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Zero Waste Indicators - Waste prevention monitoring in the European Union

Content

1 Introduction

The physical manifestation of global economy is the international flow of materials. Besides primary raw materials and products, secondary raw materials and waste shipments have an increasing importance. Today the problems and opportunities generated by resource use and waste are cross-borders. Scarcity of resources is one of the basic principles of economics giving grounds to aspirations increasing the availability of them: this led to the organic development of secondary raw material market, besides the primary market. Sustainable management of resources has gained significance and has become more conscious since the publication of the Brundtland Report (WCED, 1987).

An obvious solution to the waste problem is presented by the frequently cited circular economy concept. Although it is often used as a synonym for recycling, it has some very important implications, the concept includes the goal of shrinking the loop. Working towards zero waste, it declares the need to reduce the amount of waste entering the loop. This dissertation focuses on the aspect of waste prevention within the circular economy. Whereas, in the European Union all types of waste treatments are strictly regulated and monitored against targets, waste prevention in reality has no priority, even though it is confirmed in the regulations to be the most important treatment method within the so-called waste hierarchy. The heterogeneity of waste prevention policy measures causes uncertainties and hardship in monitoring. Not to mention the distinctive factor that waste prevention is more about products (yet not becoming waste) rather than waste, falling under totally different type of regulation. This leads to missing policy outcomes and indicators. This dissertation is an attempt to present an overview of waste prevention in the European Union, and to identify appropriate indicators to monitor progress in this field. All waste management methods of the hierarchy are accurately regulated, and monitored by fairly standardised statistics in the European Union. The introduction of mandatory targets for Member States regarding reuse and recycling, the mandatory diversion of organic waste from landfills and the overall drastic reduction of landfilling has clearly led to the development of waste treatment technologies, and a shift upwards the waste hierarchy. The only element of the waste hierarchy that remains without any targets is waste prevention, even though considered as top priority in the European Union's overarching regulation, the Waste Framework Directive (WFD, Art. 4). As a result, waste prevention today is often treated as an important principle referred to in the preambles of legal and policy documents, but without any further commitments.

Waste management – depending on the operation – may be local (disposal) or global (trade of recyclables, trade of residue derived fuels, trade of waste for reuse, and some hazardous waste for recovery or disposal under strict rules). Prevention is rather local, but its aggregated impact is significant on global level – typical case for thinking global, acting local (Steel, 1996). Recycling is said to be the ultimate, economically viable solution for waste problems. However, in case of the two

most important waste streams (plastic, paper) it is not working efficiently within the boundaries of the European Union. These waste fractions remain part of a linear economy: although separate collection is carried out, but there is no loop in the EU, no extensive recycling in effect (Graczka, 2018). The end of the "loop" or rather line was in China and today some other countries are accepting waste, very often incinerating instead of recycling it. This was revealed in public by intense media coverage when China announced its ban on import waste from 2018. Europe and developed regions faced the problem that circular economy does not exist: the problem of waste is just being exported to other regions of the world. Even in 2021 – according to Eurostat – more than 11,8 million tonnes of paper and cardboard waste were exported within the EU and 4,4 million tonnes outside the EU. India is taking up above 1 million tonnes followed by Turkey, Ukraine, South-East Asian countries (Indonesia, Vietnam, Malaysia), Switzerland and the UK. In case of plastic waste EU Member States export to 79 countries reaching 2,5 million tonnes intra EU and 1,1 million tonnes outside the EU. Destination countries are of the same group of countries as of paper and cardboard, except for India. Having seen that recycling as the publicly 'best' solution does not work, prevention of waste, or dematerialisation of the economy (Bartelmus, 2003) is inevitable to stay within the limits of the Earth's carrying capacity. In fact, resource efficiency should be clearly linked to waste prevention as research reveals that people in the EU have a lack of knowledge about the relationship between waste reduction and resource efficiency (Minelgaite et al., 2019).

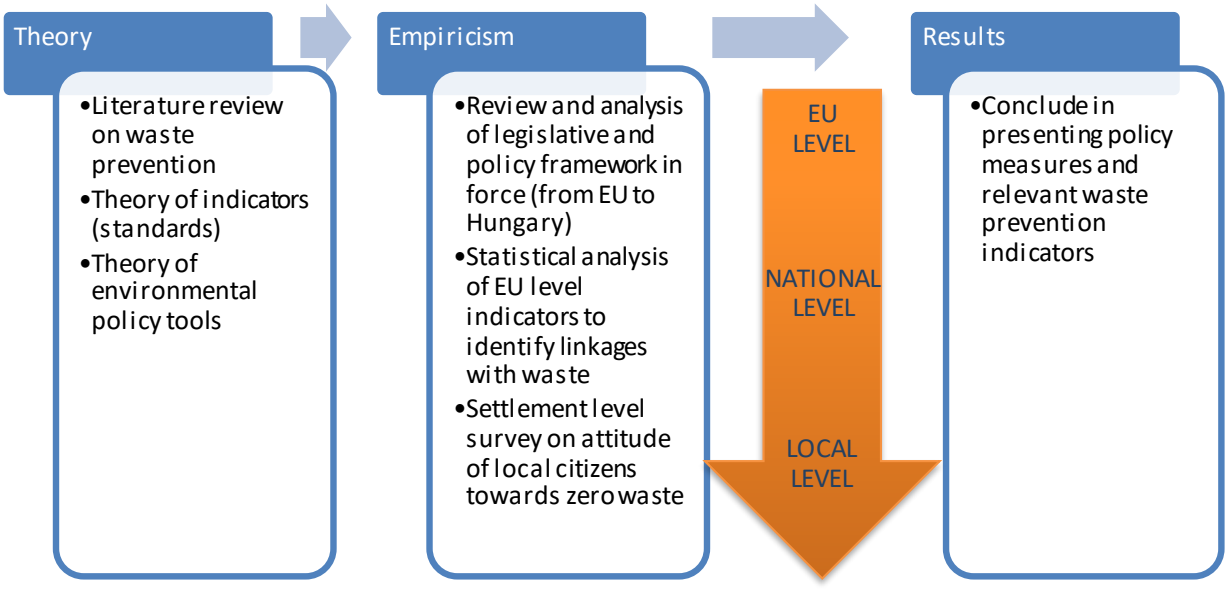
European countries are at a turning point: we are beginning to see a drop in the amount of waste sent to landfills, in favour of composting, recycling and waste-to-energy conversion (Marti et al., 2021), but waste prevention or waste reduction is still not an issue, while municipal waste generation is still increasing in the EU. At the same time, The Lisbon Memorandum (ESSC, 2015) adopted by the European Statistical System Committee calls for scaled-up research on the interaction between statistical indicators and public policies, because statistical indicators do not only help in understanding reality, but also influence policymaking.

The dissertation shall attempt to overview the theoretical background of waste prevention via a critical literature review focusing on most important publications in the topic,as a next step it researches the policies, practices and applied proxy indicators, and based on that develop indicators for measuring the phenomenon (Figure 1.). The research questions rising are *"How can waste prevention be monitored in the European Union?"* First, we need to understand the nature, the drivers of waste prevention, or rather waste generation and invert them. Supporting question *"Which social, economic, and environmental factors affect the waste prevention?"* targets this. Supporting questions *"How does waste prevention appear in the EU and Member States' policies?"* should be answered to identify what should be measured. Finally, we need to map *"Which are the commonly used waste*

prevention indicators?", and search for potentially more informative, more precise measurement: *"Are there other, more appropriate indicators for the measurement of waste prevention?"*.

The core idea is to track waste prevention policies of the European Union all the way through policy papers and legislations from the union level to Member States' national level choosing Hungarian legislation as an example. Principles of waste prevention and management are dominantly set by the European Union. Member States are obliged to implement the priorities of the Waste Framework Directive, but the measures are chosen freely, based on local characteristics. The level of settlements is interesting, because local governments are close enough to households, have local knowledge, and also possess the policy tools to incentivise local citizen action. Local authorities, the municipalities, and communities, have a key role – especially when it comes to principles of subsidiarity – to play in supporting changes towards sustainable development. They are responsible for infrastructure development, public procurement and waste management, as well as education, social welfare and physical planning (Zotos et al., 2009). Local governments are ideal to set actions as the population of the settlement face similar circumstances, receive similar public services (e.g. waste collection services). Although municipal waste does cover a series of waste types, the name is given, because traditionally local governments are responsible for its management. The chosen sample settlement is Zsámbék in the agglomeration of Budapest for the analysis of point of intervention.

Figure 1 - Structure of the dissertation



To get a clear view on waste prevention monitoring is needed. As a next step, following the document analysis and evaluating the survey, currently applied waste prevention indicators are to be identified and analysed. Why are the currently applied proxy indicators problematic? Effects of

economic and social processes – that have the indirect ("side") effect of reducing waste – should be differentiated, from the effect of the waste prevention policy programmes or changes in behaviour. Typical case is an economic recession, when consumption falls, so does the amount of waste generated. However, this is not a long-term positive outcome. The today independently used proxy indicators (e.g. waste generated, waste generated/GDP etc.) have the shortcoming of being unable to differentiate among causes. An effective monitoring system should go more into details, to be able to follow the variety of measures and capture the drivers of waste prevention. Due to the regulatory hierarchy, it is important to develop an indicator set or composite index that is compatible with official statistics and appropriate for EU-wide aggregation and comparison.

Waste prevention is a conflicting topic, as it confronts current consumption patterns, political and economic goals. Economic growth implies growing production and consumption, whereas waste prevention is about the rationalisation of those: sticking to the very needs of human, and if necessary, reducing consumption and production. To the point that waste reduction brings savings producers and households welcome the concept, but holding back consumption is critical for the economies of the developed world. A shift in paradigm, the re-thinking of consumption and production strategies (Cecere et al., 2014) is required.

2 Literature review

2.1 Method of review

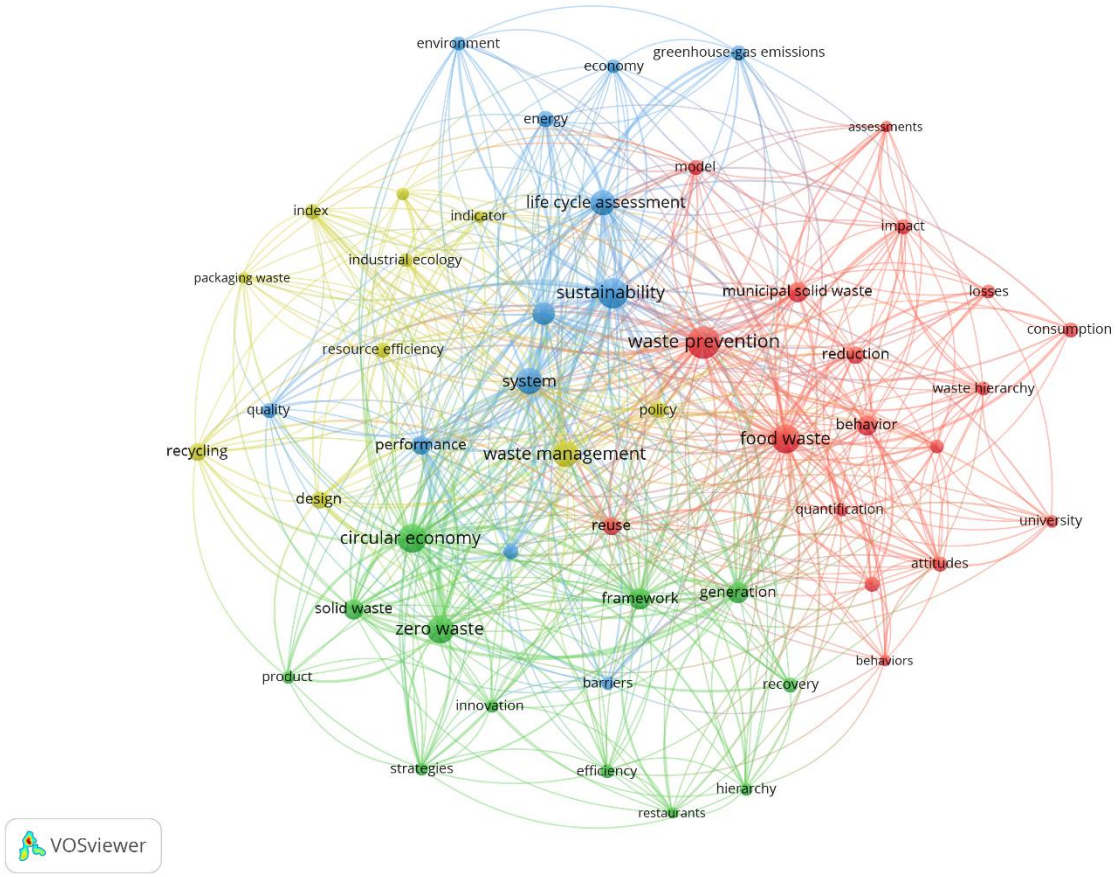
The literature review was initially run by Scopus, later was shifted to Web of Science (WoS), as in this topic there were only slight differences in hits in the two engines, and WoS turned out to provide more abundant tools for analysis. Majority of hits were in the form of scientific articles, accompanied by book chapters and conference proceedings.

Waste prevention has overall a relatively modest literature compared to waste management, or even circular economy. Its dynamics, however, shows progress over the past 15 years. As a first step the search was performed with Boolean operators and the core terms: WASTE AND PREVENTION. This gave 6386 hits by 2022, out of which 1950 was in the domain of environmental sciences and environmental studies. All others were related to natural sciences, engineering and medical science. The topics covered by articles remained quite heterogeneous, for this reason further narrowing took place introducing the new search: ("WASTE PREVENTION" OR "ZERO WASTE") AND (MEASUREMENT OR MONITORING OR INDICATOR). This resulted in 235 hits which mostly seemed to be appropriate in relevance.

A mixed method shall be carried out on the hits. By a systematic review current practices, definitions and contexts, available monitoring methods shall be mapped. The systematic review is based on findings of Web of Science, and research shall start with a bibliometric analysis looking for co-occurrences, the evolution of terms and the density of terms meaning the frequency of keywords appearing in related publications. The review shall present the research panorama, including the source types, the year range, the composition of publishers and the discipline range of publications. The list of relevant literature coded by keywords set up during the research can be found in Annex I. Following the mapping, a critical approach shall be applied to evaluate the content of findings.

The co-occurrences of key terms were examined to better identify the topics which relate to waste prevention. The bibliometric analysis was prepared by VOSviewer, not logical or too general keywords were removed, synonyms were grouped. The model originally included 57 keywords, leading to 52 after adjustment. Figure 2 shows that co-occurrences are most frequent with sustainability, circular economy, zero waste, life cycle assessment, and waste management. These domains shall later be observed in the review. Among the frequent terms ‘indicators’ can be found as our main interest. Food waste is also dominant topic in prevention, which is closely related to municipal waste, however, this field is now intensively studied, as the European Union has recently made Member States reporting mandatory, and has introduced the indicators for measuring Member States’ performance. Food waste shall be addressed to the degree necessary to get a holistic picture of municipal waste prevention, but is out of scope of the research.

