University of Kassel
Department of economics
Field of expertise Sustainable Marketing

Exposé

Performance measurement of waste disposal/ recycling under consideration of the triple bottom line approach in Germany

To obtain the degree:
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1. Problem definition

As the world's population continues to grow and prosperity increases, so does the amount of waste produced. As a result, the requirements for the disposal, treatment and recycling of waste are also increasing. It should be emphasized that a responsible approach to this problem not only reducing greenhouse emissions and, thus, makes an important contribution to climate change, but also promotes public health. This results, among other things, from the prevention of soil and water pollution, which is essential to protect the environment (Cherubini et al. 2009).

The different approaches to waste disposal differ, sometimes considerably. Reasons for these different approaches can be found in the economic performance of the country (Raab and Wagner 2018), the historical development of the waste disposal system, socio-cultural factors (Raab and Wagner 2017) or geographical conditions.

China has recognized the need to address the rapidly growing waste volume and has opted for state-of-the-art waste incineration plants. Thus, not only is the volume of the emerging mass significantly reduced, but waste incineration is also used to generate energy (Zhang et al. 2010). Japan also relies to some extent on waste incineration, not only because of limited landfill space, but also to avoid the environmental damage caused by landfilling (Sakai et al. 2008; Porteous 2005).

The increasing attention of the public in recent years has led to a higher demand for the recovery or recycling of resources. This indicates that the development of sustainable solutions is becoming increasingly relevant. Here, the triple bottom line approach offers the opportunity to describe the individual levels of sustainability and to shed more light on them. The weighting between the 3 pillars, consisting of economic, ecological and social aspects, should be balanced and can thus reveal a potential imbalance (Pope et al. 2004). Results from a large number of studies show that sustainable management of municipal waste requires a holistic approach that involves the widest possible range of stakeholders (Salem et al. 2020).

But what is the situation in Germany? Is waste disposal in Germany, often referred to as the recycling world champion, really sustainable? What is the weighting between the 3 pillars of the triple bottom line approach? Which potentials are not yet exploited?

Against this background, the bachelor thesis will deal with both the consideration of the theoretical foundations and the implementation of these in Germany. The aim of this approach

is to link the results obtained in the existing literature with German waste disposal/ recycling and thus lay the foundation for further research in science.

2. State of research/ presentation of the theoretical framework

A large amount of research literature is available on the topics of sustainability, triple bottom line approach, zero waste principle and municipal waste management. Contributions to the zero waste principle, which could be interesting in connection with this are (Zaman 2014) and (Zaman and Lehmann 2013).

However, the literary coverage of the current German municipal waste management is incomplete. Of particular interest here are current evaluations of the German state of sustainable waste management and the resulting effects, which are missing to a large extent. Current figures on the volume of waste are provided by the BMU (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety) and the UBA (Federal Environment Agency).

3. Questions

The following questions are dealt with in the context of the Bachelor thesis:

I. What are the economic aspects of waste disposal and recycling?
II. What are the ecological effects of waste disposal and recycling?
III. What social consequences result at inland and abroad from waste disposal or recycling?

In order to answer the research questions, various research projects are linked together. In doing so, already existing research results are to be linked with the current German approach to waste disposal. The basis for this is a paper in which carbon emissions in connection with the management of solid municipal waste in Germany were considered (Mühle et al. 2010). This basis will be extended to include further emissions and the two further dimensions of the triple bottom line approach.

4. Analysis of waste generation in Germany

The quantity and composition of waste varies from country to country. This is illustrated best by household waste. However, it is generally evident that the composition of waste is based on the country's prosperity. Wealthy western countries have a comparatively similar household waste composition. This is illustrated, for example, by a lower moisture content compared to China (Cheng and Hu 2010).

The composition of German household-type municipal waste from 2017 illustrates that household waste or household-type commercial waste collected via the public waste collection system together account for 30.6% of the total 46.151 million tons. This already highlights a problem of comparability between different countries. The limit when commercial waste is still classified as household waste is not always clearly visible.

It is also interesting to know what proportion of packaging material is included in municipal waste that was collected separately. Plastic, paper, glass, cardboard, mixed packaging material or even metal in the form of cans are used in everyday life as packaging material for food and consumer goods.

