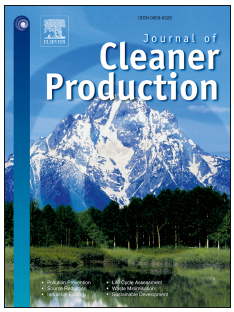
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Waste prevention in communities: a comprehensive survey analyzing status quo, potentials, barriers and measures

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Abstract

With the Waste Framework Directive in 2008, waste prevention was promoted as the first priority. However, the actual implementation of waste prevention activities has so far been hesitant, and the focus on end-of-pipe waste management such as recycling prevails. The objective of this study is to explore key factors that influence engagement in waste prevention activities, thus helping to clarify why waste prevention, although adopted at both the European and national levels, has so far not been successfully implemented. We investigate the status quo, potentials of and barriers to waste prevention within local authorities in Germany and identify measures for waste prevention.

An extensive literature review emphasizes that the overall implementation status of waste prevention is low, which is partially due to an apparent lack of guidance for practitioners. Our empirical study investigates possible reasons and provides solution-oriented insights on how to encourage activity. The study is based on a survey simultaneously addressing 386 Bavarian municipalities by questionnaire and on personal interviews with 33 executives and employees of public administration from three different local authorities.

Results verify that the implementation status of waste prevention measures among local authorities is generally low. Only 10% of all cities are about to establish waste prevention as a criterion in public procurement. The estimation of waste prevention potentials varies depending on the waste stream. A total of 70% of all respondents evaluate the potential for waste prevention of typical recycling materials, such as paper and plastic, as high or very high, while waste from building materials and construction components is considered to be hardly preventable. Main barriers are the low acceptance for waste prevention activities and a lack of information. A total of 25% of all interview partners felt that environmental awareness in general is a mandatory condition for behavioral change.

Keywords: Waste Prevention, Resource Efficiency, Local Authorities, Waste Management, Transdisciplinary Research Design

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1. Introduction

The conservation of natural resources, the improvement of resource efficiency and the decoupling of human consumption from its impacts on the environment are high on the political agendas of the European Union and each of its member states (European Commission, 2012; OECD, 2000). However, evidence suggests that so far the attainment of these goals has been incomplete. Although resource productivity improved by 28% over the past decade, total waste generation nearly stagnated within the same time frame. In 2004, 323 tons of waste were generated for every 1,000 tons of material directly used by the European economy. This number rose to 369 tons of waste in 2012, which equals an increase of 15% (Eurostat, 2016a, 2016b, 2016d). These figures indicate that the waste generated per tangible output has risen. Strengthening efforts at waste prevention could improve this performance throughout Europe. The amount of waste generated per capita, one of seven indicators used to measure an economy's circularity level and to indicate opportunities to accelerate the transition towards a circular economy (Ellen MacArthur Foundation), also hints at the necessity of preventing waste. Especially in Germany, where this indicator is 30% higher than the European benchmark (Eurostat, 2016c), waste prevention promises ecological and economic gains.

With the Waste Framework Directive (European Parliament and Council) in 2008, waste prevention was promoted as the first priority for all EU member states. In terms of resource efficiency, waste prevention is deemed to be superior to waste management options such as preparing materials for re-use and recycling. However, the actual implementation of waste prevention activities has so far been hesitant, and the focus on end-of-pipe waste management prevails (Wilts, 2012; Zorpas et al., 2014). To induce change and monitor progress in implementing waste prevention measures and concepts, specific goals and deadlines have been set by European law (European Parliament and Council). All member states have been committed to establishing waste prevention programs until December 2013, and guidelines to do so have been provided (European Commission, 2012). Up to now, 21 countries accomplished this task by either integrate waste prevention into existing waste management plans or by establishing separate programmes (European Topic Centre on Sustainable Consumption and Production, 2014). In Germany, the established programme is based on two previous research projects as well as on the further contributions of various experts in the field of waste prevention and management (Dehoust et al., 2013). The resulting program explicitly calls for the development of waste prevention concepts on a communal level (BMU, 2013).

The public sector is considered to be an important driver of waste prevention because of its legislative abilities and its considerable market power. The public sector influences a wide range of topics through both its own actions and its effect on other stakeholders (International Solid Waste Association, 2011). With public expenditures exceeding 35 billion Euros (Statistische Ämter des Bundes und der Länder, 2013), German local authorities are even more influential than the German Government or its Federal States due to their larger procurement budget (McKinsey & Company, 2008). Wisely used, this market power can encourage sustainable behavior along the supply chain from producers to consumers (Beck and Schuster, 2013). In addition, some authorities are not only creators of waste but are also in charge of waste management processes, as public waste management bodies are associated with local governments. This likely makes them the most promising developers of integrated waste prevention concepts (pre-waste, 2010).

To support local authorities with this task, our article presents results generated from the research project "Development of a Guideline for the Preparation of Communal Waste Prevention Concepts". Using a transdisciplinary multi-method approach, we explore processes and instruments to help in developing and implementing holistic waste prevention concepts. To provide hands-on instructions to

enable the implementation of these concepts within public administration processes, our research concentrates on primary empirical data and answers the following research questions:

1. What is the status quo of waste prevention among local authorities?
2. Do potentials for waste prevention exist and are they recognized?
3. What are the main barriers to engagement in waste prevention activities and how can these barriers be overcome?
4. Which measures and instruments are suitable to prevent waste?

Data are obtained using a multi-method approach comprising different qualitative and quantitative techniques. While the research at the national and international levels builds on an extensive literature review, personal interviews and a questionnaire are used to generate insights into regional local authorities. Furthermore, experts from the Bavarian Environment Agency provided specialized knowledge and insights based on their long-term professional experience with waste management and waste prevention. The article is structured as follows. First, the research questions are further elaborated. We then describe our methodological approach. The findings of the empirical study are presented in the results and discussion section within the context of the research questions. Our conclusion summarizes our recommendations for local authorities and provides pathways for further research.

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2. Waste prevention in local authorities

Waste prevention in local authorities is seldom addressed in scientific research. To provide the necessary knowledge base, we start by presenting the evolution of waste prevention and its political implications. We then define waste prevention and differentiate it from preparing materials for re-use and recycling. The following literature review elaborates on the research gap.

2.1 Origin and definition

In response to growing amounts of waste over the last hundred years, the handling of waste began to be regulated, thus turning the common practice of laissez-faire disposal into state-of-the-art waste management. As a consequence to the rising costs of waste treatment and disposal, the concept of waste prevention began to attract interest in the second half of the 20th century. Early research discusses the role of waste prevention activities and concludes that prevention saves on costs, avoids littering, conserves natural resources and reduces consumption's negative effects on the environment (Conn 1977). However, the implementation of waste prevention measures has been hesitant for years. Reasons include a lack of environmental awareness among stakeholders, a lack of incentives to motivate action, inadequate data, a general reduction in the importance of repair and reuse due to the shortening of innovation cycles and a general devaluation of products in modern life (Coggins, 2001; Nentwig, 2005; OECD, 2000; Wilts, 2012). Additionally, the distinction between waste prevention and recycling is not generally recognized by consumers (Sharp et al., 2010b). Due to the promotion of recycling and the concept of zero waste, consumers perceive waste prevention as preventing waste from entering landfills (Cecere et al., 2014; Cole et al., 2014; Sharp et al., 2010b; Zaman, 2014).

As a means towards resource efficiency, waste prevention gained momentum on political agendas in the last decade. To handle the growing ecological pressure of human consumption in terms of the environmental impacts of waste generation and management, the European Union launched several initiatives to improve resource efficiency and waste management (European Commission, 2012). One of these initiatives is the directive on waste 2008/98/EC, which prioritizes waste management options due to their supposed environmental impacts. Waste prevention is the first of five stages of this waste hierarchy and is defined as "*any measure taken before a substance, material or product becomes waste"* (European Parliament and Council). Accordingly, waste prevention takes place before the waste threshold is crossed (see Figure 1) and is therefore often referred to as resource management instead of waste management.