Figure 2 - Co-occurrence of keywords in scientific publications with waste prevention monitoring (keywords n=52)

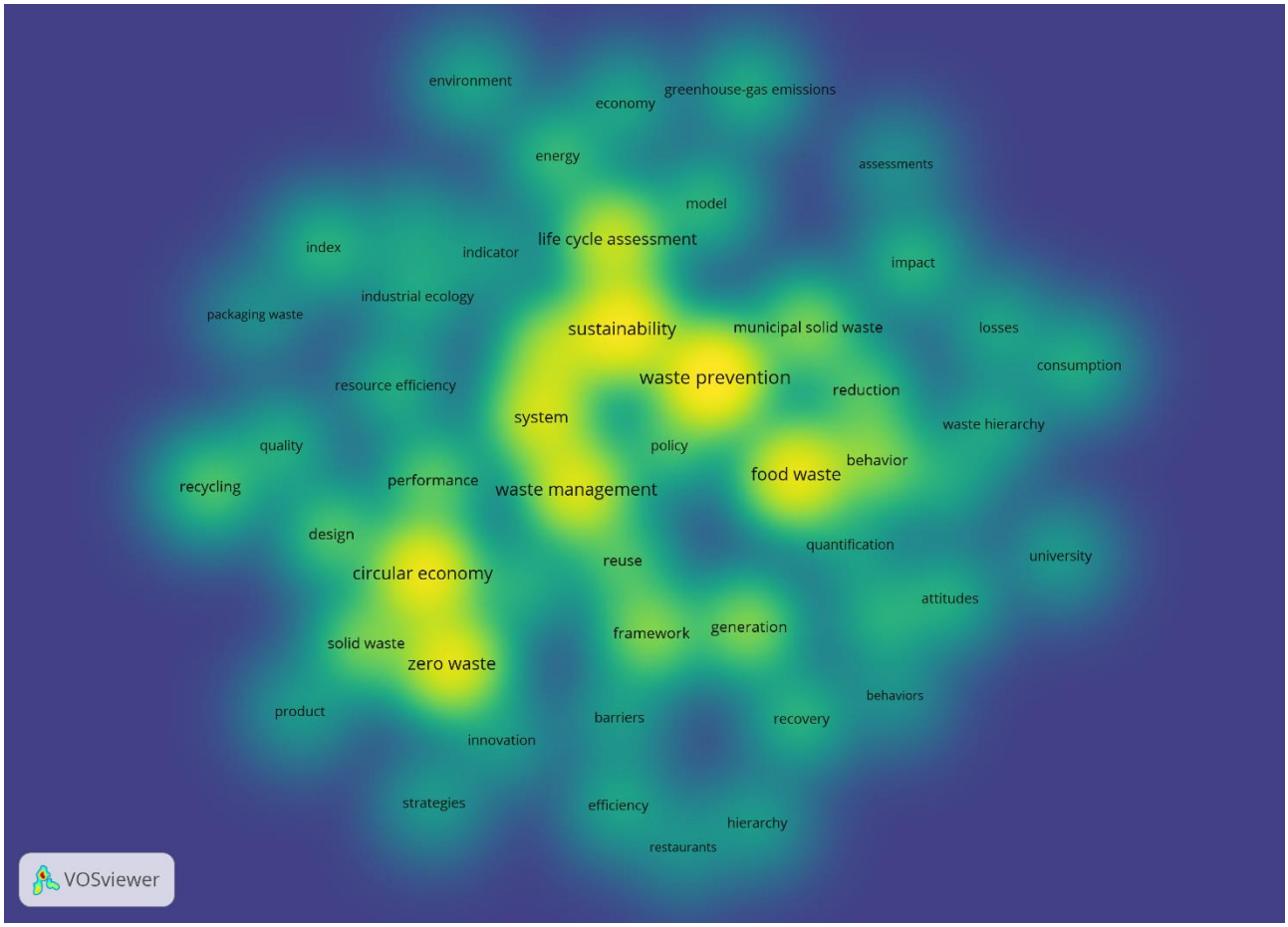


Source: VOSviewer, own compilation

Four clusters were defined with the help of the algorythm of the research software based on the association strength of keywords of scientific articles. Cluster 'Waste prevention' (red) comprises topics mostly related to households: municipal solid waste, consumption, attitudes, behaviour etc. Cluster 'Circular economy' (green) covers keywords such as efficiency, innovation, strategies, and recovery. Circular economy and zero waste are included in one cluster. This is because, the term 'zero waste' often includes not only prevention, but reycling or even energy recovery. Keywords of Cluster "Sustainability" (blue) give a wider perspective including the environmental impacts of material use. Life cycle assessment is the tool for assessment of the environmental impacto of the use of materials. It is notable that the term material use, dematerialisation is not among the top keywords only through LCA, but the topic is also extremely important in waste prevention (Domenech et al., 2019) Probably material, or material use would have been too general for authors as a keyword. Cluster "Waste management" (yellow) embodies the traditional approach of waste prevention, the one that uses the waste management as a framework probably shifting towards recycling when it comes to monitorin g.

The density profile shows the frequency of co-occurrences (Figure 3) demonstrating a pattern of the most closely related topics to waste prevention monitoring, those mentioned above.

Figure 3 - Density of co-occurring keywords with waste prevention monitoring (n=52)

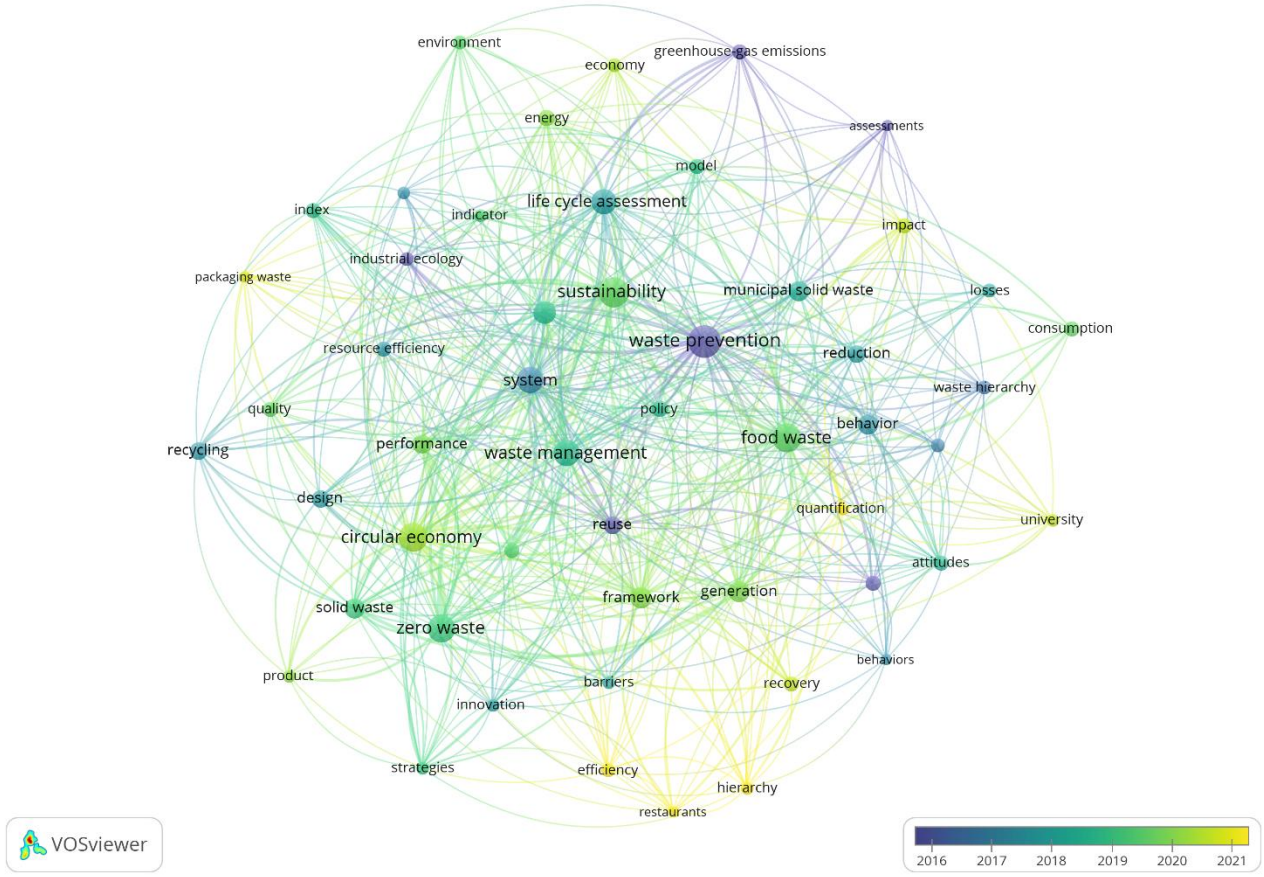


Source: VOSviewer, own compilation

The chronological view (Figure 4) shows the evolution of terms in time. The map reflects on 'waste prevention' as the oldest among dominant keywords. In 2016 the publications on waste prevention monitoring were focused on households, reuse, GHG emissions and industrial ecology. The next years the systemic approach took over using the concept of waste hierarchy, and life cycle assessment with a focus on reduction, design, innovation and resource efficiency suggesting that non-end-of-pipe approach in measurement was promoted, focuse was on the pre-waste status. Zero waste initiatives took place in Europe by that time with the aim of reducing the amount of waste generated, so the term zero waste also appears intensly in this period. Around 2019-2020 food waste was put under the spotlight together with sustainability. The food waste problem is closely connected with global sustainability measurement through the UN Sustainable Development Goals (SDGs): as a contrast, the developed world overconsuming while one of the goals is Zero Hunger. The SDG indicators methodology development progressed at a very low pace from the adoption of Agenda2030 in 2015. 2020 was a year of comprehensive review of these indicators, which might have caused the increase of sustainability-themed publications in waste prevention monitoring. Lately, the term 'circular economy' took over the first place suggesting that waste prevention is again pushed back into the context of waste management contrary to the earlier attempts to focus measurement on the

pre-waste phase. The yellow time cluster shows great variations in topic, i.e. it does not show clearly future research directions.

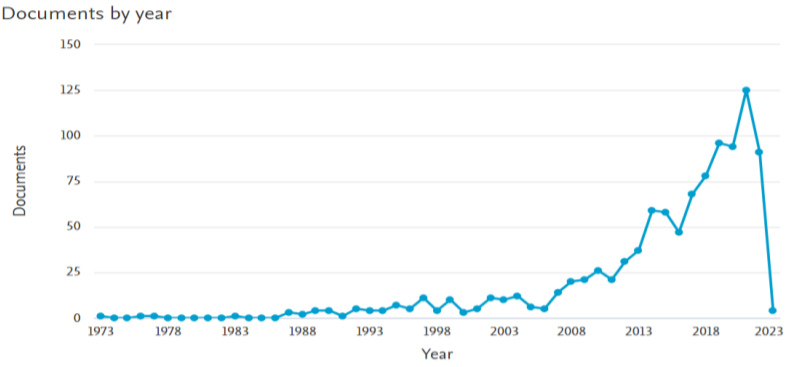
Figure 4 - The evolution of keywords in time (keywords n=52)



Source: VOSviewer, own compilation

The publications on waste prevention monitoring were stagnating between 2001-2008, and following the financial crisis the scientific activity became intense leading to the an exponential increase in the number of articles. The past few years' increase probably relates to the development of the European circular and green economy concepts. The Waste Framework Directive (EC, 2008) was revised in 2008 with the primary aim of strengthening waste prevention, and the rationalisation of production for cost saving. By making national waste prevention plans obligatory from 2013 an increase in the number of publications is also experienced. From 2020 the food waste prevention became a highlighted topic in the European policy, but the methodological development preceded this with few years (see Figure 5). For this reason, food waste has an extensive coverage within the waste prevention literature.

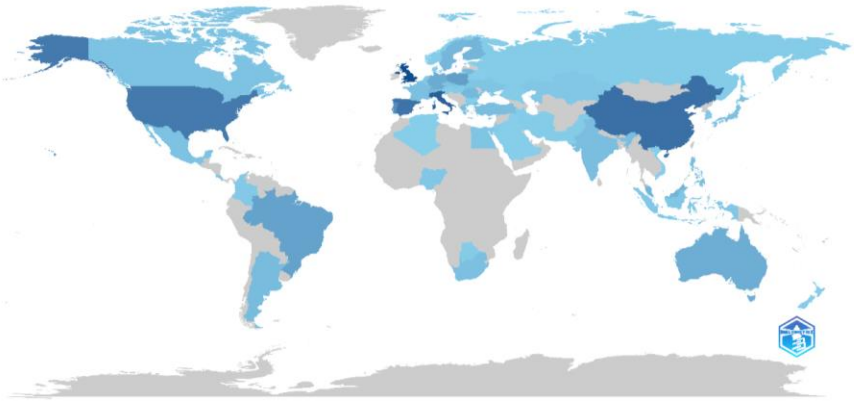
Figure 5 - Results for "waste prevention" in Scopus Database



Source: Scopus

The geographical distribution of articles shows divergence. The US is supposedly focused on zero waste, as the term originates from there. In Europe, former Member State, the United Kingdom has been the most active player, but Italy, Spain, Germany and ultimately Portugal and Poland also took place on the map. China is recently becoming an important player in waste prevention, but with intensive activity. The darker a country on the scientific production map (Figure 6), the higher is the number of publications. There is a growing trend in the number of zero waste management publications with principal regions of China in Asia, USA in America and Italy in Europe. According to Scopus the main funder of publications is the European Commission.

Figure 6 - Country scientific production (2001-2021)



Source: Bibliometrix R, own compilation

Three of the most relevant authors publish in co-authorship and their topic is life cycle assessment of products which is out of scope. Zaman, Au., Zorpas, A. A., Wilson, D. C., and Lasaridi, K. are also among the most important authors, and their work is relevant in the context of the current research as well.

According to Scopus the main journals for publication are Journal of Cleaner Production reaching the second place mainly in recent times. Waste Management, Resource Conservation and Recycling, and Waste Management and Research are journals also mentioned by Scopus.

Overall the clustering gives a broad, but informative categorisation publications in the field of waste prevention monitoring. Less relevant keywords sometimes seem less consistent, but this is normal in case of a cross-cutting topic as waste prevention is.

The following subchapters present the theoretical framework based on the literature review with particular focus on the monitoring dimension. The core terms and concepts identified by the thematic cluster are taken as a framework for the review. In each field the introduction of the theory itself is followed by the available indicators related to that specific concept and waste prevention at the same time.

2.2 The concept and measurement of the waste hierarchy

The waste hierarchy (Figure 7) is a core element in waste management. It has cca 40 years of history in setting the priority of reduction, recycling, and reuse over disposal. The first practical appearance of the concept is linked to 3M company in the US which, promoted reduction, reuse and recycling over disposal, and later it was proposed by a Dutch politician and scientist, Ad Lansink to the Dutch Parliament (Pires et al., 2019).

The so-called Lansink Ladder (van Dijk et al., 2014) has formed the basis of the concept of waste hierarchy (or pyramid) (Figure 7) developed by ranking various waste management tools based on the environmental burden caused by them (Hansen et al., 2002), and is an absolute basic paradigm in waste management to understand for proceeding with waste prevention. For this reason, the concept is presented at the very beginning of the thesis.

7. Figure – The waste hierarchy

Source: European Commission, 2018

This concept sets the environmental scientific background for policy priorities (Hultman et al., 2012), i.e., shifting waste management from landfilling and waste incineration (and recovery) towards recycling, reuse and most importantly waste prevention became targets in global, national and local environmental policies. Prevention puts least stress on environment (Csepregi et al., 2013). Waste prevention is about redesigning products and production (Loiseau et al., 2016), and about achieving a structural social change moving away from consumerism, towards a sustainable consumption based

on needs, excluding overconsumption, and considering the scarcity of natural resources. Loiseau et al. state that waste hierarchy may imply weak sustainability in environmental economics supposing the natural capital can be substituted by human made capital. It is true for the recycling, the reuse, the repair and the recovery cited in the article, ignoring waste prevention, but in fact prevention is the step of the hierarchy where strong sustainability appears. Prevention should be done for reducing the use of natural capital which cannot be substituted but is finite.

The evolution of the initial framework 3R – recycle, reuse, and recover – is promising. The latest finetuning has performed the 7Rs (Jestratijevic et al., 2022) as below (Table 1).

Table 1 - The 7Rs sustainable packaging framework

Definition	*Solution*
Rethink	Rethinking packaging design and proposing new circular solutions.
Refuse	Refusal to overpack products, and/or refusal to use single use plastic packaging.
Reuse	Use of packaging materials more than once in their original form.
Reduce	Reducing packaging weight or size or reducing the quantity of materials.
Repurpose	Packaging in its original or changed form having an alternative purpose.
Recycle	Mechanically or chemically converting packaging waste into new materials.
Rot	Composting bio-based packaging after use.

Source: Jestratijevic et al., 2022, p 336

'Rethink' addresses the production side, 'refuse' the consumption side. 'Reuse' – particularly – if it remains in product status is also prevention, the 'reduction' of material use is clearly about resource saving. 'Repurpose' makes the lifecycle of packaging longer. Only 'recycling' and 'rot' are lower in the waste hierarchy, all others belong to prevention activities. Refurbishment, remanufacturing and ultimately regift are also seen to be associated with the waste prevention.

An interesting initiative (Pires et al., 2019) attempted to develop a specific indicator that demonstrates this shift. The Waste Hierarchy Index (WHI) considers preparation for reuse, recycling as positive contributors to circular economy, while incineration and landfill are taken into account as negative performance. The authors' aim was to develop a detailed formula where up- and downcycling, composting and anaerobic digestion, biological treatment of mixed/residual waste, as well as incineration with energy recovery were also included, but the lack of data made them redesign the formula simplifying variables as follows:

$$WHI = \left[\frac{\left(1x(Preparing\ for\ reuse + Recycling + Composting\&Digestion)\right) + (-1x(Incineration + Landfill))}{Total\ waste\ treated}\right] x100$$

Preparing for reuse, recycling, composting, and digestion are positive contributors to the circular economy, while forms of disposal – incineration and landfilling – have a negative co-efficient as they divert the economy from reducing waste. Even though, Pires et al. (2019) draws attention on the concept of waste hierarchy, the top priority to prevent waste is dismissed from the above formula for

keeping the balance between the numerator and denominator, i.e., prevention is not part of the waste generated or treated and measurement – proposing further research in the waste prevention concepts.