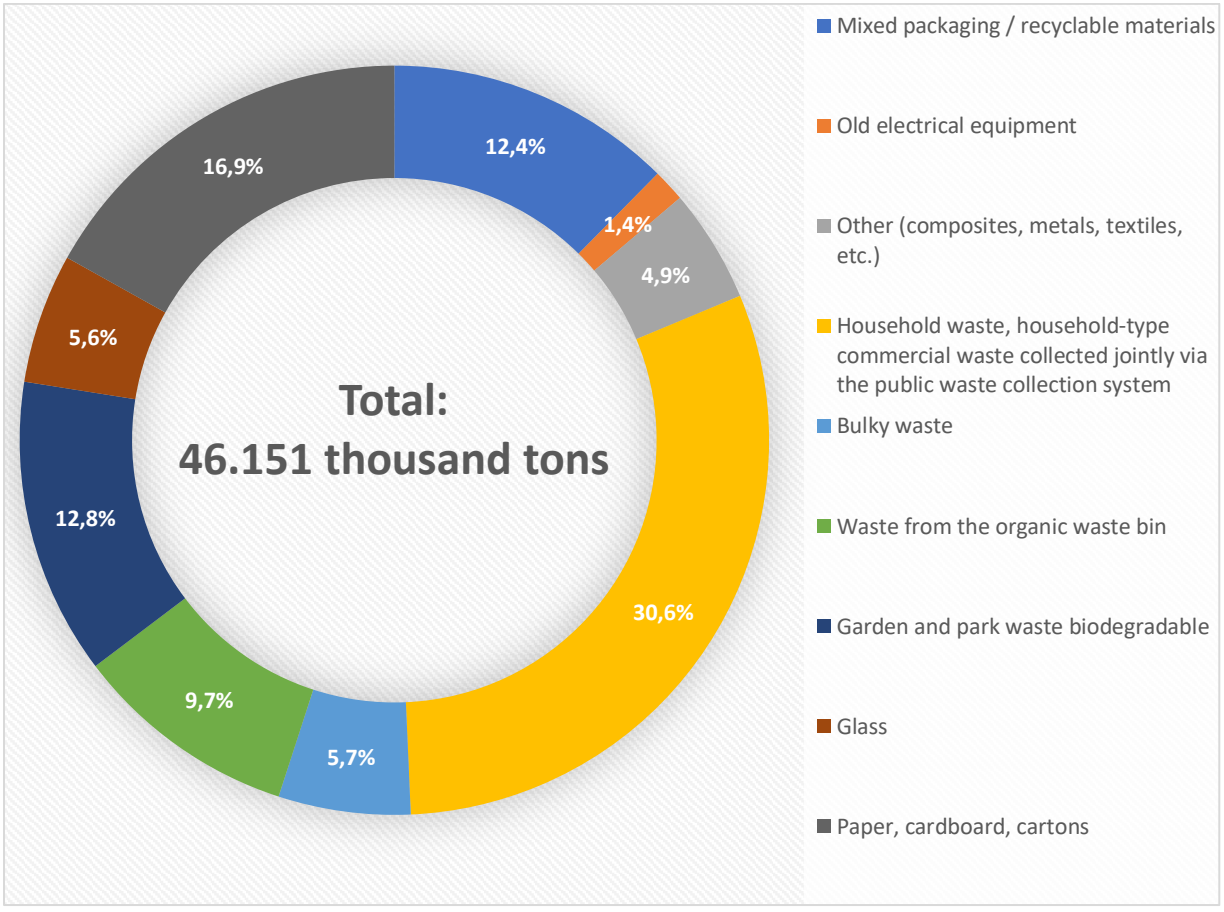

Figure 1: Composition of household-typical municipal waste in 2017 (Federal Statistical Office, Waste Balance Sheet 2017)

But how high is the recycling rate of municipal waste in Germany? According to the Federal Statistical Office, the recycling rate was 67.2% in 2017. This means that the target of a recycling rate of 65%, which the Federal Government had set itself for 2020, was reached ahead of schedule.