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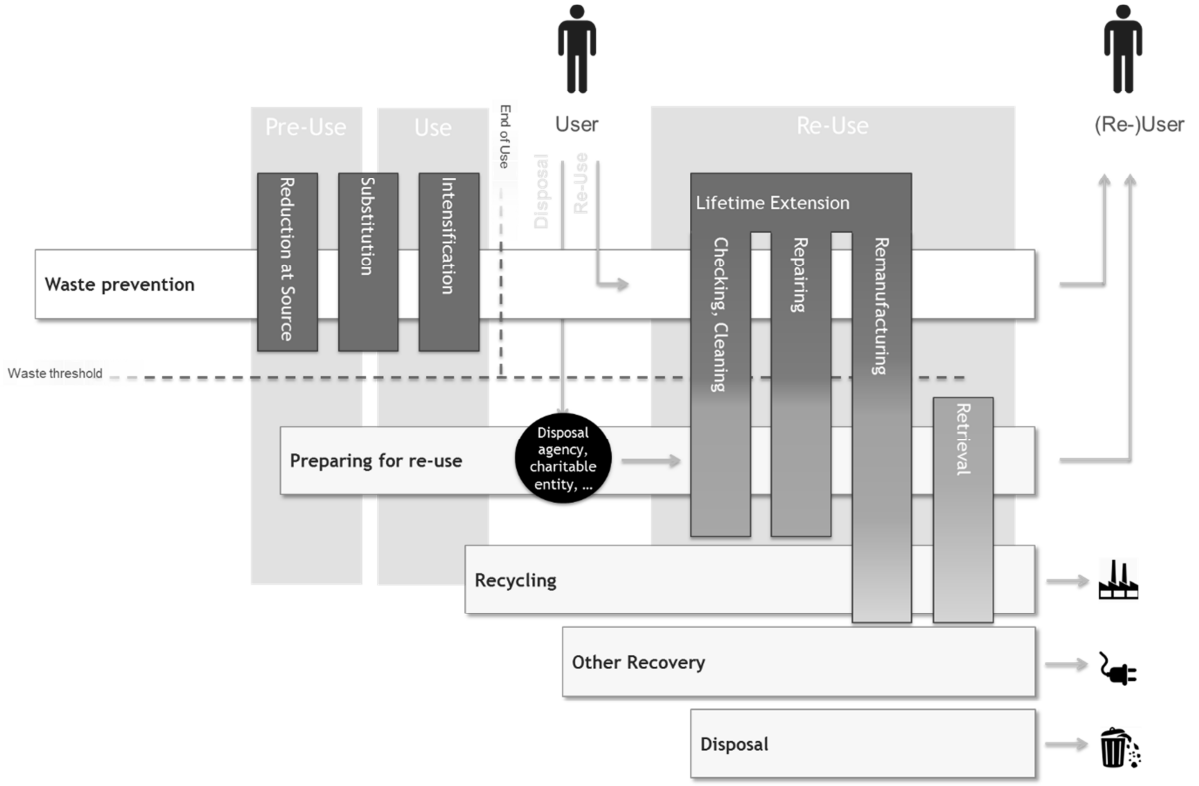


Figure 1: Definition and types of waste prevention

Waste prevention can be attempted during most phases of the product life cycle, as displayed in Figure 1. In the pre-use and use phases, types of waste prevention vary with the stage of the product life cycle. During design and production, **Reduction at Source** is possible (e.g., eco-design or designing-out-waste) (Allwood, 2014; Mazzanti and Zoboli, 2008; Osmani, 2012; Yuan, 2013). Additionally, **Substitution** refers to either a substitution of the materials used in production to reduce factors such as criticality or toxicity, or to substitute the product or service itself. If the product is produced and sold through retail, the consumer can choose to substitute it with an alternative that meets the requirements of waste prevention, for example improved durability or reparability. **Intensification** is usually accomplished during the use phase. Once acquired, the product's usage can be intensified either by sharing the product with many users, possibly through product service systems like car sharing, or by prolonging and/or exhausting the product's usage time. This can be achieved by utilizing repair networks, donating used goods, and through a general change in consumption patterns (Dehoust et al., 2013; European Commission, 2012; International Solid Waste Association, 2011). When a product has reached its end of use (EoU), the user determines the subsequent path according to his action. Waste prevention at this stage can be accomplished by **Lifetime Extension** if the former user chooses not to discard the product but directs it to re-use instead. The type of waste prevention depends on the state of the product and may include processes such as checking & cleaning, repairing or remanufacturing (European Commission DG Environment, 2010; European Parliament and Council). These processes can occur at re-use facilities such as second hand stores, building parts exchanges or repair workshops. If the product is discarded at the EoU, waste prevention by definition is no longer possible. In this case, it can be prepared for re-use, which uses the same processes. After being prepared for re-use, the product enters the use phase again and ceases to be waste. The process of retrieval occurs when only selected parts of a product are re-used while the rest is recycled.

The following examples of measures are drawn from literature and categorized to clarify the the phases and types of waste prevention we identified in the previous section. Various measures to

prevent waste are discussed and recommended by governments and environmental institutions alike. For an extensive list of measures and a detailed analysis which countries recommend to implement them, please see the European Topic Centre on Sustainable Consumption and Production (EIONET) (European Topic Centre on Sustainable Consumption and Production, 2014).

Table 1: Examples for different types of waste prevention

Phase	Type	Measure	Reference
Pre-Use	Reduction at Source	Eco-design and designing-out-waste	(EIONET 2014)
		Tax on packaging	(BMU, 2013)
		Procurement guidelines	(EIONET 2014)
Use	Substitution	Ban on “to-go” products	(BMU, 2013)
		Bottleless water	(European Commission, 2012)
		Nappy services	(European Commission, 2012)
	Intensification	Product service systems	(BMU, 2013)
		Industrial symbiosis	(European Commission, 2012)
		Food donations	(EIONET 2014)
Re-Use	Lifetime Extension	Checking, Cleaning, Repairing	(European Commission, 2012) (BMU, 2013)
		Waste prevention center	(BMU, 2013)
		Supporting SMEs in re-use operations	(EIONET 2014)

2.2 State of the art and research gap

Recent research focuses on the implementation of waste prevention strategies and examines several case studies to sample the status quo of waste prevention in different regions, the compatibility of waste prevention with other waste management practices (Wilts, 2012; Zunft and Fröhlig, 2009), categorization systems for measures and activities (Salhofer et al., 2008) and approaches to quantifying waste prevention (Gentil et al., 2011; Mazzanti and Zoboli, 2008; Sharp et al., 2010a; Zorpas and Lasaridi, 2013). Quantification is attempted by comparing the waste generated with and without waste prevention actions taken using forecasting data. The projection of the generated waste is usually based on regression analysis, with factors such as production (Bruvoll and Ibenholt, 1997) and income (Mazzanti and Zoboli, 2008) as independent variables. Other approaches directly measure results at a micro level, for example within one institution or district. Subsequently, these results are aggregated to a macro level, thus measuring waste prevention for cities or countries (Salhofer et al., 2008; Sharp et al., 2010b; Tasaki and Yamakawa, 2011; Wilts et al., 2013). Some of these studies prove that effects at a regional scale do not appear in national or international statistics (Salhofer et al., 2008; Wilts and Rademacher, 2014) and that waste prevention can therefore not be captured by mere data analyses. So far, there is no consensus on how to quantify waste prevention.

Potential opportunities for waste prevention have to be assessed in terms of their quantitative and qualitative effects. The environmental impacts of waste differ according to its composition, which underlines the importance of assessing various waste streams (Bruvoll 1997). Construction and Demolition Waste (C&D Waste) and Municipal Solid Waste (MSW) are among the waste streams most frequently addressed by scientific research (Osmani 2012; Poon et al. 2001; Yuan 2013; Cox et al., 2010; Gentil et al., 2011; Osmani, 2012; Poon et al., 2001; Salhofer et al., 2008; Sharp et al., 2010b; Yuan, 2013; Zorpas et al., 2015a). Although it consists of mostly inert materials, C&D Waste is considered important, especially in terms of quantitative waste prevention. Accounting for approximately 30% of waste in the European Union and more than 50% in some of its member countries (European Commission, 2016; Statistisches Bundesamt, 2013), C&D Waste is the main

contributor to overall waste generation. Simultaneously, the construction sector is one of the largest consumers of primary resources and therefore an important factor in a nation's overall resource efficiency (Malia et al., 2013). MSW, on the other hand, is possibly the most "common" waste stream, with the highest data availability in terms of both quantification and consumer behavior. Electronic devices, as a component of MSW, represent an interesting subset as they contain a multitude of materials, some of them rare or critical, some of them valuable and some of them toxic substances (Cahill et al., 2011). Additionally, their share within the overall waste stream is growing (Nuss et al., 2016). Food waste, also component of MSW, has attracted some interest in recent years because of the overall environmental impacts related to food production; consumer behavior as well as food retailers have been analyzed (Lebersorger and Schneider, 2014; Quested et al., 2013). Other waste streams are less frequently addressed in the literature. Business Waste is rarely the subject of waste prevention research, partly because its prevention potentials seem to be exploited already (Wilts and Rademacher, 2014) for economic reasons. There are studies reviewing measures of and attitudes about business waste prevention in the Czech Republic and the UK (Pongracz, 2009; Wilson et al., 2012). Laner and Rechenberger (2009) develop a model to evaluate waste prevention in small and medium sized enterprises.