2.3 The concept of waste prevention and monitoring

According to the WFD article 3 paragraph 12 "Prevention means measures taken before a substance, material or product has become waste, that reduce:

(a) the quantity of waste, including through the reuse of products or the extension of the life span of products;

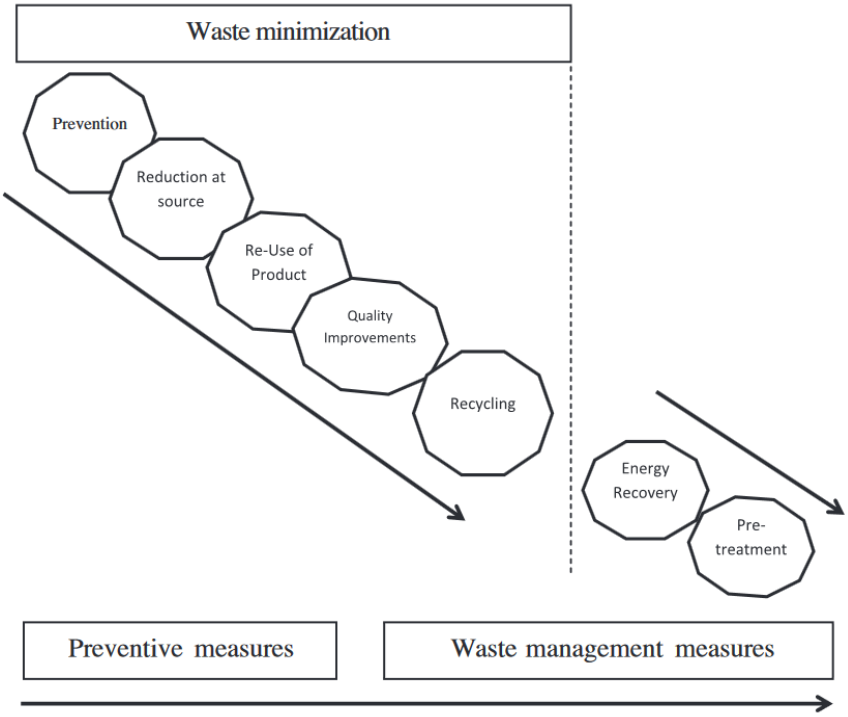
(b) the adverse impacts of the generated waste on the environment and human health; or

(c) the content of harmful substances in materials and products;"

Methods of waste prevention (Bartus, 2010) may be production technology development, eco-design of products, increasing the period in use of products, and the shift of consumer expectations. The main characteristics of waste prevention are the heterogeneity of activities relative to other waste management methods, the feature that the amount of waste prevented that can only be measured indirectly (Sharp et al., 2010), and that the transaction cost of indicators development may be high.

Confusing in the definition are the boundaries of waste reduction as waste minimisation and waste prevention are also used as synonyms, even though there is substantial difference between them. The interpretation of countries of the term waste minimisation occurred in the 1990s under the auspices of OECD. According to their research (OECD, 1998) waste minimisation included reduction of waste quantities, reducing the hazard, and increasing reuse, recycling, and recovery rates. Energy recovery was the most controversial issue during the discussions, as some countries refused to include that in minimisation. Contrary to waste minimisation prevention strictly deals with actions preceding the so called 'waste status' of products, it is about production and consumption, it strictly means reduction of waste and hazard whereas minimisation also includes preparation for reuse (the situation when an item becomes waste, but following repair, exits waste status again) and recycling (Zorpas et al., 2013) as seen above. Recycling reduces waste in terms of diverting waste from landfilling and incineration, but does not make part of prevention, as it covers operation related to the waste status of products, meaning it is practically part of waste management; in this sense it is an end-of-pipe management method (Figure 8).

Figure 8 - Waste prevention and minimization



Source: Zorpas et al., 2013., p 1049

Reuse may either be associated with waste prevention – until the reused item does not enter waste status –, or may form part of the second step of the waste hierarchy named 'preparation for reuse'. This means that the item first becomes waste, and following repair, refurbishing, etc. it re-enters the product status. This case is not prevention, as waste has been generated, even if it was later sent back to the economic cycle as a product. The borderline is still fairly blurred as the same type of repair may occur when a product was simply not classified as waste by its owner. For example, the repair of an old washing machine may count as prevention, if it was simply repaired by the owner or a service, but it is part of waste management, and preparation for reuse, if the owner had dumped it to a reuse centre or a waste yard as waste and repair happened there. Another interesting issue whether such cases should only be included in the reuse statistics, if there is a change of ownership (sales or donation) or if reuse happens by the same owner. This was later agreed on the "EU-wide reporting on reuse flows" workshop series for national experts in 2022 (Eionet, 2022) mainly for practical reasons as the data availability of in-house reuse is even less certain.

Another theoretical distinction to be made is among the motivations for waste prevention. As long as waste prevention actions are cost-effective a strong incentive is present, but when it comes to either reduction of consumption or comfort, it needs sacrifice. The first could be called 'passive' prevention, as prevention comes as a type of positive externality of a financial decision (e.g. it is cheaper to take bag for shopping, than to buy a new one). The conscious rationalisation or reduction of consumption really needs action, change in attitude, so this may be called the 'active' form of

waste prevention (e.g. buying from short supply chains to avoid packaging waste and environmental burden of transportation even if that cost more, or it costs the same, but you have to pick it up every week at a given appointment). A shift in production and consumption patterns that leads to reduction of volume – referred to as strong sustainable consumption program (Corvellec, 2016) –, sometimes includes investment of additional financial sources (e.g. greening technologies) having slow return, or no direct return except for eliminating – usually non-monetised – externalities. Lilja (2009) sets this discourse as follows: waste prevention equals resource efficiency, plus moderation of consumption and prevention of hazardousness. Resource efficiency is mainly about cost-effectiveness, while consumption moderation needs action with special pro environment commitment.

O Zacho has categorised the publications on waste prevention measurement as follows (O Zacho et al., 2016): the first category 'Potential' refers to the reduction potential of waste streams, the social and economic potential of reuse, the environmental impact of waste prevention (Gentil et al., 2011). Publications have set up models for calculating how much waste could be saved by prevention actions, like the research showing highest potential for food waste (Cox et al., 2010) and another publication on the potential of paper waste (Salhofer et al., 2008).

The second category was "Social and behavioural aspects", followed by "Monitoring and measuring" and "Planning, management and policy". Social approach was leader in the number of articles. As of households there is a consensus, that motivators for prevention and recycling are clearly different (Barr, 2007). Prevention activity is linked to inner drivers, values and beliefs, and environmental concerns, while recycling is rather normative, motivated by social pressure (Bortoleto et al., 2012, Cox et al., 2012, Barr, 2007). Planning, management, and policy was second in the number of publications, the concept category of potential calculations ended up at the third place and the least discussed concept was monitoring and evaluation. Based on Brook Lyndhurst (2009) and Zorpas et al. (2013) the main behaviour domains for households in waste prevention were junk mail, reuse, sharing, smart shopping and purchasing choices (e.g., avoiding overconsumption, single life products, buying loose/bulk, food waste prevention, home composting, repair, and others (e.g., avoiding hazardous waste). Barriers to waste prevention – according to Barr (2007) – is not only consumerism, but the habits, and the lack of tools and knowledge. Continuing with reuse, that is mainly driven by social concerns (donations) and saving (bargain).

Waste prevention is closely linked with the concept of closing, slowing, and shrinking the circular loop, by business models founded on common and long-lasting use, like sharing or leasing economy, performance economy, product service system. Collaborative consumption models are part of circular economy, and deemed to be one of the best choices for the shift on the consumption side

(Ghisellini et al., 2014). The common concept of the above models is that they are oriented towards higher service content, and by changing the ownership structures they increase producer responsibility (Fischer et al., 2015) for example, by optimizing the product lifetime, or becoming interested in repair. A research on product service system model in electrical and electronic equipment was carried out evaluating its material use and waste generation reduction potential (Tasaki et al., 2006). Three cases were examined – a no-reuse/no-lease, a reuse (second-hand possession) and a lease system based on the annual product demand (APD).

$$APD = \frac{N}{L}$$

N = the number of product use,

L = lifetime of product in use.

The higher the ADP, higher is the material use. The research found that a lease system could use more materials in case of oversupply, because if that happens, a certain amount of product shall be discarded as waste. To reduce the material use of the lease system to the reuse system's level either the number of leased products should be reduced, or the lifetime of leased products should be extended to that of the firstly owned products or the lease system should increase the number of reused products in use. A key factor in determining the material use of a system is whether it extends or shortens the lifetime of a product, not the type of the system.

When it comes to monitoring, the domains should be precisely covered. Salhofer et al. (2008) give a detailed list on criteria and classification that could serve as the basis for monitoring (Table 2).

Table 2 - Classification of waste prevention activities

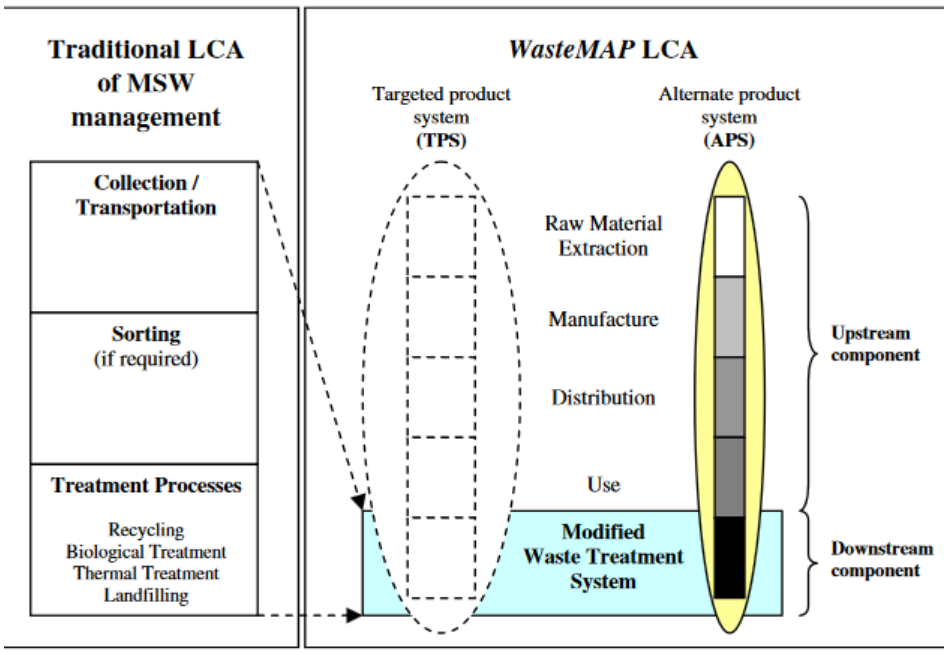
Criteria	**Classification**
Wastestream	• By material (paper, hazardous waste...) • By product (packaging, diapers…) • By source of generation (household, industry...) • By field of application (big events, procurement....)
Target group	• Private households • Retail (commerce and service) • Industry • Public administration
Instruments	• Regulatory instruments (licencing, laws, product standards...) • Economic instruments (subsidies, incentive taxes, charges...) • Collaborative agreements (public-private agreements, certifications, and labels...) • Service and infrastructure (repairing, second-hand shops…) • Communication and diffusion (presenting information, persuading about options…)
Purpose	• Reduction at source (complete avoidance, reduction by optimisation of processes....) • Substitution (one-way by refillable packaging, by a less hazardous material...) • Reuse (extension of product use-phase, increased use of a product by sharing…)

Source: Salhofer et al., 2008, p 247

The monitoring and measuring has the least extensive literature, being one of the great challenges of waste prevention to be prioritised (O Zacho et al., 2016). Measurement of changes in environmental pressure as a result of waste prevention was carried out in high-tech and low-tech waste management scenarios. High-tech meaning energy recovery capacities, and high-quality recycling technologies, while low-tech scenario is dominated by landfilling (Gentil et al., 2011). It basically concluded that avoiding production, alias waste prevention is more beneficial – causing less environmental burden – in low-tech environment. The most effectively avoidable waste stream is food waste.

Once environmental burden of waste prevention is an issue, it may be obvious to address life cycle assessment (LCA) methods. The core problem with LCA when calculating for waste management is that prevention is usually not included in the analysis. LCA models that calculate the environmental burdens per kg or tonne of waste generated are inadequate for waste prevention (Ekvall et al., 2007). If changing the functional unit from waste to waste prevented, calculations may be possible, but the complexity makes the evaluation more expensive. The lack of basic data behind LCA, and the relativity of the outcome depending on the setting of system boundaries causes difficulties in its application probably as the question "can one manage waste that has not been generated?" cannot be replied. However, the waste prevention is not a management process applied to absent waste, that is the consequence of waste prevention (Cleary, 2010). Cleary has identified 8 types of waste prevention activities (WPAs) which were considered: the first category was material consumption reduction without substitution (e.g. no 'junk mail'), the dematerialisation is when a substitution takes effect (e.g. textile bag instead plastic) and the third group of actions included waste prevention at collection (e.g. backyard composting). The alternate product system (APS) corresponds to the above-mentioned case of substitution (e.g. textile bag), while the targeted product system (TPS) is the original one (plastic bag). The system boundaries of the LCA (Figure 9) should be set up by including the waste potentially generated throughout the entire life cycle of the textile bag, including the upstream phase (raw material extraction, manufacturing, distribution and use) and the downstream phase as well (waste treatment). In case of the targeted product system (e.g. plastic bag), the waste avoided should be included in the system of analysis.

Figure 9 - The system boundary of waste prevention in LCA



Source: Cleary, 2010, p 584

The calculation is as follows for net residential waste generation (RNET):

$$RNET = (\sum_{WPA-1}^{n} RAPS_{WPA} - \sum_{WPA-1}^{n} RTPS_{WPA})$$

where RAPS is the residential waste generation potentially added to municipal waste treatment due to the waste prevention action, and RTPS is the residential waste subtracted from municipal waste treatment due to its avoidance. RNET < 0, if WPA (waste prevention action) takes place. To calculate a particular environmental emission (WMP) of this substitution:

$$WMP = REF - \sum_{WPA-1}^{n} TPS_{WPA} + \sum_{WPA-1}^{n} APS_{WPA}$$

where REF stands for the reference waste management scenario without any waste prevention action. The emission from the waste treatment related to the targeted product systems is deduced, while the emission from the introduction of an alternate product is added to the equation. WPA shall be deemed effective, if the overall contamination remains less than in case of the original scenario.

If the net change of emission of the remaining municipal waste (NETDOWN, see below) is not significant, then the above equation and the typical LCA for municipal waste could be applied.

$$NETDOWN = DOWN - (REF - \sum_{WPA-1}^{n} DownTPS_{WPA} + \sum_{WPA-1}^{n} DownAPS_{WPA})$$

DOWN is a typical traditional municipal waste LCA, DownTPS and DownAPS respectively represent the emissions of the downstream of the targeted removal and the alternate product. If NETDOWN is significant, meaning that there is a significant impact on the change in emissions due to waste management, then the following applies

$$WMP = DOWN - \sum_{WPA-1}^{n} DownTPS_{WPA} + \sum_{WPA-1}^{n} DownAPS_{WPA}$$

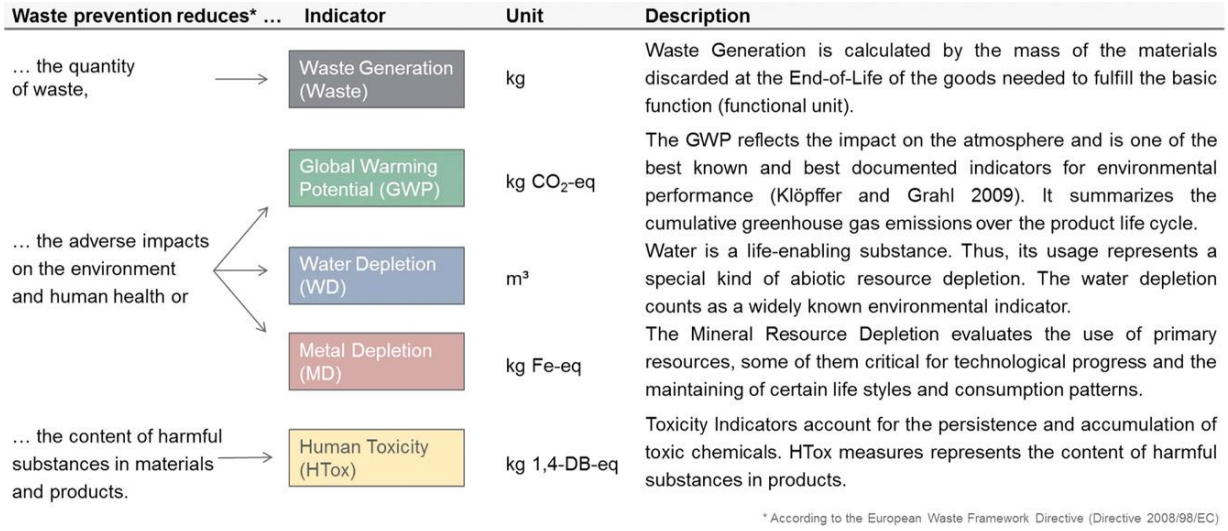
If the waste prevention action has substantial effect on the emission of the remaining municipal waste, then the upstream-related emissions should also be observed.

$$WMP = DOWN - REF - \sum_{WPA-1}^{n} UpTPS_{WPA} + \sum_{WPA-1}^{n} UpAPS_{WPA}$$

This allocates the upstream emission effects and the effect on the emission of the municipal waste management that was not subject to the waste prevention action. Cleary has run LCA on waste prevention actions (Cleary, 2014) including reducing advertising mail, reuse of disposable bags, substitution of online newspaper articles for printed one, refillable wine/spirit packaging for single use bottles, lightweight glass and PET bottles and cartons for conventional containers. In all cases the analysis concluded that waste prevention actions do reduce the environmental emission. Cleary's model is one of the most thoroughly compiled and tested concepts proving that waste prevention should have a place in life cycle analysis.

