) produced in a landfill depending of the amount of waste and their type. The waste generation projections mentioned above were included in the calculations, always in respect to 2010 baseline. The types, and their correspondent percentage, considered within these calculations are; wood and wood products (4.80%), pulp, paper and cardboard (5.3%), food, food waste, beverages and tobacco (6.6%) and garden, yard and park waste (83.30%). Glass, plastic and other inert materials are not considered, since these are collected by locals and sold to recycling companies. The amount of waste by type is calculated according to these percentages. The volume of waste per type is, in turn, used to calculate the methane generation potential based on the amount of degradable organic carbon, the mass ratio (CH4:C) and a correction parameter to avoid uncertainties. By multiplying the amount of methane produced by its global warming potential, it is possible to estimate the quantity in ton CO2 e per ton of waste. An example of the calculation sheet is given in the figure on the next page, taken from the BAU scenario.

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	Parameter	Variable	Unit	Value
1	Parameter	Variable	Unit	Value
2	Project commissioning year		y	2008
3	Waste deposition per year		t / y	1,341,924
4	Waste deposition days per year		d	350
5	Deposition trend			0%
6	Midpoint year			1
7	Landfill closure (in years)			30
8	Waste conditions			wet
9	Regional climatic conditions			tropical
10	Regional precipitation conditions			wet
11	Model correction parameter for uncertainties	Phi		0.9
12	Fraction of methane captured in the baseline	f		0.0
13	Global warming Potential CH4	GWPCH4		25
14	Oxidation factor	OX		0.0
15	Fraction of methane in LFG	F		0.5
16	Fraction of degradable organic carbon	DOCf		0.5
17	Mass ratio CH4:C	16/12		1.33
18	Methane correction factor	MCF		0.8
19	Waste stream			

Determination of DOCj and kj depending on input parameters. Do not edit this table!

Waste stream		Unit	Value	Degradable organic carbon DOCj (fraction)		Decay rate kj boreal / temperate climate		tropical climate		Applied Parameters		Methane generation potential	
				wet waste	dry waste	dry	wet	dry	wet	DOCj	kj	t CH4 / t waste	t CO2e / t waste
20 Wood and wood products	A	%	4.80%	0.43	0.50	0.020	0.030	0.025	0.035	0.43	0.035	0.103	2.580
21 Pulp, paper and cardboard	B	%	5.30%	0.40	0.44	0.040	0.060	0.045	0.070	0.40	0.070	0.096	2.400
22 Food, food waste, beverages and tobacco	C	%	6.60%	0.15	0.38	0.060	0.185	0.085	0.400	0.15	0.400	0.036	0.900
23 Textiles	D	%	0.00%	0.24	0.30	0.040	0.060	0.045	0.070	0.24	0.070	0.058	1.440
24 Garden, yard and park waste	E	%	83.30%	0.20	0.49	0.050	0.100	0.065	0.170	0.20	0.170	0.048	1.200
25 Glass, plastic, metal other inert	F	%	0.0%	0.00	0.00	0.000	0.000	0.000	0.000	0.00	0.000	0.000	0.000
26 Total		%	100.0%										

28 Calculations

			2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
30	Deposition trend:		0.0%	0.0%	100.0%	102.9%	105.4%	108.4%	110.5%	113.4%	117.3%	121.0%	124.9%	129.0%	133.5%	138.3%
31	**Year**		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
32	**Waste deposition**															
33	Wood and wood products	t / year	0.00	0.00	64,412.35	66,287.68	67,860.42	69,805.15	71,163.73	73,022.67	75,532.84	77,921.07	80,421.95	83,096.71	85,966.69	89,056.28
34	Pulp, paper and cardboard	t / year	0.00	0.00	71,121.97	73,192.65	74,929.21	77,076.52	78,576.62	80,629.20	83,400.84	86,037.85	88,799.24	91,752.62	94,921.55	98,332.97
35	Food, food waste, beverages and tobacco	t / year	0.00	0.00	88,566.98	91,145.56	93,308.07	95,982.08	97,850.13	100,406.18	103,857.65	107,141.47	110,580.19	114,257.98	118,204.19	122,452.38
36	Textiles	t / year	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
37	Garden, yard and park waste	t / year	0.00	0.00	1,117,822.69	1,150,367.48	1,177,660.99	1,211,410.16	1,234,987.30	1,267,247.65	1,310,809.44	1,352,255.23	1,395,655.97	1,442,074.16	1,491,880.18	1,545,497.47
38	Waste deposition total	t / year			1,341,924.00	1,380,993.37	1,413,758.70	1,454,273.90	1,482,577.79	1,521,305.71	1,573,600.76	1,623,355.62	1,675,457.35	1,731,181.47	1,790,972.61	1,855,339.11
39	Waste deposition (cumulative)	t	0.00	0.00	1,341,924.00	2,722,917.37	4,136,676.07	5,590,949.97	7,073,527.76	8,594,833.46	10,168,434.23	11,791,789.85	13,467,247.20	15,198,428.66	16,989,401.27	18,844,740.38
40	**Methane emissions**															
41	Wood and wood products	t CO2e/yr	0	0	5,716	11,401	17,031	22,640	28,176	33,687	39,231	44,796	50,392	56,032	61,734	67,513
42	Pulp, paper and cardboard	t CO2e/yr	0	0	11,540	22,636	33,263	43,520	53,327	62,805	72,091	81,177	90,097	98,893	107,609	116,289
43	Food, food waste, beverages and tobacco	t CO2e/yr	0	0	26,279	44,659	57,622	67,104	74,014	79,405	84,043	88,126	91,883	95,493	99,083	102,751
44	Textiles	t CO2e/yr	0	0	0	0	0	0	0	0	0	0	0	0	0	0
45	Garden, yard and park waste	t CO2e/yr	0	0	209,706	392,733	552,267	693,191	816,508	926,597	1,027,648	1,120,677	1,207,304	1,289,096	1,367,445	1,443,604
46	Methane emissions total	t CO2e/yr	0	0	253,241	471,429	660,183	826,455	972,025	1,102,494	1,223,012	1,334,775	1,439,675	1,539,514	1,635,871	1,730,156
	t CO2e per t of waste deposited each year	t CO2e/t waste	#DIV/0!	#DIV/0!	0.19	0.34	0.47	0.57	0.66	0.72	0.76	0.82	0.86	0.89	0.91	0.93
	t CO2e per t of waste (cumulative)	t CO2e/ t waste	#DIV/0!	#DIV/0!	0.19	0.17	0.16	0.15	0.14	0.13	0.12	0.11	0.11	0.10	0.10	0.09

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