The regions and scales covered by research are mostly national and international. While Mazzanti and Zoboli (2008) and Cecere et al. (2014) focus on waste prevention in the European Union, there are several studies of individual countries such as Austria (Salhofer et al., 2008), Cyprus (Zorpas et al. 2015b), Finland (Melanen et al., 2002), Germany (Wilts et al., 2013; Wilts and Rademacher, 2014), Japan (Tasaki and Yamakawa, 2011) and the UK (Coggins, 2001; Cole et al., 2014; Cox et al., 2010; Wilson et al., 2012). So far however, only a few studies exist on a smaller scale, even though data at the regional or municipal level may provide local authorities with much-needed guidance regarding good practices for the development and evaluation of waste prevention concepts (Mazzanti and Zoboli, 2008; Sharp et al., 2010a).

Even though waste prevention measures as well as Best Practices are discussed in science and politics, there are rarely any guidelines for public executives on which measures to implement and how to implement them. As local authorities are considered the most responsible bodies (pre-waste, 2010), these guidelines should account for local circumstances such as regionalized waste management systems (Kurisu and Bortoleto, 2011) as well as different waste compositions, community sizes and consumer behaviors. Accordingly, recommendations on which measures to implement should also vary according to local circumstances and regional environmental pressures. Regarding the latter, Wilts and Rademacher (2014) suggest the ecological backpack as a decision factor for the prioritization of measures. However, as this indicator reflects only one of many environmental impact categories, a holistic approach using full-scale LCAs is often called for. So far, LCAs mostly compare different waste management options, largely neglecting waste prevention.

Against this background, the *Guideline for the Preparation of Communal Waste Prevention Concepts* is designed to help local authorities not only with their decisions about which measures to implement and how to implement them but also with their evaluations of waste prevention impacts on the environment.

3. Material and Methods

Following an initial literature review process that selected focus areas, questions and epistemic objects, we used a transdisciplinary multi-method approach to elaborate on our research question. The design of both quantitative and qualitative research derives from research in the scientific literature and is coordinated with the steering board that accompanied the project. Experts supported the research process with their long-term experiences, especially in the fields of waste management and public administration.

3.1 Overall Research Approach

Our research approach contains six subsequent steps in three phases (Figure 2).

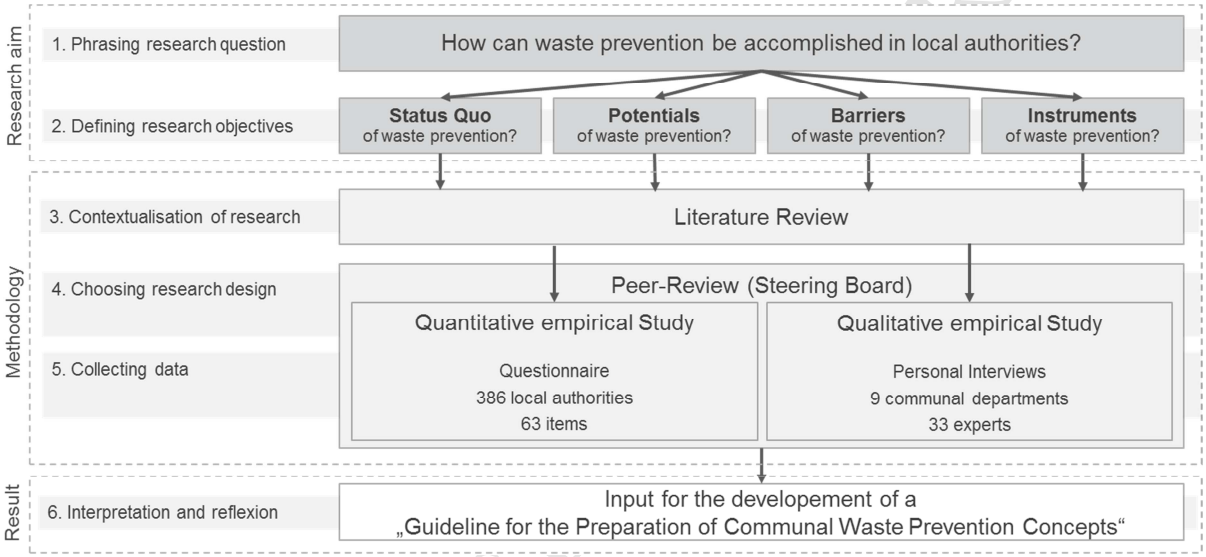


Figure 2: Research approach phases

The first phase clarifies our research aim and operationalizes the research question into four distinct fields of interest: status quo, potentials, barriers and instruments of waste prevention. Each of these fields can be specified by more detailed research goals and items (Table 2).

An extensive review of existing literature contextualized the research aim and formed the basis for designing the next steps of the research process. The literature review covered scientific articles; existing waste prevention programs in different countries and their ex ante studies; legal frameworks and statements of a variety of stakeholders and interest groups from the fields of producing industry, waste management, science, politics and NGOs. With the information gained in this phase, a system analysis revealed the preparation and implementation of waste prevention concepts to be an “ill-defined” problem necessitating a transdisciplinary approach (Dubielzig and Schaltegger, 2004; Stindt et al., 2016). A key feature of transdisciplinary research is a research question that derives from both societal problems and scientific issues. As a consequence, a team of academics from different specialties, as well as experts from societal practice, are needed to answer the resulting questions (Bergmann et al., 2012).

Within our project, the accompanying specialists represent academic disciplines such as business and national economics, environmental science and chemistry, and practitioners in the fields of waste, resources and municipal administration. Additionally, to gain insights into waste prevention in Bavarian municipalities as well as to obtain information concerning daily communal practice, we chose a two-

study research design. Merging quantitative and qualitative data "*provides an overall picture of the research problem*" and supports the development of a conceptual framework, especially in new research fields (Srnka and Koeszegi, 2007). Thus, both a multiple-choice questionnaire directed to 386 local authorities and personal interviews with 33 experts in various fields of study were conducted from September 2013 to August 2014. The consecutive steps of planning, data acquisition and data analysis are displayed in Figure 3 and follow common rules of questionnaire construction and analysis (Petersen, 2014; Porst, 2008); they adapt the approach of grounded theory (Corbin and Strauss, 1990) to the case at hand. See the subsequent chapters for a detailed description of the methodology.

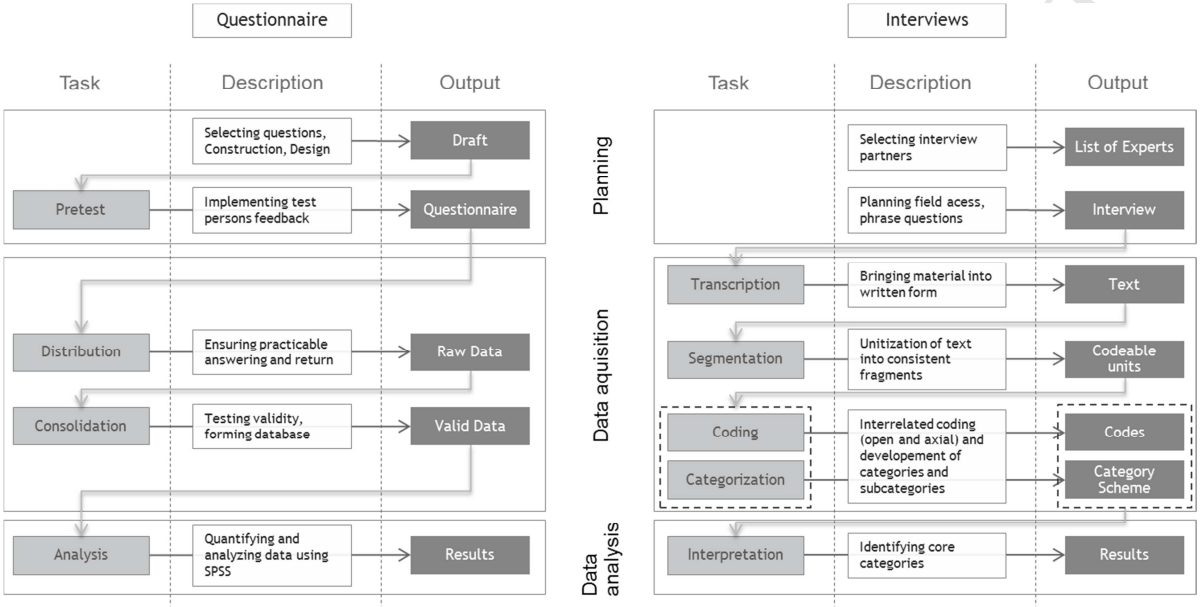


Figure 3: Description of two-study research design

Literature research provided further insights where necessary. The chosen methods each illuminate different aspects of the research objectives.