Another research focusing on the environmental effects of waste prevention actions is also based on LCA (Hutner et al., 2018). It examined five selected municipal level actions: equipment for electronic workstations within the public administration, provision of drinking water in offices and public buildings, the use of refillables for events, the implementation of specific e-government applications and the configuration of lighting systems. Within the LCA framework the indicators – i.e. the waste reduction potentials of actions – calculated for each were the following (Figure 10):

Figure 10 - The environmental impact of waste prevention actions



Waste prevention reduces* …	Indicator	Unit	Description
… the quantity of waste,	Waste Generation (Waste)	kg	Waste Generation is calculated by the mass of the materials discarded at the End-of-Life of the goods needed to fulfill the basic function (functional unit).
… the adverse impacts on the environment and human health or	Global Warming Potential (GWP)	kg CO_2-eq	The GWP reflects the impact on the atmosphere and is one of the best known and best documented indicators for environmental performance (Klöpffer and Grahl 2009). It summarizes the cumulative greenhouse gas emissions over the product life cycle.
	Water Depletion (WD)	m^3	Water is a life-enabling substance. Thus, its usage represents a special kind of abiotic resource depletion. The water depletion counts as a widely known environmental indicator.
	Metal Depletion (MD)	kg Fe-eq	The Mineral Resource Depletion evaluates the use of primary resources, some of them critical for technological progress and the maintaining of certain life styles and consumption patterns.
… the content of harmful substances in materials and products.	Human Toxicity (HTox)	kg 1,4-DB-eq	Toxicity Indicators account for the persistence and accumulation of toxic chemicals. HTox measures represents the content of harmful substances in products.

* According to the European Waste Framework Directive (Directive 2008/98/EC)

Source: Hutner et al., 2018, p 1056

Considering the entire lifespan of products is crucial monitoring of waste prevention, as seen above. In a smart city context this means that 3 elements should be connected (Esmaeilian et al. 2018).

- Collection of product life cycle data,
- New business models based on product life cycle data,
- City infrastructure, intelligent and connected devices.

To promote waste reduction the type of data to be collected in the phases of the product life cycle are:

- Beginning of life: design specifications (materials, parts, components), production information provided by the producer
- Middle of life: product status, condition of use (e.g. distribution, aftersales services) provided by the retailer and citizens
- End of life: retirement condition, reuse and recycling value provided by cities/waste management companies and by citizens.

Esmaelian et al. draws attention of IoT (internet-of-things) and mobile device applications when it comes to data collection. The data collection process is an ideal, if not utopistic model, however, this may serve as a standard to be once reached.

Calculating waste prevention potentials could also be interesting not only as a concept category, but as a monitoring tool. It is particularly useful in production but may also be applied for waste streams. Salhofer et al. (2008) have conducted case studies on selected wastes – advertising material, beverage packaging, diapers, food waste and waste from events. Waste prevention measures applied resulted in cca 10% prevention potential in case of advertising material and beverage packaging, and

1-3% in municipal solid waste. Cox et al. (2010) have also put forward a list of prevention potential of UK campaigns revealing that the greatest diversions may be achieved in food waste, home composting and bulky waste.

Monitoring from the consumption side relates to waste prevention intervention and should be made prior to and after the intervention. Methods may include self-weighing of waste in households, pre- and post-intervention surveys focusing on attitudes and behaviours and participation rates, tracking waste via collection data and/or composition analysis, and finally, estimation/modelling (Cox et al., 2010). Tackling monitoring from the consumption/waste side is more precise, detailed, and gives valuable inputs to the local governments' level.

The question "What do we measure?" answered by Table 2 is followed by "How?". One extensive research on waste prevention measurement and evaluation methods was carried out by (Zorpas et al., 2013) – presented below – in the framework of the UK DEFRA Waste and Resources Evidence Programme (WREP) launched in 2003. The extensive program aimed at measuring the effectiveness of local government campaigns. The most successful campaigns based on the evaluation (Read et al., 2009) were mail preference registrations to reduce junk mail, home composting and door-stepping. Indicators were alternatively determined: according to the Waste Watch Report cited outcome indicators and output indicators were distinguished: outcome referring to the final impact of a waste prevention measure, e.g., behavioural change, while output meant the performance of project deliverables (e.g., number of registrations on the so-called Robinson lists to avoid junk mail). Another interpretation of indicators were inputs (e.g., number of leaflets distributed), outcomes (e.g., the increase in the number of citizens becoming aware of the issue), and impacts (e.g., the number of participants in a campaign or scheme).

The methods for measuring waste prevention were the following:

- Self-weighing, monitoring, or reporting. Cc. 50-60 households engaged in monitoring their own waste. The evaluation was based on short-term campaigns (1 week – 4 month) to long-term campaigns (2-3 years). This was combined with surveys, interviews and focus groups.
- Use of the collection round data. Mixed monitoring methods were applied as the waste tonnage/collection was measured and additional surveys were run to evaluate the impact of the campaign. Given the different geographical coverage of the local government's authority and the collection routes, this data did not give adequately detailed data.
- Control and pilot groups. This was for comparison of areas intervened and those where intervention did not occur. No changes were allowed in services during the monitoring, and a particular focus had to be given on making the samples and collection areas match.

- Attitude and behaviour surveys. Baseline and post-campaign evaluations were made. Diaries were completed by households to understand behaviours, and focus groups helped in identifying the motivation and opinions on the campaign. The large number of variables make it impossible to distinguish the factors leading to waste prevention. There are attitudinal (values, beliefs, norms), and contextual (non-internal factors and constraints) variables, personal capabilities (behaviour-specific knowledge and skills), habits, routines to be considered.
- Participation surveys. Monitoring focuses on outputs like the number of responses, the distributed incentives, and reach rates of campaigns.
- Participation monitoring. This measures impact of campaigns (e.g., home compost bins distributed; number of people contacted by the doorstep team).
- Compositional analysis. Measuring the distribution of waste streams in household waste. Best method is to monitor at the gate of disposal site (IPPC).
- Conversion factors, estimates and modelling. Combining available data with proxy indicators or coefficients.
- Hybrid. Mixed monitoring techniques, combining the above.
- Point of sales (POS) data. Generated when scanning products by retailers. Waste data calculations based on sales.

Figure 11 shows advantages and disadvantages of evaluation methods.

Table 3 - Advantages and disadvantages of the monitoring and evaluation approaches

Advantages and disadvantages of the monitoring and evaluation approaches.

Methodology	Advantages (strengths)	Disadvantages (weaknesses)
Self-weighing, monitoring or reporting	Observable, direct and provide measurable quantitative data on reduction	Inconsistent data can be derived due to different start and stop times, new entrants, incomplete diaries, and lack of buy-in from participants for weighing waste translate measurements
	Locates the participants in touch with their waste – visibility impact	Conversion factors are needed to
	Provides motivational feedback to participants	High drop-out rates are experienced as project progresses
	Observational monitoring can provide alternative to weighing	There are risks of self-selecting samples
		Sample sizes can be too small to be statistically accepted
Use of collection round data to accurately measure waste increase	Allows accurate quantity and comparison of changes in waste increase	Can only be used to monitor waste increase in a specific geographical location
Control and pilot groups	Can provide sufficient timeframe and planning for a number of different evaluations to take place	Detailed and careful planning is needed to ensure similar populations/collection systems
	Large sample sizes can provide representative populations which are likely to be more statistically robust	Quality and detailed waste collection data is essential but challenging to derive
	Can help to reduce bias as target groups are pre-selected	This approach cannot be used if communities are not geographically defined
Attitude and behaviour surveys including metrics, interviews and focus groups (outcome focused)	Provides a baseline for monitoring change	Small sample sizes or low respondent rates can be insufficient to be representative or robust
	Provides both quantitative and qualitative data and information for evaluation	Requires careful survey design to provide comparative analysis with waste data
	Provides valuable input to design a campaign	Using a Citizen Panel can bias the sample
	Allows for large-scale surveys to be conducted	Self-completion surveys can give potential for bias
	Focus groups can provide insight into attitudes and behaviours which can be relatively easy to organise and are cost effective	Focus groups are not suitable for collecting weight data
P.O.S (Point of Sales Data)	POS data to estimate the reduction of specific product wastes and explore the applicability of using the methodology for waste prevention	Providing us with detailed sales data by product
Hybrid – a combination of any or more of the above approaches	Provides the context for built- in pre and post surveys with interim self-weighing or observation reporting	Can be complex and resource intensive evaluation of data monitoring, surveys and self-weighing/observation needs to be integrated which requires careful planning at the outset which can be daunting for small-scale projects
	Enables mixed approaches to be used in both short and long-term monitoring and evaluations	
	The results from one method can be used as a check on another (e.g. focus groups acting as check on survey data)	

Source: Zorpas et al., 2013, p 1053

Timeframe is critical for measuring outcome. Zero waste relies strongly on consumer habits, changing them requires longer time. The impact of awareness raising, or introduction of a new community action may not appear prompt, reaching the mass effect needs more years (Vancini, 2000). This should be born in mind in case of comparative analyses also. The choice of baseline data is also critical in tracking performance.

Research of UK Waste Resources and Evidence Programme (WREP) faced additional problems in measuring household waste prevention: one cannot know, if prevention has happened, even if it has happened. Furthermore, following the identification of an action as preventive, it remains unknown whether it was accidental or maintained.

Another methodology was tested on Kyoto city for measuring prevention actions (Matsuda et al., 2018). Three options were compared. First indicators described the relative change of waste according to a baseline year. Matsuda et al. point out the significance of baseline choice which can distort the outcome. Matsuda uses the following equation for calculating it for every waste stream appearing in the compositional analysis:

$$Mprv_i i(t) = Mw_i(t_0) - MW_i(t)$$

Mprv: mass prevented waste (ton/year)

Mw: mass of generated waste (ton/year)

t: year

t_0: baseline year

i: type of waste.

The second method was to calculate the absolute change of potential waste generation. The current waste data is compared to the amount of waste that would have been generated in case waste prevention action did not take place. Data on waste generation by waste streams is necessary, and a survey provides data on the level of waste prevention activities. It is however, not clarified in the article how to cope with the problem of simultaneously having to measure two scenarios (with and without waste prevention activity): this means that the waste generation level (from national statistics as mentioned) shall be anyway affected by the activity. Potential waste generated must derive from projection or estimation based earlier years.

$$Mprv_i(t) = Mpot_i - Mw_i(t)$$

$$Mprv_i(t) = Mpot_i(t) x AL_i(t) x Pmax_i$$

Mpot: mass of potential waste generation (ton/year)

AL: activity level (%)

Pmax: preventability (%) - maximum percentage of waste prevention when activity level is 100%.

The third method was measuring the absolute amount of waste prevented by activities, relying solely on survey data. In this way, the frequency of waste prevention activities per household is

$$Mprv_i(t) = Nprv_i(t) x U_i x HHD(t)$$

Nprv: number of waste prevention activities (times/HHD day $^{-1}$)

U: mass of prevented waste per activity (ton/time)

HHD: number of households in Kyoto city.

The methodologies of Matsuda et al. (2018) rely strongly on surveys, which incur high level of data uncertainty, or if carried out at large scale and with representativity seems to be costly.

The EU (EC DG ENV, 2009) and the OECD (OECD, 2004) have both published indicator proposals for waste prevention although these are rather proxy indicators due to the lack of direct data. Yano et al. (2016) have collected these proposed indicators (Table 4) and completed them with a list recommended by the Nordic Council (Watson et al., 2013), and by the Japanese set of indicators. Only general indicators are cited in the text, but the entire list can be found in Annex II.

Table 4 - Indicators of waste prevention

References	Indicators	Unit
OECD	**Direct pressure indicators**	
	Generation of waste type I	
	I: municipal waste (MSW), C&D waste, non-hazardous industrial waste	tons/year
	MSW generation/population	tons/cap./year
	MSW generation/private final consumption for MSW and its components	tons/value/year
	Generation of waste type I/gross domestic products	tons/GDP/year
	I: C&D waste, non-hazardous industrial waste	
	Direct response indicators	
	For short-to-medium-term purposes;	
	Number of companies with a certified environmental management system (EMS)	company/cap., company/GDP
	Consumption of virgin material and recycling of the material for selected materials (e.g., glass, paper, and metals)	tons/year
	''No thanks'' -stickers hand out (percentage of total households) %	
	For long-term purposes;	
	Existence of a national waste prevention plan or strategy	yes or no
	Number of products and/or product groups targeted by extended producer responsibility	products
	nationally or regionally	
	Number of households with variable-rate pricing households	%
	Material flow accounting-based indirect pressure and response indicators	
	Hidden flow index (domestic hidden flows/total material input)	tons
	Waste disposal index (waste disposed of/net additions to stock)	tons
	Manure utilization index (dissipative use of manure/total generation of manure)	tons

Source: Yano et al., 2016, p 41-43

The high number of relative indicators may give a more accurate picture. Both the EU and the OECD applied the Pressure-State-Response model later discussed. The proposal of the Nordic Council is for four waste streams: food, construction and demolition waste, WEEE and textile waste. Again, the amount of waste generated is related to the population size, or the GDP. Other indicators go into details, and in fact would really give an in-depth picture on how prevention is performing, but they lack data. At least regarding EU Member States reporting obligations, those do not form part of national statistics. The generation data combined with indicators going into details of prevention could be useful. Waste generation and treatment data also appear among Japanese indicators and are

completed by resource productivity and some other soft indicators without targets on citizens' awareness and engagement.

Focusing on production and value chain there is a wider literature, only one study is mentioned here having a holistic approach, stating that the problem of not integrating upstream resource consumption, or not paying attention to potential side-effects of substitution for shifting to light-weight (e.g. from metal to aluminium), and the resource consumption related to imported goods carries severe risks in miscalculating effects (Wilts et al., 2019) The research suggests volume of waste related to specific product groups as general indicators. These groups fall under the EPR scheme (large and small household appliances, IT and telecommunication equipment, toys, leisures and sports eqjuipment, electrical and electronic tools, food waste and motor vehicles) for which Eurostat regularly publishes data. Specific indicators could address the barriers to waste prevention within the above mentioned product groups. Indicators on ecodesign, reselling, repair and sharing/leasing models go give insight on the obstacles.

Following the literature review an important document was published by the European Environmental Agency in 2023, which gives proposal on waste prevention monitoring by a list of selected indicators. Due et al. (2023) have founded the narrative-based analysis on the national prevention programmes of EU Member States, and the RACER model. In each case the authors evaluated available indicators based on their Relevance, Acceptance, Credibility, Ease and Robustness: relevance to waste prevention, acceptance by stakeholders, credibility meaning confidence in the indicator, easy to communicate the numbers (easily understood), and robustness of data quality. The researchers have formed 3 clusters: "the System context" including the drivers, the "Policy enabler" indicators that closely record the policy performance operating with output indicators, and "Waste output" indicators relating to waste production, the hierarchy and the environmental impact (Table 5).

Table 5 - Indicators of total waste prevention

Cluster 1: System context	Cluster 2: Policy enablers	Cluster 3: Waste output
1. **Population** (average population — total) 2. **GDP** (main GDP aggregates per capita, chain-linked volumes) 3. **Household final consumption expenditure** (final consumption expenditure of households by consumption purpose (COICOP 3 digit), chain-linked volumes) 4. **RMC** (material flow accounts in raw material equivalents and	1. **Presence of each type of measure** in WFD Article 9, categorised by policy instrument type (number of Member States of all 27 Member States) 2. **Presence of targets** categorised by policy instrument (number of Member States of all 27 Member States) 3. **Presence of indicators** categorised by policy instrument (number of Member States of all 27 Member States)	1. **Total waste** (excluding major mineral waste) generation (tonne per year, in total and per capita) 2. **Waste intensity** of net waste volume (without major mineral waste) (per GDP unit, kg per thousand euros per year) 3. **Municipal waste generation** (kg per capita per year) 4. **Residual municipal waste** (kg per capita and per cent of waste generated)

by final uses of products — modelling estimates) 5. **Value added from reuse, repair and recycling** (gross value added related to circular economy sectors, value added at factor cost (aggregated indicator as available on Eurostat)) 6. **Turnover in repair sectors** (annual detailed enterprise statistics for repair services).	4. **Development and evaluation of waste prevention programmes over time** 5. **For a specific waste stream**: • Presence of each type of **measure** in WFD Article 9, categorised by policy instrument type (number of Member States of all 27 Member States) • Presence of **targets** categorised by policy instrument (number of Member States of all 27 Member States) • Presence of **indicators** categorised by policy instrument (number of Member States of all 27 Member States)	5. **Weight of reuse** (kg per capita, in total and per product category) 6. **GHG emissions from waste management** (GHG emissions by source sector for selected waste management categories) 7. **Substances of very high concern** in products placed on the market 8. **Food waste** (kg per capita) ***Notes:*** *COICOP, Classification of Individual Consumption by Purpose; GHG, greenhouse gas; RMC, raw material consumption*

Source: Due et al., 2023 p 9

The above indicator set seems rather comprehensive including population data, the raw material, the consumption and the waste phase as well, in the policy evaluation, but it focuses on total waste (excluding mineral wastes), so it may require slight modifications when the scope is municipal waste. On the other hand, it includes recycling data, which although informative, but in our case is not strict enough.