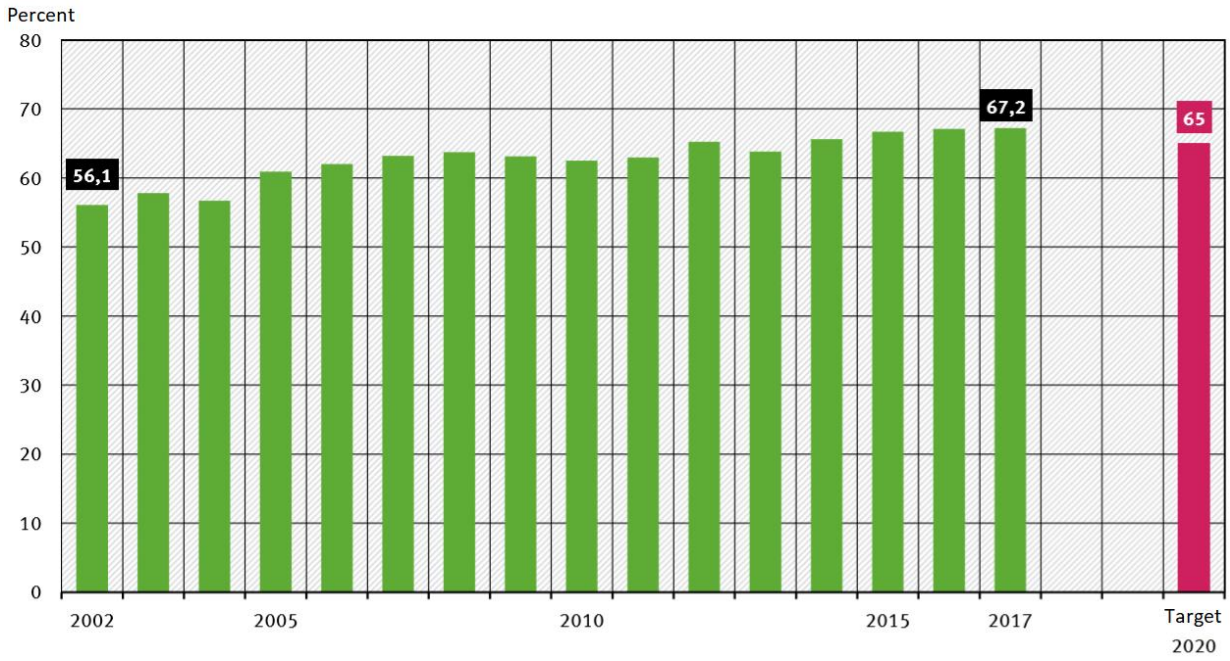

Figure 2: Share of treated and recycled municipal waste in total municipal waste generation (Federal Statistical Office, waste balances, various years)

Recycling within the meaning of the closed substance cycle and waste management act (KrWG) is any recovery process by which waste is processed into products, materials or substances either for the original purpose or for other purposes; it includes the processing of organic materials, but not energy recovery and processing into materials intended for use as fuel or for backfilling (Act on the promotion of closed substance cycle and waste management and ensuring environmentally compatible management of waste, §3 Definitions para. 25).

The ecological impact of our consumption behavior can be reduced by recycling materials in the form of e.g. granulates obtained from municipal waste through treatment processes. This can be achieved by substituting primary resources with secondary materials that come from recovery and recycling. In other words, the production of a recycled material that re-enters further life cycles represents a potential credit for avoiding the production of a corresponding amount of new products (Blengini et al. 2012). However, this does not only have an environmental impact, but also influences the economic and social level of sustainability.

Recycling creates a demand for labor, which is needed for the delivery of materials and the various processes of recycling. On the one hand, this leads to costs that are charged to the recycled materials and on the other hand to the income of the new workers. Furthermore, people are aware of the need to behave in a socially responsible and environmentally friendly manner. Satisfaction with compliance can be observed (Salem et al. 2020; Raab and Wagner 2019).

Looking at the recycling rates of the individual packaging materials over time, it can be seen that the recycling rates in the individual packaging categories have risen dramatically between 1991 and 2017. It becomes clear that paper, cardboard and wood had a consistently high recovery rate of over 99.4% in 2017. A similarly high recycling rate is recorded for metals of different types and qualities. Here the recycling rate for all metals is 91.1%, which is a difference of 67% compared to the recycling rate in 1991. The lowest recycling rate for packaging materials is found for other packaging materials. This can have various reasons.