Table 2: Research goals and research items

Field of interest	Research goal	Research item
Status Quo	Analyze the status quo of waste prevention in Bavarian communities	
		Identify waste prevention measures
		Investigate present opinions and knowledge
		Assess existing methods to measure and quantify waste prevention effects
Potentials	Quantify waste prevention potentials	
		Evaluate prevention potential of different waste streams and measures
		Investigate actors' perceptions of waste prevention potentials
		Explore possible deviation from actual to perceived waste prevention potential and its reasons
Barriers	Identify main barriers to engagement in waste prevention activities	
		Compile a set of possible barriers
		Evaluate and categorize existing barriers
		Identify main obstacles and possible actions to overcome them

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Measures	Develop suitable instruments to prevent waste	
		Determine possible roles for local authorities
		Compile a set of suitable measures and instruments
		Analyze, evaluate and prioritize these measures and instruments
		Recommend strategies on how to implement these measures and instruments

3.2 Questionnaire

The questionnaire primarily aims at providing a general impression of waste prevention in the German county of Bavaria. In particular, this involves existing measures, waste prevention potentials and barriers as well as the current knowledge base and municipalities' roles in waste prevention activities. As the focus on public administration is new, there were no existing validated questionnaires to be used. We therefore constructed the questionnaire following the main steps outlined in Figure 3. First, we chose the array of questions based on extensive literature research and the experience of experts on waste management and waste prevention. The main items are outlined in Table 3. The design of the questionnaire accounts for all major principles, such as dramaturgy and succession (Porst, 2008). Starting with general information, the succeeding questions increase in complexity. One of the main difficulties was to ensure the understanding of the term *waste prevention* and its distinction from other waste management concepts, such as recycling, without using extensive definitions. This was attempted by presenting, in the first questions, examples of common waste prevention measures such as repair networks, paperless offices, second-hand markets or exchanges for building materials.

Table 3: Questionnaire topics

Question group	Topics	Number of items
General information		5
Potentials	Waste streams	9
	Quantity estimation	5
Status	Measures, Instruments	19
	Implementation status	3
	Barriers	8
Role perception	Target areas	10
	Type of engagement	4

A pretest was carried out with the project steering board comprising representatives of local authorities, waste management organizations as well as the Bavarian Stat Ministry of the Environment and Consumer Protection. After the implementation of feedback which mainly pertained to wording and phrasing the questions, we distributed the document electronically in November 2103. Due to the wide range of addressed topics, sometimes more than one person would have to answer the questionnaire. Considering this, the file is configured with the capability of being saved and forwarded before the final transmission of data. Participation was voluntary, and no incentives for answering were provided. The study addressed all cities and counties in Bavaria. The only exclusions were the two administratively independent cities Augsburg and Munich, as these are cooperating parties and therefore participated both in the steering board and in the personal interviews.

In total, questionnaires were sent to 386 municipalities, consisting of 71 counties (encompassing associated market towns and smaller communities) and 317 cities as you can see in Figure 4 (Bayerisches Landesamt für Statistik, 2016; Bayerisches Staatsministerium des Innern, für Bau und Verkehr, 2015). Figure 4 displays the structure, average size and position of these municipalities as well as a characterization of the different types of local authorities. A total of 117 recipients responded to the questionnaire, which amounts to a response rate of 30%. Out of these answers, we tested the validity and reliability of each response and identified 107 questionnaires (28%) to form the database for further analysis. The analysis was carried out using IBM SPSS.

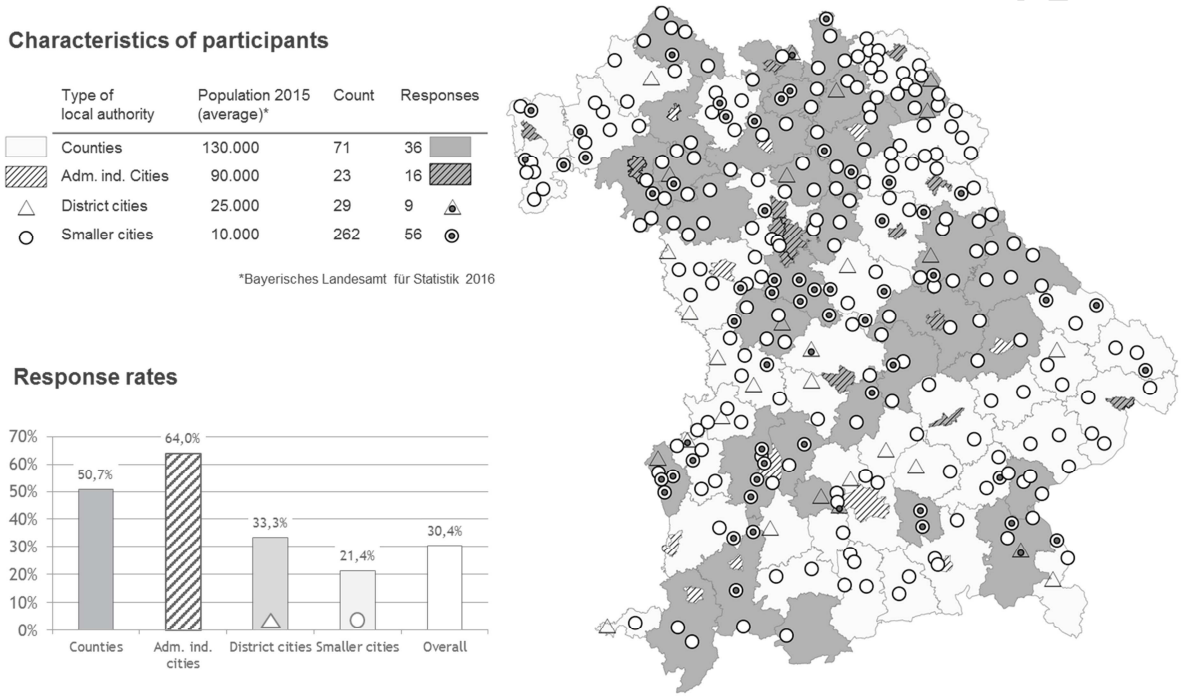


Figure 4: Area and characteristics of questionnaire survey

3.3 Personal interviews

Simultaneously, we interviewed experts from relevant departments within local authorities. These personal interviews were crucial to obtaining required information about the daily practices and existing processes of the target group. To address the complexity and interdisciplinarity of waste prevention as well as the mixed background of the respondents, we chose a problem-focused approach. The interviews covered all aspects of the research question. The questions sometimes involved more than one research objective, as a sharp distinction is not possible in all cases (Figure 5). The question topics were usually presented in the following order:

1. Status Quo of waste prevention within the community/department
2. Waste generation within area of influence
3. Potential opportunities to prevent these wastes
4. Instruments to be used
5. Barriers to waste prevention in general and specific measures

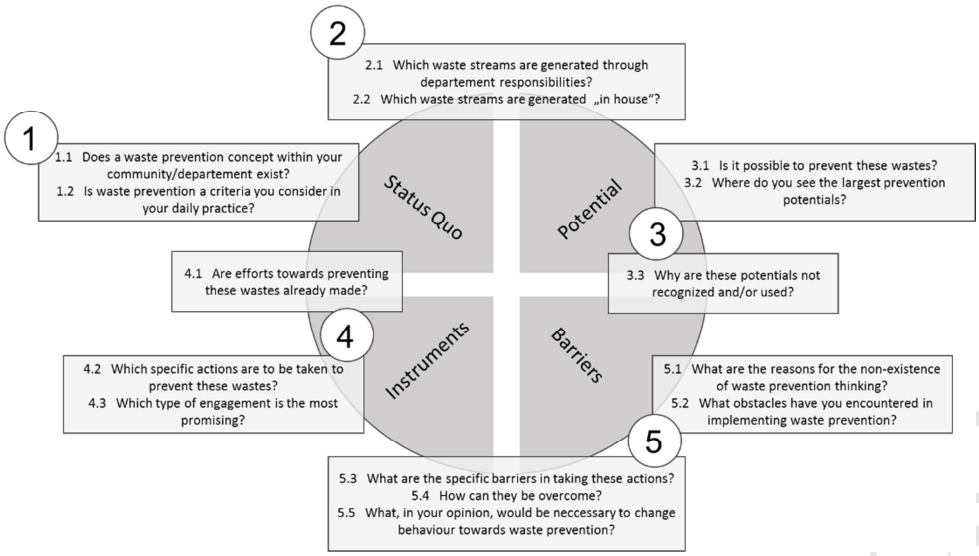


Figure 5: Mapping of research objectives and interview questions

We conducted interviews in three Bavarian municipalities. The city of Munich was chosen because it is the largest local authority in Bavaria, and Augsburg was chosen as the capital city of one of Bavaria's administrative districts. The county of Miesbach is representative of all 71 counties. Each of these three municipalities is among the 86 corporate bodies charged with the management of waste in Bavaria. The interviewed experts within the administrative bodies belonged to various departments, ranging from Construction to Waste Management (Table 4). An intermediary acted as coordinator within the local authority and organized the initial contact with possible interview partners in each of the cities.