Based on the literature very few waste prevention indicators exist and are either limited in their use or are proxies substituting the real measurement. In the latter case, indicators usually rely on available waste statistics (Wilts, 2012, Vancini, 2000). To date, there is no general method to monitor and evaluate the effects of waste prevention measures (O Zacho et al., 2016).

2.4 Material use and waste prevention monitoring

The material use approach is centred around the input side of the economy grasping the very beginning of the life cycle of production and consumption, with the attempt to optimize resource use or achieve resource savings – in line with the aim of waste prevention. The origins go back to the Limits to Growth (Meadows et al., 1972) stating that economic growth is a threat to environment. This was attempted to be described by the Environmental Kuznets Curve (EKC) which supposes an inverted U function between the income and the quality of environment suggesting that following an initial accumulation period of income with intense emissions to the environment, the further growth of an economy shall decreasingly put pressure on the environment. This was criticized by several authors (Stern et al. 1996, Cleveland et al. 1999). Just a few contradictions were that international trade relations, the specific structures of the economies were not taken into account, however research on EKC has revived recently.

Dematerialisation refers to the absolute or relative reduction in the quantity of materials used by an economy and/or the quantity of waste generated in the production of a unit of economic output (Cleveland et al., 1999). Decoupling depicts the same phenomena assessed as absolute, if the Domestic Material Consumption (DMC) decreases in absolute terms, or relative, if the growth of economy (in GDP) overcomes the growth rate of material consumption (Domenech et al., 2017). Dematerialisation is criticised stating that it would only be possible in a non-growth driven economy fully internalizing the costs of both production and consumption. But this would make the commodities so expensive that markets would collapse, and in the current sustainability scheme economic growth is also a prioritised goal (Fletcher et al., 2017).

Going backwards from the end of the product life cycle, the waste hierarchy is a supporting concept for dematerialisation, but was originated in the desire to divert waste from landfills taking up too much space, causing health and environmental risks. The waste hierarchy does not state that the loop should be closed, meaning that no waste should be generated, but it aims at reducing material use by increasing resource efficiency, and by circulating material in the economy. By prioritising recycling, reuse and recovery it does not close the loop. Prevention is the only step oriented towards the reduction of material input and waste output, in this sense, leniency towards lower options of the waste hierarchy and the lack of incentives for prevention remain limitations for absolute reduction of material use (Van Ewijk et al., 2016). The authors propose to integrate reuse into collection schemes of waste management, price the waste collection according to the environmental impact of the treatment method and to support shift with taxation.

The most frequently used indicator for material use, resource productivity was a reaction given to the Clube of Rome report: The Limits to Growth. The 1997 Club of Rome Report (Von Weizsäcker et al., 1997) stated that albeit there are limits, the efficiency may be increased through productivity. The term resource efficiency has become widely used following the political commitment of the EU towards it as a goal (EC, 2011c), and forms the basis of the circular economy. Typical indicators are developed from domestic material consumption: resource productivity (GDP/DMC) or resource intensity (DMC/GDP). Between 2000 and 2021 the resource productivity grew by 35% in the EU, with absolute decrease of domestic material consumption, and steady increase of municipal waste, while the environmental pressure caused by the production of the imported goods not taken into account could also be highly misleading.

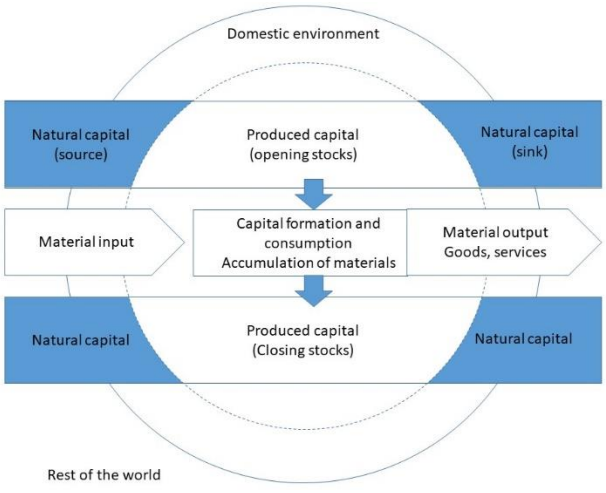
The MFA (Material Flow Accounts) is based on the thermodynamic laws of conservation of energy and matter and is applied to countries or economic regions. Today it is the state-of-the-art indicator system and accounting method for material throughput. As of the theoretical background, it relies on the input-output model of Leontief being complemented by environmental elements by

himself (Leontief, 1970). Leontief has described the input-output model as a matrix that depicts interdependencies between nations and regions, later between sectors of the economy. The matrix included the production where not only input appeared and final consumption as the output, but the intermediate consumption also – output of one sector becoming input of another. In addition, pollutants were integrated in the input side (sectors on the use side of inputs and being suppliers for other sectors and households) and anti-pollutants at the output or demand side in physical units.

The other root of MFA goes back until 1992 when F. Schmidt-Bleek has developed the concept of material intensity per unit service (MIPS) to measure eco-efficiency of infrastructures, goods, and services. The idea is to project the total material input on the number of services (e.g., in case of a car, the material input should be divided by the kms run). Manufacturing, transport, packaging, operating, reuse, recycling, and remanufacturing are accounted for and so is the final waste disposal. It is usually split up into five categories of materials: biotic, abiotic, earth movements, water, and air (Hinterberger et al., 1999).

MFA is integrated in standardised statistics in the European Union, later discussed, and is also part of the System of Integrated Environmental and Economic Accounting (SEEA). SEEA includes a growing number of environmental accounts which have the same logic as the System of National Accounts (SNA) including supply and use tables, but are usually in natural units, and are interpretable independently from SNA. These are called satellite accounts. The methodology for monetary accounting is under development, and there is a reporting obligation of Member States towards the EU for 6 environmental accounts including MFA. The SEEA shows the overall environmental pressure caused by the economy. The following model gives a view on how MFA and the SEEA relate to each other (Bartelmus, 2003) (Figure 11).

Figure 11 - The link between SEEA and MFA



Source: Bartelmus, Wuppertal, 2003, p 64

The material flow in the middle of Figure 11 demonstrates the material inflow and outflow in the national economy. Outflow covers partly the products and services for consumption and partly the waste and emissions to the environment. The accumulation of materials occurs in case of durable goods or fixed assets or inventories. Horizontally there is a flow approach, whereas vertically the stock approach – with opening and closing stocks – is integrated. The stock approach is a principle in the SEEA.

Currently, available disaggregation for MFA is based on material flows only: biomass, metal ores, non-metallic minerals and fossil energy materials. There is an urging need for further breakdown to sectors of economy, and also to disaggregate the above material flows to get a more precise view. The other direction of development is about the uncertainties of material use related to imports. There is evidence that at least carbon emissions related to consumption based on imports have huge environmental effect outside the borders (Palm, 2018), and this is sure the case for latent material use of production abroad as well (e.g., waste generated by production), not being demonstrated in the economy-wide material flow accounts with reliable data. This is why the EU recently prepared first estimates for raw material consumption (RMC) including environmental burdens caused by imports. The third track for development is linking input and output data, i.e., linking MFA to waste statistics, which was first ever done by Schandl et al. (Schandl et al., 2018) for Australia, China, Germany, Japan, and the United States. This is a challenge for waste data is not standardised as MFA, waste accounts are optional also within the EU leading to discrepancies in reporting. Once the waste potential of a country derived from its material input is calculated, it can be compared to the reported statistics of waste. This comparison showed significant underreporting of waste in Australia, more moderate underreporting in Japan and the United States, while China was the most coherent in terms of material input-based waste potential and actual waste statistics. Germany showed higher waste statistics than it was derived from its material input. This linkage between material input and waste is basically about statistically closing the loop.

2.5 Zero Waste and waste prevention monitoring

The term of zero waste was first used by Palmer in the 1970s in the context of recovering chemicals (Zaman, 2015). In the 1980s the West Coast of the USA made first steps to divert waste from landfills. The term pay-as-you-throw (PAYT) was introduced in Seattle and few years later Lindhqvist has put forward the notion of extended producer responsibility (EPR). PAYT means that household pay the waste fee based on the actually generated mass of waste. This needs measurement at source and identification of the waste bin by RFID, for example. EPR is later discussed in depth, but is about producers' responsibility to look after and finance the management of waste generated by their operation, and also to find solutions throughout the product and production process

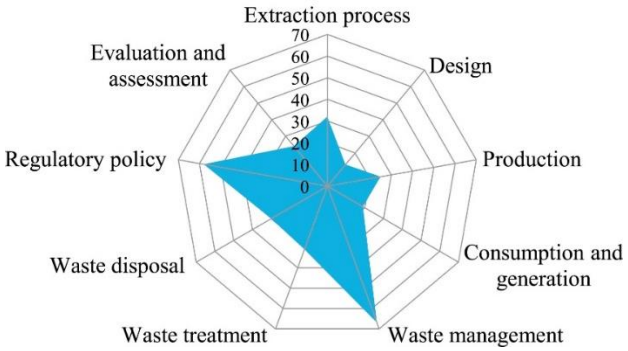
development that support waste reduction. The zero waste topic became more and more known alongside the USA and has also gained ground in Australia, and New Zealand. The first city with zero waste target was Canberra adopting a related bill in 1997. The Global Alliance for Incinerator Alternatives was founded in 2000, followed by the Zero Waste International Alliance (ZWIA) in 2002 (Connett, 2013). Hungarian member of the Alliance is Humusz Waste Prevention Alliance.

The ZWIA – as the founder of the zero waste movement – has created the peer reviewed definition: "Zero Waste is a goal that is ethical, economical, efficient and visionary, to guide people in changing their lifestyles and practices to emulate sustainable natural cycles, where all discarded materials are designed to become resources for others to use. Zero Waste means designing and managing products and processes to systematically avoid and eliminate the volume and toxicity of waste and materials, conserve and recover all resources, and not burn or bury them. Implementing Zero Waste will eliminate all discharges to land, water or air that are a threat to planetary, human, animal, or plant health" (ZWIA, 2009). However, the term is inconsistently used in the scientific literature demonstrating that the theory is still being formed, not final. Zero waste is often used as "zero waste to landfill" (O Zacho et al, 2016, Silva et al., 2016, Lilja, 2009), meaning the diversion of waste from landfills, in this form including all other steps of the waste hierarchy, like energy recovery, recycling and preparation for reuse as well. Incineration and energy recovery according to ZWIA should not form part of zero waste, nonetheless it does appear in several cases with that interpretation in the literature. In the broader sense, the aim of zero waste strategies is to minimize the overall amount of waste no matter whether it is done by prevention (slowing, shrinking loop), or by re-entering waste as secondary raw material, or by improving separate collection and recycling. The task of waste minimisation is assigned to waste management operators; however, they have limited tools to intervene in the production and consumption phase, and have no expertise on that (Wilts, 2012, Sharp et al, 2010).

The material loss indicator (Sahimaa, 2017) which was tested on 7 Finnish cities follows the logic of ZWIA, but it is practically an 'inverse' indicator: instead of focusing on prevention it measures the waste landfilled and the non-renewable and recyclable materials incinerated, i.e. the materials lost.

An interesting earlier review (Zaman, 2015) confirmed that distinction should be made according to what authors mean under the term. The distribution of relevant studies classified into categories of the zero waste process – relying on the life cycle approach – showed the priority of waste management (22%) and regulatory policy (19%) (Figure 12).

Figure 12 -The scope of zero waste studies in different phases



Source: Zaman, 2015, p 16

Zaman's guidelines based on the review defines four phases of zero waste development. Phase 1 is concentrated on extraction, product and production process design, Phase 2 is about waste avoidance during consumption by responsible purchasing choices, including collaborative consumption models. Phase 3 refers to waste reduction and minimisation during waste management, and finally, Phase 4 should provide the overall framework of the zero waste system through regulation, assessment and policies. The proportions show that zero waste is rather used as part of waste management, i.e. recycling. Publications are mainly linked to consumption and production, in other words waste prevention phases at a very low rate.

The research was continued later for identifying the key issues in the development of Zero Waste Strategy for policy makers (Zaman, 2017). The top priorities show that producer responsibility is deemed important. Data availability only ranked at the 6th place even though this should form the basis of strategy making. The consumption side developments include awareness and behaviour as well as concrete actions. Infrastructure and collection related aspects were not valued highest, which may be either because zero waste is focusing on non-waste, or because it is known that innovations in this field are slow and expensive. The key aspect for zero waste strategy is the following (Figure 13) (Zaman, 2017).

Figure 13 - Key elements of the zero waste strategy

Phases	Strategic Elements	Action Plan	Relevant policy level in Hungary*
Waste prevention and reduction	Effective public awareness programme on the waste management system should be provided by the governing body (educational institutes, city councils, etc.) through formal and informal education systems.	Inclusion of waste education programmes at the school curriculum and organize awareness promotional programmes on waste avoidance and reduction.	local (supported by national)
	Zero waste programmes (transformative knowledge) should provide proactive support strategies to motivate behaviour change towards responsible and sustainable resource consumption practices.	Hands-on training and knowledge sharing programmes (short-term and long-term) that motivate behaviour change should be organized.	local (supported by national)
	Sustainable and responsible living should be embraced and practiced by consumers by focusing on the principle of environmental conservation and stewardship.	Global citizenship initiatives through responsible shopping and consumption behaviour should be enabled.	local (supported by national)
	Consumption of resource should be improved through a shared-ownership of product service systems.	Collaborative consumption (shared-ownership) activities and services should be promoted.	local (supported by national)

	Products should be designed by following a cradle-to-cradle design principle so that resource can be recovered at the end-of-life phase.	The designing for disassembly practices at design and manufacturing of products should be promoted.	international, national
	As manufacturers are responsible for managing their end-of-life products, waste products should be managed and recycled under the extended producer responsibility principle.	Mandatory take-back scheme for producers, especially for hazardous and non-disassembly products should be introduced.	national
	The use-life of post-consumer products should be expanded by up-cycling (repairing/reusing) and contributing to the circular economy.	Revitalize social capital in reuse and repair activities to expand the use-life of post-consumer products should be revitalized.	national, local
	A favourable market condition for post-consumer goods and recycling materials should be ensured and enabled considered as economically viable commodities.	Regulatory and economic policy to promote completive market conditions for post-consumer recycling products should be introduced.	international, national
Waste management and treatment	Appropriate waste infrastructure such as separate bins, kerbside collection system systems should be provided for continuous improvements of waste management practices.	Three bin and kerbside collection systems should be introduced to improve waste sorting, recycling and collection efficiency.	national
	Local government should provide decentralized recycling and resource recovery facilities within the closed-proximity of the community.	Both community based and remote recycling facilities in urban precincts should be established.	national for services covered by public operator, other waste streams may be managed locally
	Empower social technologies such as reuse, re-pair and recycle through community participation.	Activities that promote social technology and enhance social capital should be promoted.	local (supported by national)
	Source reduction by enabling and introducing regulatory policies and programs should be improved.	PAYT scheme to promote source reduction should be introduced.	national
	Application of environmentally friendly waste treatment technology to ensure a maximum resource recovery with a minimum environmental pollution should be encouraged.	Environmentally friendly technology such as composting, anaerobic digestion, etc., instead of landfill should be ensured.	national
	WTE technology should not be applied as a mass-burn solution of waste treatment unless no alternative and feasible solution is available.	The mass application of WTE should be regulated and restricted unless no alternative and feasible solution is available.	national
	Landfill should be banned and applied as an interim disposal option.	Waste diversion from landfill targets should be introduced.	national
	Economic incentive mechanisms should be facilitated to motivate and promote effective management practices.	Various economic incentives policies such as refund, landfill levy, etc., should be introduced.	national
Monitoring and assessment	Annual waste management data should be collected by maintaining a standardized data collection and reporting systems.	Implementation of waste data collection and monitoring systems is necessary in city/municipality level for building national waste database.	national
	Research on zero waste should be conducted to provide a better industrial design solution for manufacturers and to improve resource recovery efficiency from waste.	National and international collaborative zero waste research activities should be promoted.	local, national, international

**Following the principle of subsidiarity.*

Source: Zaman, 2017, p 3 with own amendment

The amendment made to Figure 13 is based on current Hungarian regulations. Where local level was mentioned, the national level policy support is not inevitable for proceeding, however, steps are made easier, if national coordination and financial support for action would exist. The amendment clearly shows that waste management, which is operated by nationally coordinated public service providers, is not the domain of local governments unless bearing the obligation of providing public service, whereas waste prevention remains their field of action.