Packaging material	1991	1997	2001	2005	2007	2008	2010	2012	2013	2014	2015	2016	2017
Glass consumption	4.636,6	3.750,3	3.343,6	2.878,5	2.824,7	2.868,5	2.711,8	2.807,1	2.758,0	2.748,3	2.690	2.808,1	2.891,8
Recycling quantity	2.491,5	3.132,3	2.844,5	2.376,7	2.364,9	2.357,9	2.335,7	2.376,6	2.446,0	2.445,5	2.292	2.401,8	2.440,3
Recycling rate in %	*53,7*	*83,5*	*85,1*	*82,6*	*83,7*	*82,2*	*86,1*	*84,7*	*88,7*	*89*	*85,2*	*85,5*	*84,4*
Metals													
Aluminium consumption	108,4	87,2	96,5	83,5	91,0	93,4	90,6	95,7	97,7	107,4	109,7	114,2	123,3
Recycling quantity	18,0	69,5	72,7	63,6	67,5	74,7	79,5	87,4	90,5	98,5	100,2	104,6	112,3
Recycling rate in %	*16,6*	*79,7*	*75,3*	*76,2*	*74,2*	*80,0*	*89,3*	*91,4*	*92,6*	*91,8*	*91,3*	*91,6*	*91,1*
Tinplate consumption	818,3	712,3	733,8	534,4	499,8	501,7	478,1	503	496,9	492,0	501,4	505,9	516,3
Recycling quantity	303,9	566,4	555,5	447,9	457,9	469,5	446,1	467,8	465,6	457,9	455,7	459,5	469,3
Recycling rate in %	*37,1*	*79,5*	*75,7*	*83,8*	*91,6*	*93,6*	*93,3*	*93*	*93,7*	*93,1*	*90,9*	*90,8*	*90,9*
Consumption of other steel	409,9	321,9	296,5	280,3	262,6	316,6	264,7	305,8	295,6	328,8	336,1	338,4	344,4
Recycling quantity		286,6	257,7	247,4	238,1	292,2	246,7	283,2	277	305,8	314,8	318	324,6
Recycling rate in %		*89,0*	*86,9*	*88,3*	*90,7*	*92,3*	*93,2*	*92,6*	*93,7*	*93*	*93,7*	*94*	*94,3*
Total metal consumption	1.336,6	1.121,4	1.126,8	898,2	853,4	911,7	833,4	904,5	890,2	928,2	947,2	958,5	984,0
Recycling quantity	321,9	922,5	885,9	758,9	763,5	836,4	772,3	838,4	833,1	862,2	870,7	882,1	906,2
Recycling rate in %	*24,1*	*82,3*	*78,6*	*84,5*	*89,5*	*91,7*	*92,7*	*92,7*	*93,6*	*92,8*	*91,9*	*92*	*91,1*
Plastics consumption	1.655,9	1.502,1	1.889,9	2.367,9	2.643,8	2.732,4	2.690,1	2.836,7	2.873,3	2.945,6	3.052,2	3.097,7	3.184,9
Recycling quantity	192,9	916,2	978,9	1.127,0	1.645,4	1.869,1	2.016,7	2.808,5	2.863,1	2.931,5	3.035,8	3.079,6	3.165,9
Recycling rate in %	*11,6*	*61,0*	*51,8*	*47,6*	*62,2*	*68,4*	*75,0*	*99*	*99,6*	*99,5*	*99,5*	*99,4*	*99,4*
Paper, cardboard, paperboard													
Paper and cardboard consumption	5.598,2	5.238,1	6.060,9	6.658,1	6.928,9	6.725,9	6.998,2	7.087,1	7.661,8	7.969,9	8.156,8	7.927,3	8.172,5
Recycling quantity	3.121,0	4.640,8	5.572,2	6.067,9	6.019,4	6.131,4	6.479,6	7.045,0	7.649,4	7.949,6	8.132,6	7.907,8	8.149,5
Recycling rate in %	*55,8*	*88,6*	*91,9*	*91,1*	*86,9*	*91,2*	*92,6*	*99,4*	*99,8*	*99,7*	*99,7*	*99,8*	*99,7*
Consumption of liquid board	193,0	209,7	213,6	238,2	219,5	213,6	198,0	185,3	177,1	178,9	174,4	180,7	176,1
Recycling quantity	0,0	129,2	134,2	148,7	146,5	144,9	143,5	183,1	176,5	177,9	173,4	179,7	175,1
Recycling rate in %	*0,0*	*61,6*	*62,8*	*62,4*	*66,7*	*67,8*	*72,5*	*98,8*	*99,6*	*99,5*	*99,4*	*99,4*	*99,4*
Total consumption of paper, cardboard, liquid packaging board	5.791,2	5.447,8	6.274,5	6.896,3	7.148,4	6.939,5	7.196,2	7.272,4	7.838,9	8.148,8	8.331,2	8.108,0	8.348,6
Recycling quantity	3.121,0	4.770,0	5.706,4	6.216,6	6.165,9	6.276,3	6.623,1	7.228,1	7.825,9	8.127,5	8.306,0	8.087,5	8.324,6
Recycling rate in %	*53,9*	*87,6*	*90,9*	*90,1*	*86,3*	*90,4*	*92,0*	*99,4*	*99,8*	*99,7*	*99,7*	*99,7*	*99,7*
Wood consumption	2.184,0	1.892,2	2.367,7	2.408,3	2.620,1	2.570,9	2.549,7	2.746,4	2.743,2	2985,9	3110,1	3.159,8	3.288,7
Recycling quantity		1.600,0	1.500,0	1.670,0	1.820,0	1.760,0	1.700,0	2.709,7	2.728,5	2964,2	3091,5	3.139,2	3.267,4
Recycling rate in %		*84,6*	*63,4*	*69,3*	*69,5*	*68,5*	*66,7*	*98,7*	*99,5*	*99,3*	*99,4*	*99,3*	*99,4*
Consumption of other packaging materials	16,0	16,9	15,3	21,3	22,1	21,8	21,4	19,5	20,0	20,9	22,2	24,9	25,2
Recycling quantity		0,0	0,0	0,0	0,0	0,0	0,0	16,5	15,9	16,4	17,6	19,6	19,9
Recycling rate in %		*0,0*	*0,0*	*0,0*	*0,0*	*0,0*	*0,0*	*84,5*	*79,7*	*78,3*	*79,3*	*78,9*	*78,8*
Total consumption	15.620,3	13.730,7	15.017,8	15.470,5	16.112,5	16.044,8	16.002,6	16.586,6	17.126,9	17777,7	18153,1	18.161,8	18.723,2
Total utilisation	6.127,3	11.341,0	11.915,7	12.149,2	12.759,7	13.099,7	13.447,8	15.977,9	16.712,4	17347,3	17613,6	17.609,8	18.124,3
Overall recycling rate in %	*39,2*	*82,6*	*79,3*	*78,5*	*79,2*	*81,6*	*84,0*	*96,3*	*97,6*	*97,8*	*97*	*97*	*96,8*