Table 4: Interview partners

Department	Employees	Executives	**Respondents**
Organizational Structures	3	2	**5**
Construction	1	3	**4**
Environmental Affairs	4		**4**
Events	2	2	**4**
Human Resources (incl. Education and Social Affairs)	3	1	**4**
Procurement	4		**4**
Markets	1	2	**3**
Sports and Culture	3		**3**
Waste management	2		**2**
Total	23	10	**33**

Collection, processing and examination of data were carried out using a 5-step model. After preparing and performing the interviews, we transformed the material into text and then into codeable units. These segments of text were labeled, categorized and finally interpreted into conclusive results. This model is an adaptation of the five stages of the Qualitative Analysis Process by Srnka and Koeszegi (2007), thus enabling a flexible approach suited to our field of research. While Srnka and Koeszegi propose to first develop a categorization scheme, which can then be used as a basis for the final coding, we used open and axial coding (Corbin and Strauss, 1990) reflexively within the fourth and fifth steps to develop categories. In doing so, we were able to instantly adapt the scheme in relation to the emergence of new codes. This was necessary in our case as the interviewees differed widely not

only in their fields of expertise but also in their skills and educational backgrounds. The material consequently varied in content and structure, and the development of a categorization scheme using only a part of the material would inevitably have been incomplete.

The results gained from these interviews form the basis of understanding waste prevention in local authorities and provide a pool of possible measures and instruments.

4. Results and Discussion

In the following we present the results generated by the structured research process of literature research, questionnaire and interviews, and elaborate on each of the main topics: *status quo, potentials*, *barriers* and *measures*.

4.1 Waste prevention status

Understanding the status quo of waste prevention is necessary when presenting guidance to local authorities. Existing literature indicates that the potentials of local authorities are not sufficiently exploited (Cole et al., 2014; Wilts et al., 2013), and it is argued that information and education – to raise the awareness of all stakeholders – are crucial to achieving waste prevention (BMU, 2013). Investigations about the quality of existing information services and an analysis of the information provided online showed that existing public relations are not, in all cases, adequate to the task of preventing waste. Information is often limited to a short description of waste prevention on the homepage. Only 22 out of 86 public waste disposal authorities in Bavaria provide detailed advice, offer adequate information about waste prevention, and provide infrastructure that enables people to act accordingly. Approximately 50% do not even mention waste prevention on their websites at all. These figures support the thesis that public waste management bodies are hesitant to introduce ways to enhance resource efficiency and to change their routines. This is not surprising as the waste management sector in general appears to be slow to adapt to change: "*only 12.9% of the waste management companies are planning to take investment at all in the next 3 years*" (Wilts, 2012: 34).

Figure 6 shows the status quo of waste prevention measures in local authorities according to the questionnaire. In the opinion of 80% of all respondents, the information provided is sufficient to raise awareness of waste prevention. The instruments are mainly Waste Counseling and Public Relations.

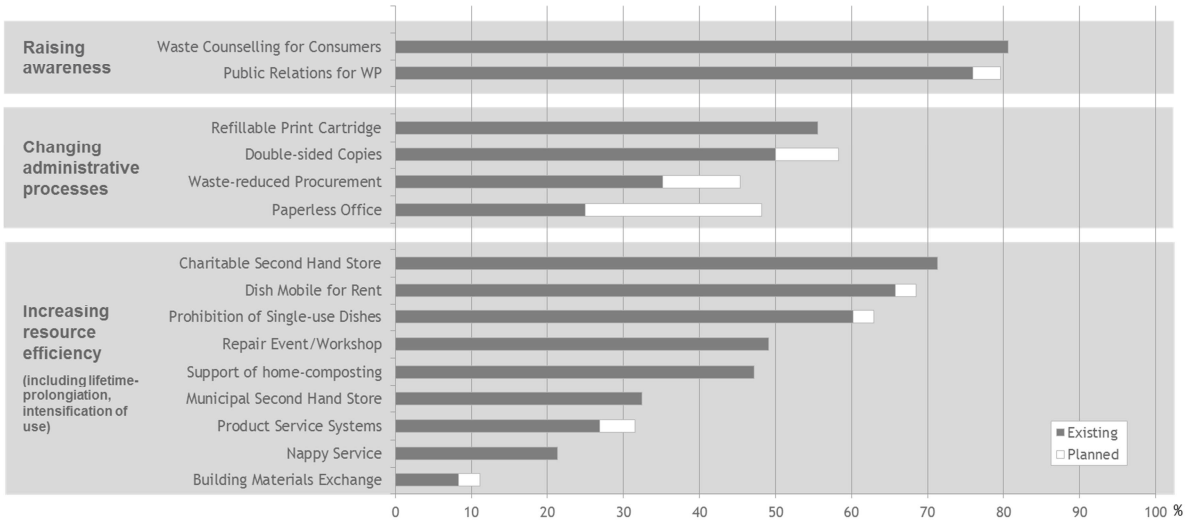


Figure 6: Status Quo of waste prevention measures in local authorities

The application of waste prevention within public administration is moderate and should be intensified. One way to accomplish this is by making Waste-reduced Procurement routine, thus including norms such as durability and reparability in the procurement process. Until now, price has been the sole procurement criterion, according to more than 20% of all interviews. In some cities, adequate actions are planned. For example, 10% of all cities are about to stipulate waste as a criterion within their public procurement processes, the district towns being the most ambitious with 44% of them currently planning to implement this change. Paperless Offices are another measure of implementing waste prevention within administrative units and exist in 25% of all cities. An additional 25% plan to take action towards paperless processes. In particular, smaller cities (up to 20,000 inhabitants) participate in measures promoting waste-reduced offices and print and copy double-sided automatically. In contrast, only every fifth city with more than 100,000 inhabitants uses this default setting for printing devices.

We find the support of measures to increase resource efficiency to prevent waste (e.g. increasing product lifetime and usage intensity) to be low, as appropriate infrastructure is not available. Municipal Second Hand Stores – which provide an opportunity to re-use goods – exist in 30% of all local authorities. Product Service Systems are even less common, but are beginning to gain attention in cities. For some of these measures, the structure of the community seems to be important. In cities, for example, the type of Second Hand Store is related to the number of inhabitants. While only one private store exists among all cities with fewer than 20,000 inhabitants, 24% of these smaller cities have municipal second hand facilities. Charitable providers are even more common and can be found in 70% of all cities with more than 5,000 inhabitants.

The wastes least often targeted by waste prevention measures are building materials and construction components, as a component of Construction & Demolition (C&D) Waste. These could, in part, be prevented with a specific second hand market or exchange for these products in Germany called “Bauteilbörse”. In only 9 out of 108 questioned communities is a “Bauteilbörse” actually available; 3 more are planned.

4.2 Waste prevention potentials

Waste prevention potentials differ depending on targeted waste streams and measures. Waste prevention has the potential to reduce the amount of waste (quantitative waste prevention) as well as its environmental impact (qualitative waste prevention). Data and assessments to quantify these potentials are discussed in the literature, but so far are incomplete. In the European Union, a study states that 4% of total waste could be prevented by 2020 (BIO Intelligence Service, 2011). Other projects calculate a prevention potential of 16% for a given set of measures and waste streams (pre-waste, 2010). The overall prevention potential for Germany amounts to 8% (Wilts and Rademacher, 2014). Estimates for the prevention of municipal solid waste range from 1 to 3% when no reduction in consumption takes place (Salhofer et al., 2008). Food waste as a part of MSW is theoretically fully preventable, but experience proves a potential of 20% to be more accurate (Gentil et al., 2011; Salhofer et al., 2008). Additionally, 12.5% of paper waste could be prevented by encouraging paperless processes in schools and offices (pre-waste, 2010), and design changes could cause a reduction of 30% of C&D waste (Osmani, 2012). Public procurement is one of the most powerful instruments for waste prevention in local authorities as it influences a wide range of decisions. However, no quantification takes place at present because of the complexity and long-term effects of this measure. It is argued that the *“ecological benefit of ecological public procurement in general and the waste prevention potential in particular, currently are only insufficiently exploited”* (Wilts et al., 2013: 827).