Zero waste as a comprehensive policy focusing on the upper sections of waste hierarchy (with a broader interpretation) is more accepted. In this sense, the policy measures and monitoring are worth to be based on the zero waste concept, but waste prevention should remain in the spotlight, especially that the interpretation of zero waste is fairly inconsistent.

As mentioned, low number of indicators exist, and those relevant explicitly for waste prevention were discussed earlier in the related chapter. In case of a zero waste policy a set of indicators seem to be viable. A total of 56 zero waste indicators were proposed by Zaman (2014) – and tested by expert interviews – based on the key elements of zero waste strategy. Indicators were grouped: geo-administrative indicators, socio-cultural, waste management, environmental, economic, organisational, governance and policy. The basic data geo-administrative and socio-cultural is relevant for waste prevention as well, obviously avoidance programs are important. The environmental and economic considerations, the organisational, governance and policy priority areas could be interesting, if they are disaggregated in a way that waste prevention activities could be directly assessed by them. After filtering the relevant indicators could be (Table 6):

Table 6 - Identified most significant indicators of zero waste management (filtered to prevention)

• **Geo-administrative** ○ Demographic and administrative ▪ Geo-administrative area ▪ Area covered by waste service ▪ Population in the service area ○ Built environment ▪ Number of buildings (housing, etc.) ▪ … ○ Household's income ▪ Household purchase capacity ▪ Household expenditures • **Socio-cultural** ○ Consumption ▪ Food consumption ▪ Resource consumption ▪ Consumption expenditures • **Management** ○ … ○ Avoidance ▪ Avoidance programme ▪ Item exchanged/resell. ▪ Item reused ○ … • **Environmental (disaggr. waste prevention)** ○ Environmental burden and benefit ▪ Environmental emissions ▪ Environmental savings	• **Economic (disaggr. waste prevention)** ○ Economic cost/benefit ▪ Economic cost ▪ Revenue ▪ Net cost benefit • **Organisational (disaggr. waste prevention)** ○ Human resources ▪ No of employees/tonne waste management ▪ No of training programmes ▪ … ○ Waste informatics ▪ Central waste data ▪ Time series data ▪ Waste forecasting • **Governance and policy (disaggr. waste prevention)** ○ Governance and policy ▪ Regulatory scheme and programme (CP, EPR) ▪ Regulatory laws and rules (ban, restriction) ▪ Incentives (tax, incentives) ○ Compliance and auditing ▪ Degree of satisfaction ▪ Auditing and monitoring ○ …

Source: based on Zaman, 2014 p 691

Interestingly, another publication of Zaman (2013) proposes the so-called Zero Waste Index (Zero Waste Index) for cities which is simplified respective to the above indicator set effecting in an index that is not measuring waste prevention directly at all.

$$ZWI = \frac{\Sigma_1^n WMSi * SFi}{\Sigma_1^n GWS}$$

WMSi: amount of waste managed by system (i.e., I = 1, 2, 3, …)

n: amount of waste avoided, recycled, treated, etc.

SFi: substitution factor for different waste management systems based on their virgin material replacement efficiency

GWS: total amount of waste generated (tonnes of all waste streams).

2.6 Circular economy and waste prevention monitoring

The theory of circular economy embraces waste prevention usually to the extent of an important principle, often totally neglecting the top priority of the waste hierarchy. This is because it is often discussed as a new form of waste management, whereas it is a new holistic concept which shifts the economy from the linear, throw-away model at micro, meso and macro levels towards an economic system that strives to close the loop of resources, buy eliminating waste and redirecting materials to the economy.

According to Ghisellini et al. (2016) the circular economy is rooted in Boulding's concept of the Earth being a closed cyclical system, to this end the economy relying on it should also be shifted from being open-ended towards being closed referred to Pearce and Turner. The environment provides resources, is a life support system and is a sink for waste and emissions. Georgiescu-Rogen explained that shift is necessary because of the law of thermodynamics leading to the degradation of matter and energy. The second origin is industrial ecology which aims to internalise costs of environmental externalities by pricing environmental pressures, emissions. Ghisellini et al. (2016) pointed out that the third origin is the General Systems Theory of von Bertalanffy stating that all organisms should be considered as systems, and that the system determines the operation of the parts, not the other way around. This root promotes system thinking and holistic approach.

The key principles of circular economy are the 3Rs (Reduce, Reuse, Recycle) which was completed by three more by the Ellen MacArthur Foundation: the appropriate design, the reclassification of materials into "technical" and "nutrients" – the first standing for inorganic and the second for organic matter, latter to be returned to the biosphere, and the renewability which means the economy should be founded on renewable energy (EMF, 2015). Later, the definition was redesigned by integrating all earlier criteria under three holistic principles: the elimination of waste and pollution, circulation of products and materials (at their highest value), and the regeneration of nature (EMF, 2023). It fosters the transition to renewable energy and materials and decouples economic activity from the consumption of finite resources. It is a resilient system that is good for business, people, and the environment.

The circular economy model on the production side includes eco-design, and cleaner production, the consumers' responsibility and green public procurement in the consumption phase and environmental impact prevention in waste management. Ghisellini et al. (2016) also address collaborative consumption models as part of CE. Additional concepts relating to the circular economy

(Andrade et al., 2021) are industrial symbiosis (waste of one business is resource of another), cradle-to-cradle (life cycle approach with the aim of closing the loop, minimising resource use and emissions), performance economy (product-service-system, selling the service, ie. service that the product provides, sharing economy), blue economy (the best for health and the environment is cheapest and the necessities for life are free thanks to a local system of production and consumption that works with what you have according to Pauli), biomimicry (nature as model, nature as measure and nature as mentor), environmental and ecological economics (environmental economics internalises externalities, while ecological economics states that not all limitations were taken into account).

Observing the relation of sustainable development and circular economy there are scholars believing that CE is more progressive than sustainable development as the latter is rooted in the linear economy. Others believe that it could be the operationalisation tool for achieving the SDGs (Merli et al. 2018).

There are lots of similarities in the zero waste and circular economy concepts. Both rely on the waste hierarchy, and both have moved away from waste management towards a holistic perspective. The main difference in zero waste and circular economy is that the first defines the need to move upwards the hierarchy by prioritising prevention as the final goal. On the contrary, circular economy is initiated from avoiding waste going to landfill, i.e., moving upwards the waste hierarchy, prioritising economically, promoting recycling, reuse and prevention keeping this order in practice, even if, theory is the other way around. This practical order is underpinned by the ReSOLVE findings of Ellen MacArthur Foundation. ReSOLVE is a framework that aims at categorising the CE activities discussed in papers in order the support operationalisation of CE. Almost half of the CE related publications dealt with recycling practices, optimisation, i.e., increase in efficiency was the second followed by regeneration, sharing schemes, exchanges and only 1.2% of the articles focused on virtualisation, i.e., dematerialisation (Merli et al., 2018).

Regarding the ‘loop’ the concept of waste prevention does not only stimulate the closing of it, but it supports the slowing, and the shrinking (or at least not growing) of the loop. Closing the loop would halt the use of additional resources, slowing appears with collaborative consumption models and reuse, while shrinking means reducing overconsumption. Altogether, the dematerialisation of the economy. A sensitive issue dividing waste prevention and circular economy, is the expectation of economic growth. Waste prevention supposes the limitations of natural resources, that should be directly reflected in action, it could be conceptualised as the strong sustainability criteria for circular economy. Circular economy promoters are mostly oriented towards blue economy solutions or to some adjustments to be made in the current economic structure by innovating, optimising. Borrowing

the words of (Geng et al., 2014) calling for radical structural change: "Until we fundamentally change the growth paradigm, all of our efforts are as useless as rearranging the deck chairs on the Titanic as it plugged to the bottom of the ocean."

Geographically, China was the first and Europe followed in adopting the concept as policy. While China's CE evolution is top-down – even if the planning levels were micro, meso and later macro -, the European movement was rather bottom-up (Ghisellini et al., 2016). Germany's Waste Law was the early bird in Europe in 1996, while Japan promoted recycling in its legislation since 1991.

The circular economy concept was integrated into the EU policy by the Europe 2020 Strategy through the Resource Efficient Europe – Flagship initiative (EC, 2011b) rolled out in details in the Roadmap to a Resource Efficient Europe (EC, 2011c). The overall goal was to reduce, reuse and recycle as much as possible, to keep the circular flow of material in the economy continuous (Graczka, 2018). The Circular Economy Action Plan of the EU (EC, 2015) refers to the efficient use of raw material by reducing production needs – in processes and product design –, rationalised consumption needs and effective waste management, then redirecting material to the economy (EC, 2014a). As of waste prevention its main requirements for products were reparability, upgradability, durability, and recyclability, and concerning the production process best available techniques were to be published, and a stronger support was declared towards the realisation of the waste hierarchy. To follow progress, the Resource Efficiency Scoreboard (EC, 2020b) was set up, and in 2018 the Circular Economy Monitoring Framework (EC, 2018a) was established. This is a selection of ten indicators – that already have data with time series –, and measure goals of the Circular Economy Action Plan relative to production and consumption, waste management, secondary raw materials and competitiveness and innovation.

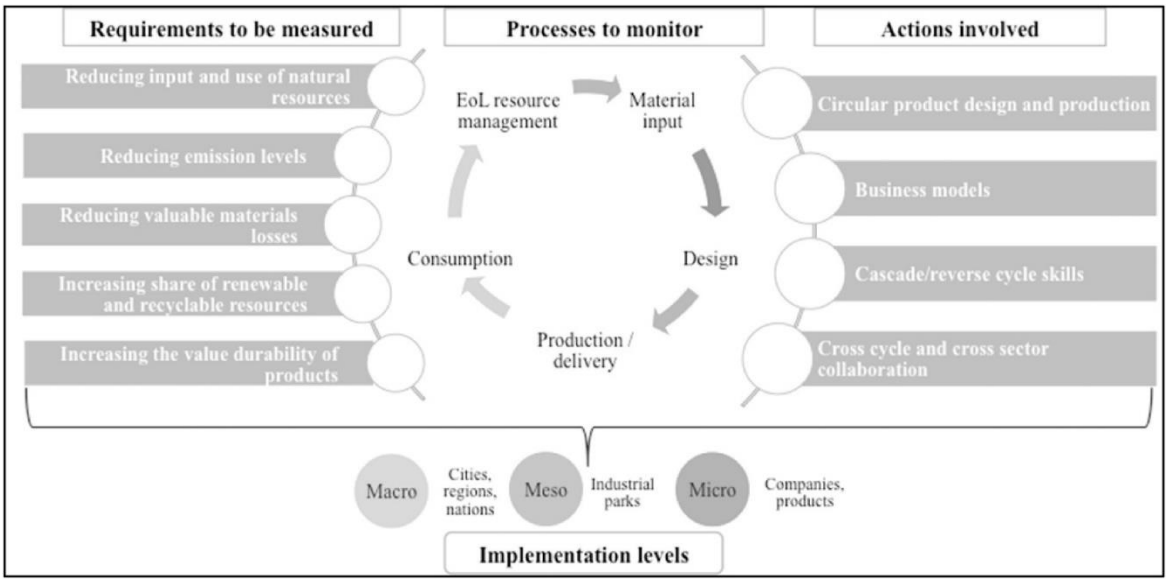
In China a circular economy policy first appeared in before 2005 and is focused on closing the loop in industrial parks, promoting industrial symbiosis, and by 2020 turned towards the restoration of the environment due to public pressure (Graczka, 2018). The evolution of the circular economy policy of China (Mathews et al., 2011) led to a broad, environmental approach, including topics like pollution control and improving conditions of the environment in general, which is very much different from the EU's circular economy policy focusing narrowly on waste and resources, and the business opportunities (McDowall et al., 2017).

The central issue within circular economy is decoupling, resource efficiency and increased recycling. In this sense waste and also material flow is to be measured.

A four-level framework was created to support measurement of CE (Elia et al., 2017) (Figure 14). Actions were defined by Ellen MacArthur Foundation in 2013, the requirements to be measured are derived from the European Environmental Agency, the fields of intervention were defined based

on the research of Ghisellini et al., 2016. The monitoring model is comprehensive, follows the entire track of product life cycle, this includes waste prevention as well by drawing attention on the pre-waste phases, not reducing circular economy to recycling.

Figure 14 - The circular economy framework and measurement



Source: Elia et al., 2017, p 2742

For the index-based methodologies – single indicator or indicator set – four categories were introduced: material, energy flow, land use, consumption. For the material flows single indicators could be the Water Footprint (WF), the Material Inputs Per Unit of Service (MIPS) and the Ecological Rucksack (ER) (equal to the total sum of the material input minus the mass of products), while multiple indicators could be the Material Flow Analysis (MFA) together with Substance Flow Analysis (SFA) were examined. MFA and SFA turned out to be the most comprehensive and flexible in terms of the levels that it can be applied to (micro, meso, macro). The advantage of MFA is that it is systematic, the standard methodology increases comparability, but it does not account for all environmental impacts and does not give information about the quality of material although it would be important to distinguish between primary and secondary raw materials. The SFA estimates flows and stock of hazardous substances. It is more effective in monitoring the harmful substances in detail, but it cannot quantify the environmental impact.

The European Circular Economy Monitoring Framework and the earlier introduced Resource Efficiency Scoreboard are indicator sets that are being practically used by the policy, so they are discussed later, in the framework of the empirical research presentation.

2.7 Sustainable development and waste prevention monitoring

The topic of sustainable development is mentioned in almost every waste prevention related publication; however, it is a holistic, extensive theory, and waste prevention, resource efficiency and

savings through circular economy and zero waste policies is only one aspect of it. Sustainable development has a dual, antagonistic characteristic: through its comprehensive interpretation of development, it reaches every discipline to some extent. This way, it has admittedly a strong impact in forming attitudes, the way of thinking. It has become imperative, inevitable factor when talking about theories. On the other hand, its holistic, diverse characteristic and the fact that the Agenda 2030 is only a recommendation makes is vulnerable, leaves it on the level of theories, gives ground to alternative interpretations depending on the context.

The concept of sustainable development matured gradually, but it's very first statement appeared in the Brundtland Report (WCED, 1987). The first years after the Stockholm Conference in 1972 were spent with the dilemma on how to interpret development: the financial support from the developed countries to the third world countries, or development as an overall change in the quality of human's life (Faragó, 2022). The three domains of sustainable development showed interesting dynamics over the years. Initially, the social aspects were suppressed by invigorating the green economy. The Brundtland Report itself has set the goals of sustainable development keeping the priority of economics. Today, there are two schools existing parallel (Fleischer, 2014): the weak sustainability presents the three fields as overlapping sets, and the main criteria is that the sum of the three types of capital – natural, social, and economic – should not decrease. Contrary to that, strong sustainability means that the three sets are concentric and embedded in each other. The absolute limitations are given by the environment, and in the centre the economic dimension has its place. These two are connected via the set of society unable to exist without environment, while the economy is unable to exist without the environment and the society.

Waste prevention action is based on the belief that natural resources are limited. It implies the reduction of resource use partly through optimisation of consumption not necessarily meaning reduction, rather restructuring, substitution of materials, or shrinking size weight, but keeping function, etc. But for waste prevention resource reduction also means reducing overconsumption – unlike the case of recycling or partly reuse –, and overproduction. Waste prevention has very strong environmental drivers, meaning that an open loop economy, the circularity of materials is not enough. In this sense it is based on the strong sustainability criteria, as mentioned earlier.

The Millennium Development Goals were focused on the social challenges of developing countries, the protection of the environment was secondary. The Agenda 2030 resolution (UN, 2015) adopted in 2015 does make a commitment to remedy waste problems by the Sustainable Development Goals (SDGs). "Make cities and human settlements inclusive, safe, resilient and sustainable" (Goal 11) includes the target (11.6.) "By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management"

approaching the waste issue relative to urbanisation processes. This approach is adequate for following the fast urbanisation of the developing world with huge, dense cities lacking proper infrastructure. In the developed countries, usually, the infrastructure can follow the urbanisation needs, or at least the gap is not so substantial.

The most important SDG from the waste point of view is Goal 12. "Ensure sustainable consumption and production patterns". It addresses

- food waste: Target 12.3: "By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses",
- hazardous waste: Target 12.4: "By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment",
- and waste in general: Target 12.5: By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse.

The target of preventing waste is explicitly present, however, only the target of food waste is quantified, making the hazardous waste and waste in general 'soft' targets.