Figure 3: Total packaging consumption, recycling, quotas 1991 to 2017 (in kilotons) in the Federal Republic of Germany (Gesellschaft für Verpackungsmarktforschung mbH (GVM), 2019)

Some of the other packaging materials may be mixed packaging materials that can only be separated in complex and costly processes. Therefore, recycling is economically unprofitable in some cases and in this case it is not necessary.

The recycling of glass is special in many respects. The energy required to melt down the material to be recycled is high and therefore also cost-intensive. Thus, the production of glass through primary resources has hardly any economic disadvantage. If a high degree of contamination of the used glass is added, recycling is sometimes considered unprofitable. Furthermore, depending on the situation, the processing of the highly contaminated material would lead to the advantages for the environment turning into negative ones. The removal of the contamination would therefore require a significantly higher amount of fossil fuels (Blengini et al. 2012). These trade-offs need hardly be taken into account when recycling metal, as the cost of primary resources is higher there than in the production of glass. Thus, the basic problem of waste disposal or recycling becomes apparent, because the economic and ecological levels are mutually dependent. This leads to necessary decisions by those responsible, which thus have an influence on the extent of the environmental impact.

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Gesetz zur Förderung der Kreislaufwirtschaft und Sicherung der umweltverträglichen Bewirtschaftung von Abfällen (2020), §3 Begriffsbestimmungen Abs. 25

6. Indicative outline

The following preliminary structure is used to organize this work:

1. Introduction
2. Literature review
    a. Sustainability
        i. Definition
        ii. Triple bottom line approach
        iii. Zero waste principle (5 R's)
    b. Consideration of waste generation in Germany
3. Research methodology
4. Results
5. Discussion of the results
6. Conclusion

7. Timetable

The work is to be processed with the procedure shown in the following figure:

Subtasks	Month/ Week													
	August		September				October				November			
	35	36	37	38	39	40	41	42	43	44	45	46		
Collection of material														
Literature analysis														
Content analysis														
Discussion of the results														
Conclusion and introduction														
Fine tuning														
Delivery														