Results from both the questionnaire and the personal interviews confirm the recipients' estimation of waste prevention potentials to be low, with more than 40% of all answers being *very low* or *no potential*. The answers do not vary significantly among the different administrative types of communities, but they do vary for different waste streams, as shown in Figure 7. Estimated waste prevention potentials are high for typically recycled materials such as paper or packaging waste. In the questionnaire survey, more than 70% of the participants estimate the prevention potential of packaging and paper waste as "high" or "very high". The relatively high estimation for food waste prevention potentials is, according to interviews, mainly a result of current marketing campaigns such as *"Zu gut für die Tonne"* (in English: *"Too good for the waste bin"*). Waste of Electrical and Electronic Equipment (WEEE) and Bulky Waste prevention potential is mainly seen as *very low*, and estimates for organic waste (except food waste) are equally low. The lowest potential occurs with C&D waste. Over 60% of all respondents consider construction and demolition waste to be hardly preventable at all. When asked directly, respondents indicate that this is because the construction sector is perceived as an old, established industry whose activities cannot be controlled by communities.

Comparing the results of the empirical study with the figures drawn from literature, we are able to show a discrepancy between existing potentials and their perception by practitioners, especially for C&D waste. This discrepancy is among the main barriers to the implementation of waste prevention measures and is further elaborated in section 4.3.

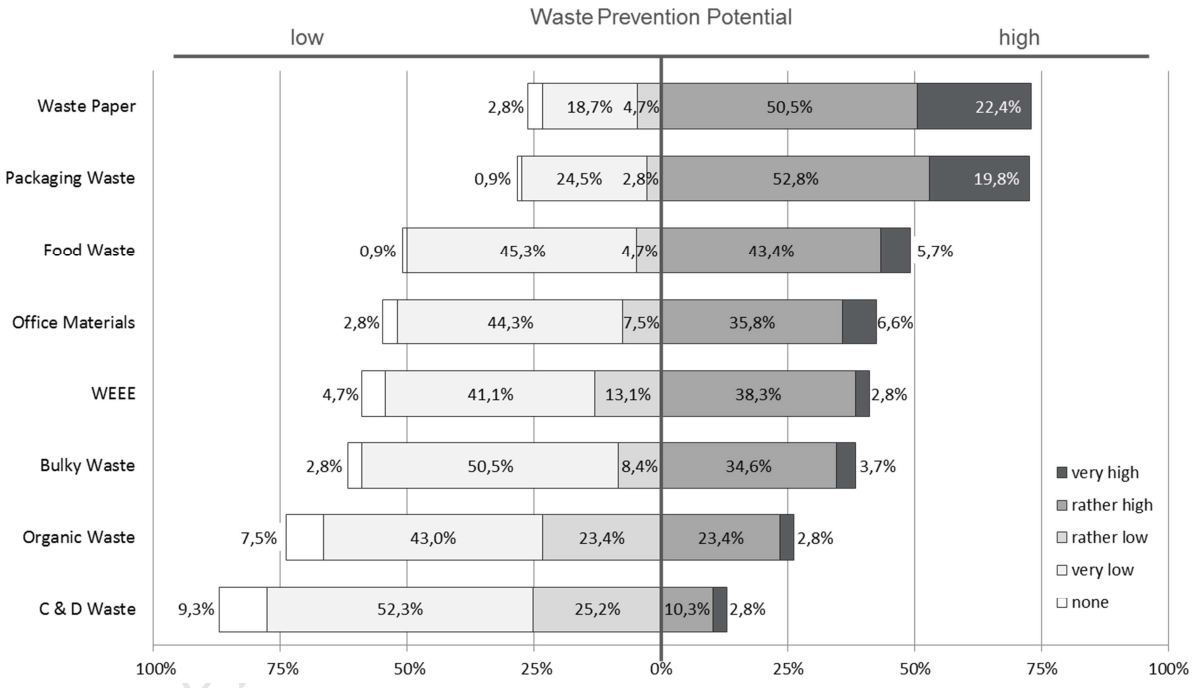


Figure 7: Prevention potential estimation of local authorities

To exploit waste prevention potentials, local authorities may choose among different types of instruments for implementing waste prevention. If waste prevention is achieved through a change in the behavior of the community itself, for example the establishment of new procurement guidelines or efforts towards paperless offices, we call this *action*. Initiatives targeting private consumers and business can be carried out either by regulation, promotion or informational campaigns. Legislation, policies and rules have *regulatory* effects and include measures such as bans on one-way dishes for public events. *Promotion* provides incentives to participate in waste prevention and *information*, for

example waste counseling and marketing campaigns, further enables and motivates citizens and industries to do so.

Communities' self-conceptions regarding which type of instrument to choose varies slightly with their structures (Figure 8). Approximately 40% of all answers from cities imply that taking action towards waste prevention is the right approach, while in counties, promotion is the top priority with 37%, followed by action and regulation with nearly equal shares (27% and 26%). According to personal interviews, this emphasis on supporting measures mostly includes information services and the promotion of information networks, as this is the most effective way to benefit all associated cities and villages within the county area. The promotion of measures concerning the necessary infrastructure for waste prevention, such as premises for product service systems or a "Bauteilbörse", fails due to the large areas and subsequently low population densities of counties.

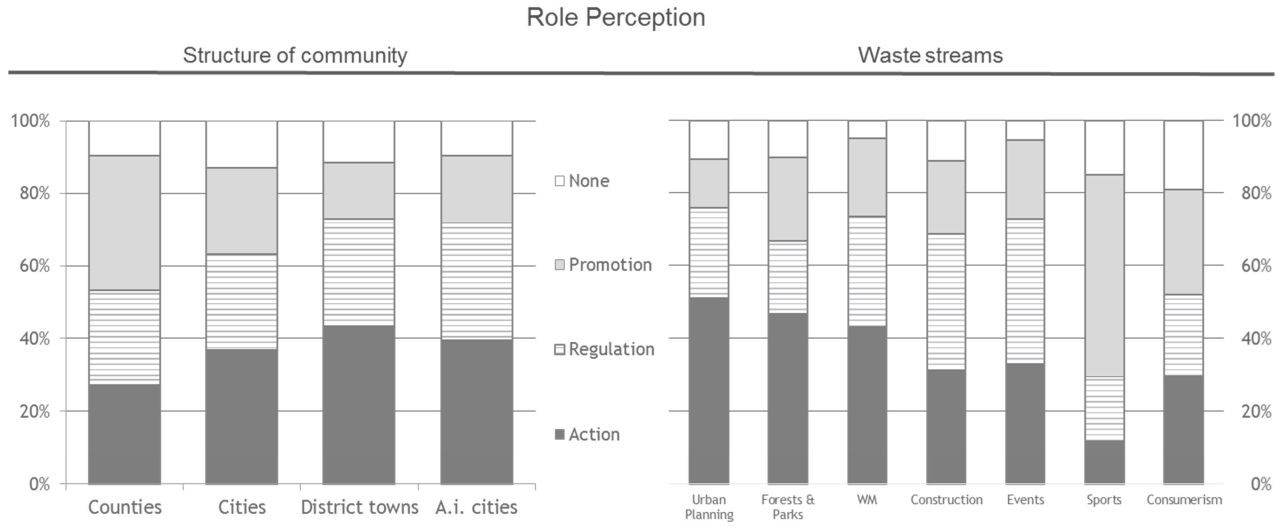


Figure 8: Role perception and favored approach for local authorities

A high percentage (over 50% of all participants) sees itself as actors in the area of urban planning. According to opinions voiced within the steering board, possible measures include the design of parks and the allocation of commercial areas within pedestrian zones, preferably not to vendors of to-go products. In the construction sector and with events, regulative measures are more common. Sport clubs and facilities can mostly be influenced by promotion, for instance by providing financial aid when installing environmental management tools. Nearly 20% of all respondents feel that the consumer behavior of citizens cannot or should not be addressed at all.

4.3 Waste prevention barriers

Current consumption patterns, lack of information and awareness, and concerns about the effectiveness of measures are among the common obstacles to the implementation of waste prevention analyzed in literature. Additionally, preventing waste is considered to have financial benefits in the long run, but the implementation of measures can create high costs. Therefore, actions often focus on waste management rather than prevention at the source (Cecere et al., 2014; Mazzanti and Zoboli, 2008). Possible negative consequences for industry are voiced repeatedly (Melanen et al., 2002; Salhofer et al., 2008). Another major factor to be considered is the perception of waste prevention and its distinction from recycling. Waste prevention often is often confused with, or considered to be the same as, preventing waste from being incinerated or landfilled and thus "lost" to the economy. Using this definition, people often refer to recycling as a means of prevention, with the material still being part of the economic system. Current efforts towards Zero Waste strengthen this

view because within these concepts, Zero Waste frequently equals “zero waste going to landfill” (Cole et al., 2014; Zaman and Lehmann, 2013). Sometimes the existence of a functional recycling system even diminishes motivation to prevent waste (Wilts et al., 2012; Zorpas et al., 2015b). Misperceptions like this, information deficits, and a general lack of environmental awareness lead to indifferent behavior. There are several strategies that aim to change this situation. Increased prices for goods and waste disposal can lead to short term behavior change, while education and awareness campaigns should tackle this problem over the long term (Polanec et al., 2013; Tasaki and Yamakawa, 2011; Wilts et al., 2013).