Goal 12 has special characteristic. While all other SDGs are prioritising problems and phenomena present in developing countries, the largest waste generators remain the overconsumer developed countries. This goal is set for them.

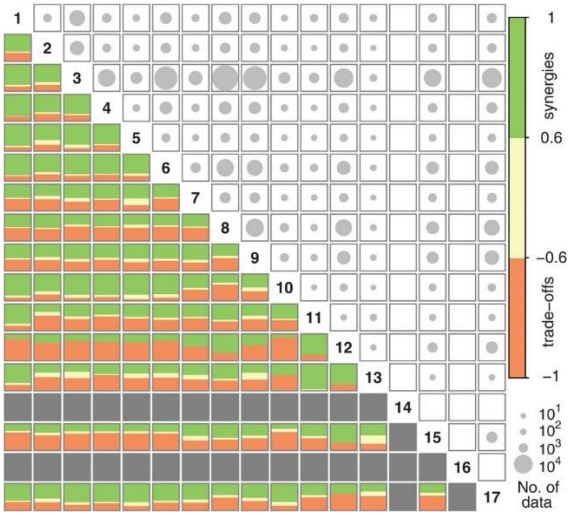
It is suggestive that the methodology (UNSD, 2022a) development of indicators belonging to this goal was among the ones in longest delay. Majority of the development took place just before 2020 (UNSD, 2022b).

Once data availability is resolved, the next problem comes from the interlinkages of SDGs. Dynamics show that there are some SDGs that are synergistic, while others create trade-offs when progressing. For example, the increase of renewables in the energy mix (7.2) is in synergy with the increase expected in energy efficiency (7.3.) but creates trade-offs when coming to the target of doubling the number of farmers producing food (1.4). The solution for dissolving the contradictions would be to create the consistency first among the policies (Miola et al., 2019) and the prioritising of SDGs by urgency, systematic effect, and the identification of gaps between policies (Allen et al., 2018).

According to Gasper et al. (2019) Goal 12 "Responsible consumption and production" is the most controversial, which is a relevant finding for the topic of the thesis, as waste related indicators

are concentrated here. This goal is in negative correlation with economic goals, and indirectly with social goals (aiming at well-being based on economic progress). Similar outcome was published with correlation examination of SDGs (Figure 15) (Pradhan et al., 2017).

*Figure 15 - Synergies and trade-offs of SDGs**



**Green indicates synergies, red indicates trade-offs, yellow indicates neutrality, grey boxes indicate the lack of data. The size of the grey circles shows the number of data pairs.*

Source: Pradhan et al., 2017, p 5

Positive correlation was observed between Goal 1 "End poverty" and other, mainly social goals, that were earlier integrated into the MDGs. "Health and well-being" also show positive correlation with development-focused goals. The most negative correlations were experienced in Goal 12 on responsible consumption and production, Goal 8 on decent work and economic growth, Goal 9 on industry, innovation and infrastructure, and Goal 15 on protecting and restoring ecosystems. This gives a pattern that main trade-offs are between environmental and economic goals.

The complex system of SDGs required intense statistical background work to accomplish monitoring. The 17 Goals were associated with 169 targets and 248 indicators (excluding multipurpose indicators 231) (UNSD, 2022c). Following the social bias of MDGs the SDGs became more balanced among the three sets – environment, society, and economy – of sustainable development.

The numerosity of the indicators has itself led to difficulties in terms of transparency, management, and communication of performance (Biggeri et al., 2019). Furthermore, the focus remaining on developing countries has strongly affected the indicator development process, resulting in specific indicators (e.g., malaria incidence, unsafe water, unsafe sanitation, etc.) which are not relevant, or do not demonstrate the core sustainability problems and their improvement in developed countries (Graczka ed., 2018). To dissolve this contradiction, it has become a widely applied method, to keep the goals (sometimes target level also), but make a re-interpretation by developing local,

national, regional level indicators adapted to the local peculiarities in achieving the goals. Redesigning monitoring made the system of SDGs more realistic, as indicators must be put into context (Havasi, 2007; Bartus, 2013). At the same time this reframing gives the opportunity to become tool for political manipulation at any level.

Problems identified during the statistical works (Graczka, 2023) are that some of the SDG indicators are so-called political indicators, which are output indicators not showing the true impact. These indicators – typically referring to the existence of political documents or legislation in the due domain – are not statistics-based. In addition, they do not measure the efficiency of implementation. SDG indicators occasionally fall very far from the goal, as indicators were the outputs of long discussions and lobbying of high number of institutions and Member States (e.g., the case of SDG 8 goal on providing decent work for all, measured by the number of ATMs). It is also observed, that for easing methodological development indicators went through simplification, and became partial when describing a phenomenon. There are also lot of discrepancies in methodologies, definitions and nomenclatures and classifications between national statistics, regional statistics (e.g. EU) and the UN statistics. These difficulties led to a five-year statistical development. In 2019 40% of the indicators were left without methodology. Methodologies were finally developed or indicators were excluded in absence of methodology during the 2020 Comprehensive Review (Graczka, 2023). Today, data availability is the main issue as a next step.

There is an ever-increasing tendency in creating new monitoring alternatives for SDGs. The Sustainable Development Solutions Network (SDSN) publishes for example an SDSN index and Dashboard (Sachs et al., 2022), while OECD follows the concept of 5Ps (planet, people, peace, partnership, and prosperity) (OECD, 2017), Sustainable Development Indicators (SDI) of the EU to mention some beyond those adaptive sets that are being created. In Hungary, the National Sustainable Development Framework Strategy was adopted in 2013 with a key indicator set of 16 based on resources (human, society, environment, economy), which was completed to 103 by the Hungarian Central Statistical Office by background ad context indicators. In 2022, the Hungarian Central Statistical Office with the contribution of Ministries has developed a new set of indicators of 139 (KSH, 2022). These indicators cover the monitoring of the 17 SDGs, but at the same time follow progress based on the National Framework Strategy, i.e. are indicators that have local policy relevance.

As regard to waste the following indicators are direct:

- Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable

- Target 11.6: By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management
    - Indicator 11.6.1: Proportion of municipal solid waste collected and managed in controlled facilities out of total municipal waste generated, by cities

- Goal 12. Ensure sustainable consumption and production patterns
    - Target 12.3: By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses
        - Indicator 12.3.1: (a) Food loss index and (b) food waste index
    - Target 12.4: By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment
        - Indicator 12.4.1: Number of parties to international multilateral environmental agreements on hazardous waste, and other chemicals that meet their commitments and obligations in transmitting information as required by each relevant agreement
        - Indicator 12.4.2: (a) Hazardous waste generated per capita; and (b) proportion of hazardous waste treated, by type of treatment
    - Target 12.5: By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse
        - Indicator 12.5.1: National recycling rate, tons of material recycled.

The waste management in controlled facilities is typically not an issue in developed countries, developed countries are rather dealing with the expectation of increasing recycling and reuse. Only two targets relate at all to waste prevention. In case of food, two indexes were set up. The Food Loss Index covers the production process – on-farm post-harvest/slaughter operations, transport, storage, distribution, processing, and packaging –, and is managed by FAO, while Food Waste Index covers the retailers and the public and household consumption phases of the food system, managed by UNEP. This is the case when food waste reporting became compulsory from 2022 on reference year

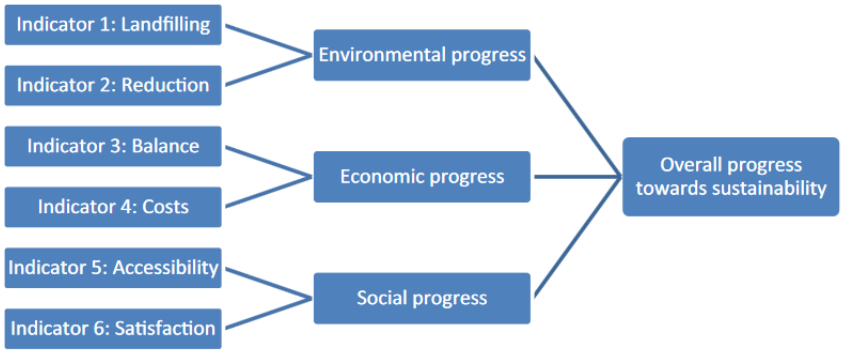
2021, and a standard methodology was developed by the EU, but the organisations did not harmonise the methodology.

The relation of target 12.5 and indicator 12.5.1 is unambiguously partial. The indicator is simplified, and only covers a small part of the target. Waste prevention is ignored, proxies excluded as well.

Furthermore, the World Bank (World Bank, 2018) has developed an indicator which is on material use, but is presented in this chapter for relying on the concepts of sustainable development: natural resources rent as % of GDP, where rent equals revenues above the cost of extracting the resources; borrowing against the future. This is a theoretical indicator, including significant estimations.

Another indicator model related to the measurement progress towards sustainability is the following (Figure 16). Progress in waste management is chosen to be measured by the landfilling rate and the reduction rate (Fernández-Braña et al, 2019) together with observing the economic balance and the social progress. The latter was calculated as progress in accessibility to separate collection, progress in complaints reduction.

Figure 16 - Progress towards sustainability in waste management



Source: Fernández-Brana et al., 2019, p 35306

Waste reduction has relevance in this context which is measured the progress in waste reduction:

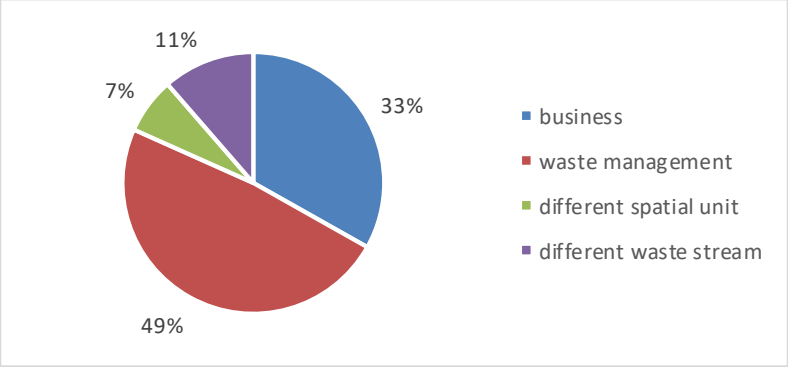
$$Progress\ in\ waste\ reduction\ (\%) = \frac{(MW\ generated_{year 1-i} - MW\ generated_{year\ i}}{MW\ generated_{year\ i-1}} * 100$$

This is a classical form of performance indexes, which fail in one case, if the denominator is zero, which is not probable in waste generation. The positive value means less, the negative means more waste is produced.

Summing up, the literature review has revealed that due to the horizontal, cross-cutting characteristic of waste prevention the topics and domains are heterogeneous. Majority of the articles found as hits based on search terms discussed at the beginning of the chapter, turned out to be irrelevant to our

field of research, however, the reason why the search was intentionally not narrowed down not to miss any important literature because of keyword issues. 235 hits were found by Web of Science for the expression ("WASTE PREVENTION" OR "ZERO WASTE") AND (MEASUREMENT OR MONITORING OR INDICATOR). Based on the systematic review of the literature major part of the turned out to be irrelevant and 31 proved to be within the scope of the research. The list of relevant literature is in Annex I. The reason of irrelevance was coded, and one reason was associated per article (Figure 17). Almost half of the articles had waste management as a topic where prevention was only mentioned, but not dealt with in depth. This is a good proof for the situation earlier discussed, i.e. that waste prevention is often mentioned in policies, but not discussed, and now there is a proof the same thing happens in scientific publications. One-third of the articles were revealed to be production or business related. Some articles were linked to chemicals used for the characteristic of waste prevention to reduce hazardousness. Different spatial unit refers to the fact, that the spatial scope was other than regions, states or cities, and that the findings were not suitable to be applied to municipalities. Most frequently zero waste activities of university campuses or other educational institutions were published among these articles. The 'different waste stream' means other than municipal solid waste. The low number rejected because of this show the relevance of MSW in prevention.

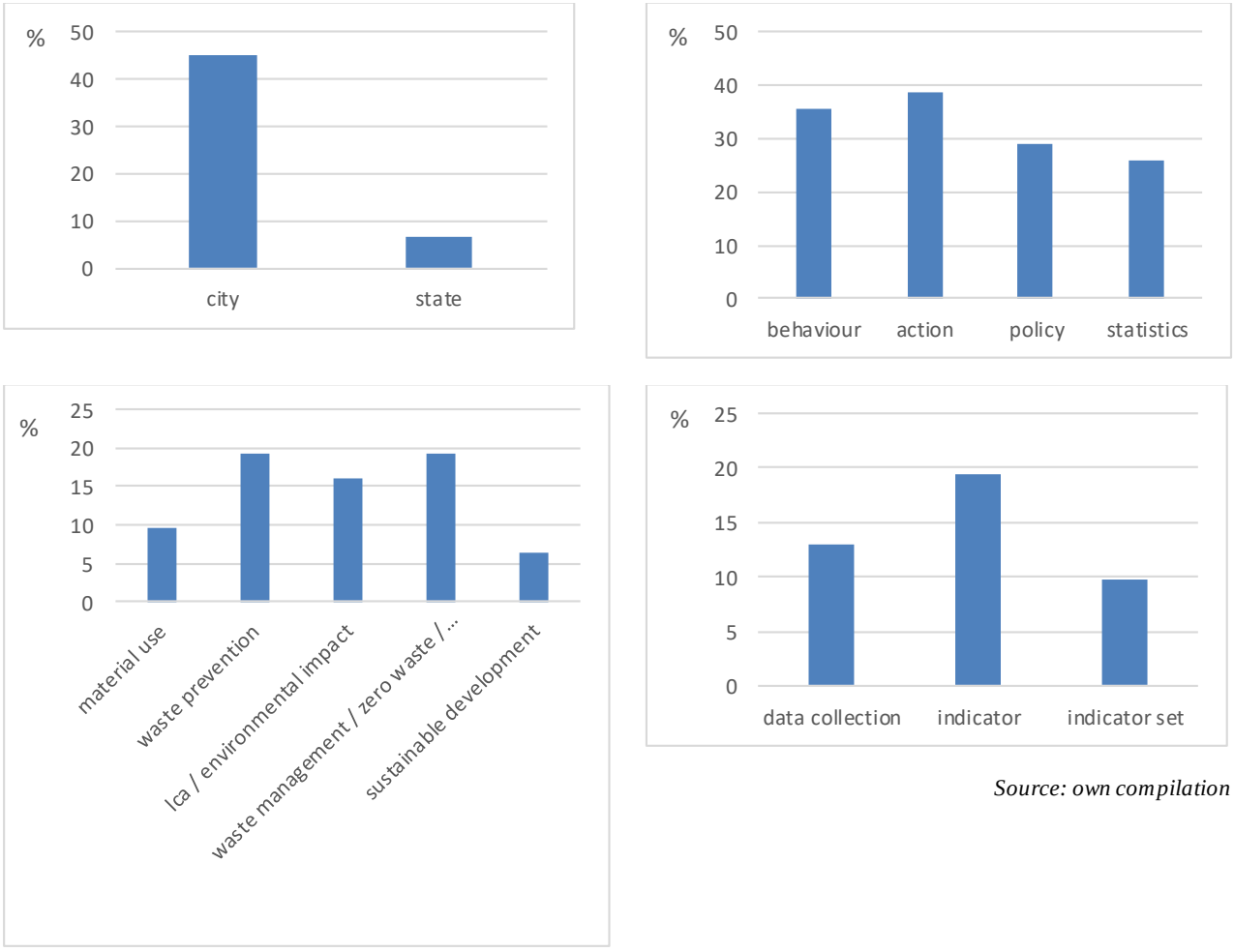
Figure 17 - The reason of irrelevance of article reviewed (n=202)



Source: own compilation

The relevant literature was allowed to be associated with more keywords during the review to get as much information as possible on them. The finding are as follows (Figure 18):

Figure 18 - Keywords of relevant literature (n=31)



Source: own compilation

Indicators, and indicators sets (usually compiled from existing statistics) were only published between cca 10 to 20% of the articles. In other cases statistical data, or calculations (e.g. LCA) were put forward. Data collection was specifically in focus in the articles that were related to the pilot project run in the UK later presented.

The relevant literature was also categorised based on the different domains that is used for contextualising waste prevention. About 20% of the literature was purely focusing on waste prevention, and the same proportion was dealing with prevention in the context of waste management. When it came to zero waste, circular economy or classical waste management, only the articles that carried out discussion on prevention were included, others were categorised as irrelevant. The shift in monitoring towards material use and sustainable development were rather theoretical discussions. On the contrary the environmental impact of waste prevention actions was presented as the outcomes of life cycle assessments following practical calculations.

The city-state ratio is not complete, as for the majority of relevant articles the geographical scope was simply not defined, but in these cases the assumption of national level is usually valid. When the geographical scope was defined the city was most frequent with high number of case studies for concrete cities. The cities chosen, however were usually not very important, as the authors were developing generally appliable models.