Identifying and analyzing the barriers to engagement in waste prevention activities on a communal level is the first step to overcoming them. Using a quantitative assessment, we determine the importance of existing barriers, while qualitative instruments help us with an in-depth analysis of the reasons. The known obstacles include high costs, modern life styles and consumer culture as well as a lack of knowledge and awareness. In consultation with the project steering board, this set of barriers was discussed, consolidated and extended to fit the scope of local authorities. In this way, we identified seven items as potential barriers. These items can be categorized as hard and soft barriers. To complement this list, the category “other reasons” was included.

Table 5: Waste prevention barriers

Barrier Category	Barrier	Description
Hard Barriers	High Financial Costs	Capital outlays as well as current expenses of implementing and operating waste prevention measures
	Availability of Personnel Resources	Ability to provide the necessary labor force and knowledge to implement and run waste prevention measures
	Legal Restrictions	Existing laws, policies and regulations that contradict long-term sustainable thinking
Soft Barriers	Low Acceptance	Lack of willingness to participate in waste prevention activities
	Measure(s) unknown	Waste prevention measure(s) not (yet) known or not recognized as related to waste prevention
	Measure(s) ineffective	Actual or estimated ineffectiveness of waste prevention activities
Hybrid	Lack of Potential	Actually lacking or unperceived/underestimated waste prevention potential
Other	Other reasons	

The analysis confirms soft barriers to be decisive, especially as related to measures concerning administrative tasks. Among all reasons specified, Low Acceptance, Lack of Potential and Missing Knowledge Base are the main barriers and cover two thirds of all answers (Figure 9). Only 7% of all respondents cite High Financial Costs as the primary obstacle. A total of 95% of all answers regarded the measures as effective, which proved that respondents do acknowledge that efficient waste prevention is possible. There is no significant distinction between the barrier assessment and targeted waste streams. However, activities targeting administrative tasks, e.g., Waste-reduced Procurement, Paperless Office or Double-sided copies, fail particularly often because of Low Acceptance (43%), even though the measures are known and potentials exist. With some categories, municipality size has a strong influence on estimations of potential. Every second city with fewer than 5,000 inhabitants assesses the potential for a repair guide and municipal or private second hand shops to be low. In municipalities with more than 5,000 inhabitants, this drops to less than a third.

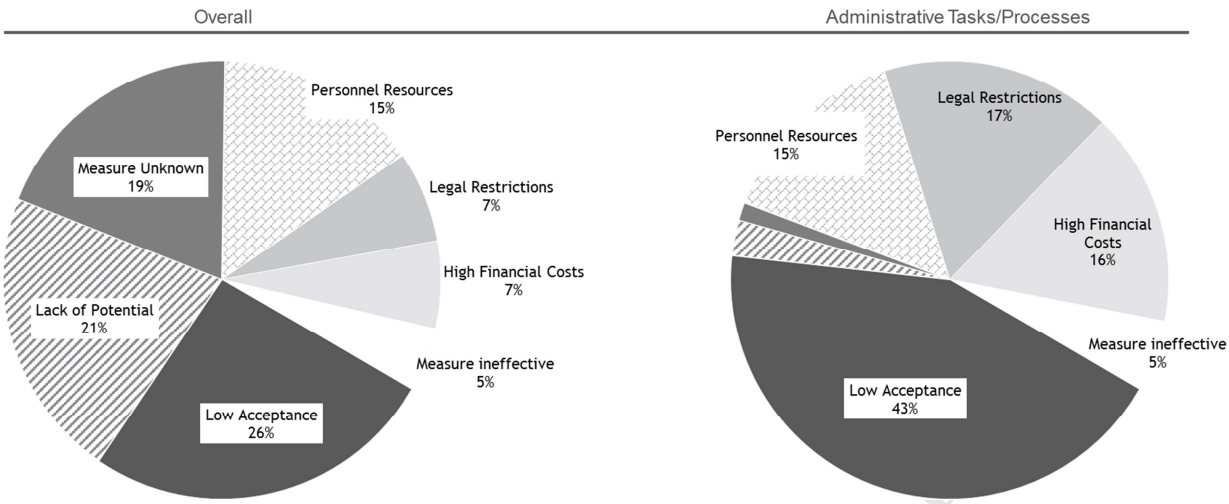


Figure 9: Importance of implementation barriers

The questionnaire identified Low Acceptance to be the main obstacle to the implementation of waste prevention measures. Therefore, the potential reasons behind this low acceptance were among the items to be addressed through the personal interviews.

In addition to a lack of general environmental awareness, which was cited in more than 30% of all interviews, experts repeatedly highlighted the lack of motivation to engage in waste prevention activities and, therefore, a resulting overall low acceptance of the implementation of measures. In addition, concerns about existing conflicts of interest were voiced. Together with the two dimensions of information deficit, we identified a set of six possible causes of the lack of engagement of individual stakeholders in waste prevention. These are displayed in Figure 10 and are described in the following sections.

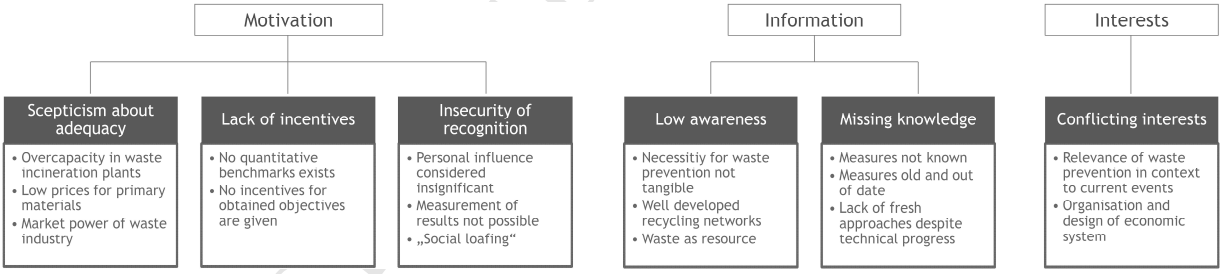


Figure 10: Reasons for the low acceptance of waste prevention

Existing **motivational** problems can be categorized as skepticism, lack of incentives and the insecurity of recognition. Throughout the administrative bodies, there is skepticism regarding whether waste prevention really is a valid option for local authorities. Waste is perceived as a resource for both material retrieval and energy generation. This is especially true with recyclables such as paper and plastic. The waste management industry is conceived of as a sector with mainly economic interests, and the recyclable components of waste are increasingly referred to as valuable secondary resources. The limitation of these resources through waste prevention is consequently seen as a hindrance to resource supply stability. Furthermore, the importance of preventing non-recyclable waste as a means of resource conservation is also discussed. As prices for primary resources are low, re-use for economic reasons is rarely necessary. In Bavaria this is especially true for building materials, which are commonly down cycled instead of re-used. As long as resource prices do not reflect all connected environmental impacts and costs continue to be externalized, this trend is likely to remain (Wilts et al., 2013). Other concerns involve energy recovery. While Zunft and Fröhlig (2009) state that waste

incineration does not have any negative effects on waste prevention, other experts suggest it might be the other way around. Existing incineration capacities in Germany are considered to exceed the country's needs by far and require minimum quantities of waste to reach the efficiency required to pay off capital investments (Wilts, 2012). Given their knowledge of these dependencies, some of the communal staff regard waste prevention not only as unnecessary but as counterproductive.

A general lack of incentives hinders the implementation of waste prevention measures. Although waste prevention is embodied in European law, some countries do not have specific prevention targets. Of the five countries with the highest overall waste generation, only Germany and the U.K. have actually launched waste prevention programs, and only parts of the U.K. have presented quantitative targets (European Topic Centre on Sustainable Consumption and Production, 2014; Eurostat, 2016b). The German *National Waste Prevention Programme* determines non-quantitative objectives, and so do counties and local authorities. Without quantifiable goals, well-targeted incentives are difficult to establish and legal consequences rarely occur. With neither incentives nor penalties, the motivation to act towards waste prevention is considerably low.

Finally, the insecurity of recognition further decreases the motivation to engage in waste prevention activities. This is especially true for measures concerning daily office processes and administrative tasks. As they consider their individual influence to be insignificant, most staff members hesitate to implement measures such as double-sided copying in the first place. Even when measures are not considered insignificant, another aspect of the insecurity of recognition is the difficulty of associating possible results with a specific entity. This occurs especially when waste prevention is linked to personal effort, for example the process of researching and weighting different procurement options instead of just ordering standard products. Ultimately, this leads to the phenomenon of social loafing.

Information deficits involve low awareness as well as a general lack of knowledge. Because Germany is often referred to as the world champion of recycling, waste is more and more regarded as a clean secondary resource. The additional energy and resources needed for the collecting, sorting and recycling processes are rarely on people's minds. The necessity of preventing waste is therefore often not recognized. Furthermore, the distinction between waste prevention and recycling is not necessarily obvious to stakeholders. Waste prevention is sometimes regarded as the minimization of waste relegated to disposal. This lack of awareness is compounded by a lack of knowledge about measures for and approaches to the actual prevention of waste.

Finally and consequently, waste prevention is not very high on communities' agendas as it sometimes **conflicts** with other **interests**. The relevance of waste prevention in contrast to current political events is low, and so is the anticipated impact on voters' opinions. Therefore, more recent and/or "visible" topics are covered first. Another often-voiced aspect of conflicting interests is the design of the current societal and economic system. In particular, waste prevention at the source is supposedly linked with reduced consumption and sufficiency. Many respondents feel that this is a goal neither desired by industry nor supported by the government and, thus, it is not viable.

4.4 Waste prevention measures

Measures named in the literature include, but are not limited to, waste-preventing public procurement (Wilts et al., 2013), promotion of product service systems (Wilts et al., 2013), design changes and "designing out waste" in architecture (Osmani, 2012; Yuan, 2013), educational campaigns and awareness raising (BMU, 2013; Cole et al., 2014; Polanec et al., 2013), food donation to social institutions (Lebersorger and Schneider, 2014), selection of waste-reduced caterer solutions (Wilts and Rademacher, 2014), the utilization of public network water (Nessi et al., 2012) and the submission of forms electronically instead of by printing (Mirabella et al., 2013). These measures are complimented

by various international and national best practice examples and the results of our empirical study. In sum, we extracted 57 possible measures for local authorities out of the questionnaire, personal interviews and literature research. These included well-known and already practiced measures such as a ban on one-way cutlery at events, the promotion of home composting, and cooperation with food-sharing agencies. Additionally, interview partners of some departments voiced original ideas, of which the following are some examples:

- Mandatory counseling for each building project constructed on communal grounds to inform the builder about waste prevention in both the planning and construction phases
- Reducing paper waste by either providing the city council with electronic devices to read and comment on reports or else by setting a limit on reports' maximum length
- Where possible and sensible, replacing road surfaces with long-lived surfaces
- Providing drinking water within public buildings (administration offices as well as libraries, schools, sports facilities) with a water dispenser
- Changing the financial planning system to include criteria such as environmental friendliness, longevity and reparability instead of only low cost

Each measure is carefully analyzed and categorized before being presented to the transdisciplinary steering board. The measures are then discussed by the experts, allowing for different views from practitioners, municipalities, scientists and local authorities. The decision criteria include the prevention potential, the financial and personnel effort required, the time frame for implementing the measure, the ecological benefits and supplementary effects. In this way, we identify 32 measures recommended for implementation by local authorities. The waste prevention measures are categorized by the type of waste prevention (Reduction at Source, Substitution, and Intensification) and the type of instrument. Concerning the latter and as already described in section 4.1, we distinguish between *Action, Regulation, Promotion* and *Information* as types of instruments. The resulting matrix (Appendix 1) allows local authorities to identify and evaluate waste prevention measures and thus create a holistic waste prevention concept. Additionally, we identify indicators that enable successful control by local authorities for each of these measures.

According to the results of this study, we prepared a "Guideline for the Preparation of Communal Waste Prevention Concepts" which indexes all of this information for local authorities (Hutner and Tuma, 2016). It features step-by-step instructions for implementing waste prevention measures into daily processes and overall values. These steps include

1. the selection of measures and instruments out of the presented matrix;
2. the declaration of objectives and definition of appropriate indicators and;
3. the implementation of these measures and objectives into a communal waste prevention concept.

With the guideline, local authorities are empowered to design individual waste prevention concepts matching their conditions and attributes and fitting their chosen focus.

In addition to specific measures, the training of staff is essential to overcome the lack of overall environmental awareness and to actually embed waste prevention measures into daily practice. A total of 25% of all interview partners felt that the creation of awareness, for example through seminars, along with a general mission statement from their employer, are both necessary to induce a change in behavior. This echoes existing studies that perceive awareness and education as prerequisites for changing everyday processes (Zaman 2014). Seminars and workshops highlight the implications of daily tasks in terms of environmental impacts. For those outside of public administration, conferences are the most efficient way to broadcast knowledge (Polanec et al. 2013).

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5. Conclusion

This contribution highlights some of the main issues to be addressed in order to successfully implement communal waste prevention concepts. Instead of addressing individuals, we focus on local authorities, a hitherto neglected target group in the scientific discussion. The empirical study explores the status quo of waste prevention in municipalities and gives insights into existing potentials and how decision makers perceive them. We further established a set of barriers and evaluated their importance. Thus, we are able to advise local authorities on important strategies and instruments to overcome these barriers and implement holistic waste prevention concepts.

Our research shows that various attempts to prevent waste already exist within communities. However, there are significant unexploited potentials that are currently not addressed. The reasons for this neglect can be categorized as soft and hard barriers. Our findings indicate that soft barriers are more relevant. Environmental awareness in general, as well as awareness regarding the impacts of waste and waste prevention, is low. Equally low is the motivation of employees to act towards waste prevention. Additionally, information deficits further hinder the implementation of relevant measures. These deficits have to be overcome by activities that increase the acceptance of waste prevention and raise awareness. We identified instruments that we summarize in a supporting tool for practitioners within local authorities, the “Guideline for the Preparation of Communal Waste Prevention Concepts”. The guideline presents a three-step-approach to setting up holistic waste prevention concepts and includes a set of over 30 measures and their specific prevention potentials, implementation details and indicators suitable for quantifying their effects.

The study concentrates on local authorities in Bavaria, Germany. A possible next step would be the comparison with other countries to evaluate the applicability of our discoveries. Also, matching the perceived potentials with a quantification of the actual potentials could be the missing link to overcoming some of the barriers. The empirical research focuses on cities and counties; smaller communities are left out even though potentials may exist. We chose this specialization because smaller communities mostly do not include all relevant departments themselves but have some issues taken care of by the responsible county administration. This is both a limitation of our research and a possible avenue for further research.

Another promising field for further research lies in the quantification of waste prevention effects in both quantitative and qualitative terms, taking into account the whole life cycle of products in order to support the raising of awareness. Hence, Life Cycle Thinking has to be applied, and Life Cycle Assessments should investigate the potential and effects of waste prevention.

In summary, our research enhances the focus of the scientific discussion of waste prevention by including local authorities. Our results helps to strengthen efforts towards actual waste prevention as a means of increasing resource efficiency.

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Appendix I: Waste prevention measures reccomended for implementation in Bavarian local authorities

	Reduction at source (R)		Substitution (S)		Intensification of Use (N) & Extension of life (L)	
Action (H)	HR1	Procurement	HS1	LED lighting	HL1	Mobile repair center
	HR2	Tap water	HS2	Water bar	HL2	Intelligent collection systems for bulky waste
	HR3	Cooperation of the departements Environment and construction	HS3	Electronic Forms		
			HS5	Oligotrophic grasslands		
	HR4	Paperless office	HS6	Electronic equipment		
			HS7	Information on USB sticks		
			HS4	Tablets for town councils		
(R)	RR1	Prolonged warranties	RS1	Refillable printer cartridges		
			RS2	One-way ban at events		
			RS3	One-way ban at sports facilities		
Promotion (F)			FS1	Nappy services	FL1	Repair Cafe
			FS2	Mobiles for lending dishes	FL2	Second hand shops
					FL3	Bauteilbörse
					FL4	Waste prevention center
					FL5	Cooperation with food donation services
Information (I)	IR1	Building demolition counselling			IN1	Information at residents‘ registration offices
	IR2	Information material with building permission			IL2	Digital repair guide
	IR3	Trainig of Architects				
	IR3	Campaigns for citizens				

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Highlights

- Introduction of Local authorities as a target group for waste prevention
- Structured transdisciplinary research design featuring collection and assessment of quantitative and qualitative primary data
- Thorough analysis of status quo, potentials, barriers and instruments of waste prevention
- Development of Guidelines for practitioners to help with the implementation of holistic waste prevention concepts

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