There is a clear distinction among articles in approaching measurement. The 'bottom-up' measurement of municipal waste prevention focuses on household actions and behaviour depending on consumption patterns and household sizes. The other approach is 'top-down' discussing usually state level policy and using available official statistics as an origo, for this reason such researches are data-driven and focus on waste generation reduction. The household activities strongly influence the waste prevention potential, thus waste generation reduction is not enough in itself (Hutner et al., 2018). This research attempts to set up an indicator system, that both includes the statistical and the holistic, activity related approach in prevention.

Besides the findings on the topic by Web of Science, it turned out to be useful to further map literature, integrating articles which although were not coded by keywords and abstracts to be found relevant by WoS, but still they had an added value to the waste prevention monitoring topic. These articles were also reviewed and presented in the work.

Summarising the outcome of review, it clearly reveals lack of focus on waste prevention, and particularly on monitoring of waste prevention, not to mention the case when narrowed down to municipal waste. The term waste prevention does not have a consensual definition, authors use it in many ways (e.g. waste minimisation, zero waste, etc.). Regarding the monitoring methods of municipal waste prevention, the above discussed bottom-up and top-down approach is valid, but has rare connection with one another. The bottom-up approach integrates accurate indicators, however, frequently lacks data. The top-down approach is based on proxy waste management indicators from official statistics, so there is less problem with the data availability, but the widely used indicators are not accurate enough. Additionally, the municipal waste-related actions are most commonly associated with the settlement level, and policies with the national level.

2.8 Theory of indicators

The development of waste prevention indicators requires knowledge on the theory of indicators, as the founding of the construction. This subchapter collects all important expectations on indicators to meet standards, and presents the types of indicators and indicator systems applicable to monitoring processes.

Scientists from various fields have defined the term indicator, typically placed in various contexts. The literature on indicators in general is much less extensive. One may use as definition

“‘indicans’’, i.e., a measure or component from which conclusions on the phenomenon of interest (the indicandum) can be inferred. Indication here is the reflection of an indicandum by an indicator” (Heink et al., 2010). The first step is to verify the correlation between the investigated phenomenon and the indicator that describes it. If that is confirmed, the next step is setting the preferred direction of change and the target, that is, transforming the indicator into a normative one.

McDowell's (2017) definition favours the quantitative nature: an indicator is a relevant variable that can be measured in time and space, and provides information about a phenomenon that is broader than the indicator itself, and enables comparison.

According to the definition of UNIQUAIMS (European-Union INCO-DEV Program to Discuss the Unification of Indicator Quality for Assessment of Impact of Multidisciplinary System), an EU project aimed at unifying the quality assessment of indicators, the variable measures a property of a subject or unit. The parameter is some value of the population (e.g. mean value) that we plan to measure. Variables are used to estimate parameters. The estimate is therefore a function of the variables, which gives an estimated value related to the population. The indicator is also a function of the variables that gives an indication, and this can be an argument of a decision-making function. The estimated value and the indicator may coincide, but the decision may also depend on other, subjective factors (Riley, 2001). Statistical indicators quantify key issues and phenomena and are based on observation (EU, 2013a).

The statistical information infrastructure (EU, 2013a) can be represented in the form of a pyramid: the bottom, the widest layer represents "data", the "accounting system" is located above that, and the "indicators" are located at the top of the pyramid. The accounting system stands for the grouping or categorising data based on given principles. While the data and the accounting system are typically multi-purpose, that is, they can be used in different statistical domains, the indicators have a specific and precise purpose. Indicators are formed from processed data in such a way that an expressed political goal is linked to it, i.e. the indicator is placed in context (for example, GDP is a general economic indicator, but R&D expenditures projected on GDP is already an important indicator of innovation policy).

Traditional statistical data sourcing includes direct surveys and data transfers from administrative sources. Surveys can be run three ways: personal interviewing (Computer Assisted Personal Interviewing - CAPI), telephone interviewing (Computer Assisted Telephone Interviewing - CATI) and Computer Assisted Web Interviewing - CAWI). In case of non-official statistics other formats of data collections also exist: via SMS, focus group discussion or in-depth interviews. Data sourcing from administrative sources is only permitted, if the organisation is an official data provider and/or fulfils quality criteria. The trend is to shift data collection from costly and less effective surveys to

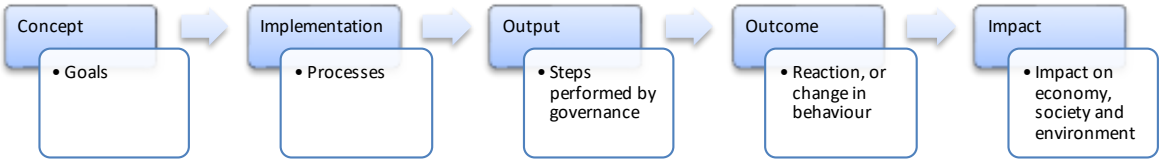
data transfers from administrative sources. This is not only cost-effective, but usually provides comprehensive data or at least large samples, and the most important is that it reduces the burden on data providers. In the current statistics program of the European Union, special attention is paid to the possibility of receiving privately owned data (EU, 2021).

When developing indicators contributors are needed from three sides: those dealing with policy determine the goals and targets. The statistician proposes what and how to measure, taking into account the available resources, while representatives of the scientific sphere add theoretical knowledge to the process.

2.8.1 Indicator typology

As a typical case, the indicators can be classified based on their relation to the policy. The key element of evidence-based policy is that it bases the planning and implementation process on concrete, quantified facts, results, and feedback, so monitoring plays a central role. When evaluating a policy, it is necessary to evaluate the initial (ex ante) and the final (ex post) state (Knoepfel, 2011). This is the dual function of policy indicators: they are used to analyse a situation, and also for evaluating the policy effect. In a more detailed version the phases can be seen below (Figure 19).

Figure 19 - Evaluation cycle of policies



Source: own compilation, based on Knoepfel et al., 2011

Contrary to outcome indicators measuring the final impact of actions (e.g., behaviour change, the amount of directly prevented waste), output indicators (Sharp et al., 2010) give only information on project deliverables, the number of actions, the number of people/companies reached, the number of players involved in actions, etc. For this reason, output indicators are only appropriate to be considered as complementary, background indicators. Output indicators are not set against hard targets, because large part of the related actions is not run by the state, rather, is expected to be run by the private sector implicating uncertainty regarding the outcome. Meanwhile output indicators with examples above take less risk by creating responsibility for actions that are concrete and are in the hands of policymakers through budgets (e.g. expenditure on campaign, number of citizens reached, etc.).

Three important questions arise in relation to indicators: why do we use them?, what do we measure with them? and how do we measure?, i.e. how objectively and directly they describe reality.

Eurostat discusses the theory of indicators along these three aspects (EC, 2014b). Why do we use it? question can be answered in two ways: the so-called descriptive indicators describe a specific situation, trend, or phenomenon in the form of numbers. On the other hand, the performance indicators evaluate them in relation to a specified goal, a target number. Given the characteristic of indicators that they are only interpretable together with their context, the same indicator can be descriptive in a specific policy context, while in another it can be a performance indicator. A frame of reference must always be defined for accurate interpretation. Knoepfel et al. calls the two types descriptive and normative indicators, these are identical to descriptive and performance indicators – typical cases are the indicators within sets presented in the literature review. Performance indicators show progress from a chosen baseline, by measuring the distance between the two states. These are typically used for monitoring the achievement of national, international policy targets, or tentative sustainability levels. Efficiency indicators are mostly relating environmental pressures to human activity (e.g., resource productivity, waste generated per GDP). The MIPS indicator is an aggregated efficiency indicator, for example. Total welfare indicators are usually complex like the Index of Economic Welfare (ISEW).

According to the subject of the measurement there are several measurement systems. The most widely known and used indicator systems are related to the cycles of the economy, or the growth of economy. Cyclical indicators can be distinguished according to the phase of the cycle they are linked to (Gyomai et al., 2012). Indicators that change before the change in the economy, or the turning point of the cycle are categorised as leading indicators, indicators that move parallel to the change are so-called coincident indicators, while indicators that are reactive and signal following the macroeconomic change are the lagging indicators. An example of the first is the stock market prices, industrial production can be an indicator that moves simultaneously with the change, while the following indicator is the employment rate, profit, interest.

The subject of the measurement can also be the impact on the environment. Based on the PSR (Pressure-State-Response) model created by the OECD in 1993 (OECD, 1993), the European Environmental Protection Agency built the extended DPSIR model in 1999 (Smeets et al., 1999), based on the interaction of human activity and the environment, mapping the environmental effects and the responses to them, relying on descriptive indicators. It can be categorized as below (Table 7).

Table 7 - Phases and indicators of the DPSIR model

Phase	Explanation	Indicators	Example
Driving force	The causes of pressure (e.g., industry, agriculture, energy industry, consumption	Indicators for driving forces describe the social, demographic, and economic developments in societies and the corresponding changes in lifestyles, overall levels of consumption and production patterns. Primary driving forces are population growth and developments in the needs and activities of individuals.	e.g., degree of urbanisation

	structure, urbanisation, etc.), human goals.		
Pressure	The human activity's effect on the environment (e.g., emissions to air, water, soil; noise; waste; resource and energy use).	Pressure indicators describe developments in release of substances (emissions), physical and biological agents, the use of resources and the use of land. The pressures exerted by society are transported and transformed in a variety of natural processes to manifest themselves in changes in environmental conditions.	e.g., waste generation per capita
State	The pressure causing change in the state of the environment.	State indicators give a description of the quantity and quality of physical phenomena (such as temperature), biological phenomena (such as fish stocks) and chemical phenomena (such as atmospheric CO2-concentrations) in a certain area.	e.g., quality of soil by landfills, quality of air at incinerators
Impact	Consequence of change in state such as the environmental, health, social and economic impacts.	Due to pressure on the environment, the state of the environment changes. These changes then have impacts on the social and economic functions on the environment, such as the provision of adequate conditions for health, resources availability and biodiversity. May happen in sequence (primary, secondary effects, one stemming from the other)	e.g. number of respiratory illnesses
Response	Responses given to the impacts by policies (laws, plans, standards, etc.)	Response indicators refer to responses by groups (and individuals) in society, as well as government attempts to prevent, compensate, ameliorate or adapt to changes in the state of the environment. Some societal responses may be regarded as negative driving forces, since they aim at redirecting prevailing trends in consumption and production patterns. Other responses aim at raising the efficiency of products and processes. Often used is environmental expenditures.	e.g. expenditure on waste prevention

Source: Smeets et al. 1999, Kristensen, 2004, OECD, 2004 and own amendment

The third major measurement framework is that of sustainable development, which takes several dimensions into account: the well-being of the generations living now, the well-being of future generations and the well-being of people living in other countries. Traditionally, it started from the four resources (people, society, environment, economy), and this is also the approach of the Hungarian National Sustainable Development Strategy. In addition, there is also the widely known thematic approach articulated by the sustainable development goals.

According to Eurostat's typology (EC, 2014b), the policy-type indicators and indicators of project-based approach maybe used effectively, but with different purposes. The project based indicators are the following:

- input indicator: shows the financial, human and material resource requirements of a project;
- output indicator: products, capital goods or services produced by policy;
- outcome indicator: measures the impact on the target group in the short or medium term, for example in the form of a change in attitude;

- impact indicator: the positive and negative, primary and secondary long-term effects, which can be direct or indirect, intentional or unintentional.

It is very common that the measurement systems are not based on purely theoretical concepts, but are derived from the policy target system. Balancing the theoretical and practical approach results in stable measurement systems. Policy indicators are often hierarchical. The following types can be identified:

- first level: headline indicator, which is widely used for communication purposes, the indicator is stable and usually time series is also available (e.g. resource productivity);
- second level: operational indicator, which is also stable, having time series, and can be linked to operational goals (e.g. household consumption);
- third level: explanatory indicator, which is more loosely connected to the given strategy, but its analysis is useful for moving towards the goals (e.g. eco-labels);
- fourth level: contextual indicator, which is not directly related to the strategic goals, does not respond to the policy, but at the same time can provide useful background information.

A single indicator is not enough to examine complex phenomena. In such a case, several mapping methods are available, which give the indicators a new typology. If several indicators are needed to describe a given phenomenon, they can form an indicator set. In such case, it is practical to ensure that those with a theoretical and political approach are presented in a balanced manner. The indicators can be grouped into a so-called dashboard, where a selection of key indicators is displayed, which do not have a normative function. These are not necessarily closely related to each other, but they are all needed to understand a part of the phenomenon. On the other hand, the scoreboards indicate the approximation to or distance from the set targets with the help of indicators that are closely related to each other.

Another form of display can be the composite indicator combining indicators with different measurement units. After selecting the components, the next step is aggregation with emphasis on weighting. The composite indicator is very sensitive and more prone to manipulation. The advantage of being able to model multidimensional situations is that it is easier to interpret respective to an indicator set, and facilitates communication between decision makers, the media, and the general public. The disadvantage is that a scientific background and political consensus are needed to establish the methodology, and it can also be misleading if it is poorly developed. It can lead to overly simplistic conclusions.

Finally, there are so-called synthetic indicators, which are built up from several basic indicators by aggregation. They differ from composite indicators in that the aggregation here is carried out at the micro, individual data level. For example, the number of social connections indicator consists of the frequency of connections and meetings with friends and relatives.

Following the Eurostat manual's logic (EC, 2014b) the third question is 'How do we measure?' which leads to two new indicator types. The direct indicator provides data directly on the subject. It is important to note that none of the indicators is direct or indirect by itself, it is always determined by the given reference frame. The indirect indicator – or proxy indicator – provides information about a phenomenon indirectly, either because the phenomenon itself cannot be measured directly (e.g. good governance or living conditions), or because direct measurement would not be cost-effective.

Based on the method of measurement, we can distinguish between objective indicators and subjective indicators. The first relies on "hard" data of databases, administrative data sources, the latter's main data source are the surveys. Characteristic of "soft" data is that the phenomenon is perceived through the filter of the respondent, which may contain personal feelings, personal perceptions, and individual value judgements. It is important to differentiate if the phenomenon is objective or subjective, or the recording itself. The phenomenon is objective, if it can be characterized by a given number in some unit of measure (e.g. environmental expenditures in EUR), subjective, if it is difficult to quantify, it can be characterised by a yes/no answer, or a numerical answer can be given on a scale (e.g. commitment towards environmental friendly shopping). It is important that both types of phenomena can be described with objective or subjective indicators.

The most common distinction in the method of measurement is according to the type of data, i.e. the type of answer given to the survey question. If the data is scale-type, in other words numbers with which mathematical calculations may be carried out, the indicator is quantitative, if the answer is categorical, which may be nominal or ordinal numbers (mostly not suitable for mathematical calculations), or text, the outcome shall be a qualitative indicator.

Eurostat makes the distinction between absolute indicators and relative indicators. Absolute indicators show the data in the original unit, either currency or in natural units. For their interpretation a basis for comparison (e.g. a base year in time series or other compared territorial units, demographic groups, ort the total population, or the overall performance of the economy) is usually need during the analysis, so that the deviations become visible. Relative indicators go one step further and integrate this type of comparability in themselves. The undoubted advantage of relative indicators is that they place a given indicator in context. The important goal of relative indicators is to present the data in a well-proportioned manner, to eliminate possible distortions resulting from other influences. Thus, for the sake of realistic comparison, in case of a territorial breakdown any indicator may be

appropriate to be projected to 100 or 100,000 inhabitants so that the different population sizes of territories do not distort. The other typical case for using relative indicators is to link an indicator to the overall economic performance of a unit. A relative indicator projected onto GDP or gross added value, which eliminates the distorting effect of positive or negative economic results, makes the results of individual countries comparable by taking into account their different levels of development.

2.8.2 Statistical standards

In addition to statistical offices and other official data providers (typically certified public bodies), most international organizations also deal with the processing and publication of national statistical data. The international standardisation of statistics came to the fore with the end of the European Eastern Bloc in the 1980s. The Conference of European Statisticians adopted the Basic Principles of Official Statistics in 1991 (CES/702). Subsequently, the need to set up a uniform global statistical framework was also expressed in the rest of the world, as a result of which the UN Statistical Commission adopted the above principles unchanged in 1994 as the UN Principles of Official Statistics (UN, 2014). With the revised preamble, the UN General Assembly adopted the same resolution in 2014. The 10 principles lay down the framework of official statistics:

- official statistics provide data for the government, the economy, the public and citizens, respecting the right of access to information;
- statistical processes must be defined according to scientific principles and professional ethical aspects;
- for the correct interpretation of the data, information on data sources, methods and procedures must be provided according to scientific standards;
- statistical organizations have the right to notice misuse of statistics and misinterpretation;
- any data source can be used, the statistical organisations decide on this, taking into account professional aspects, the quality and timeliness of the data, the costs and the data provider's burden;
- personal and individual data must be treated as strictly confidential and may only be used for statistical purposes;
- coordination between the statistical organizations operating within the country is necessary for consistent data;
- collaborations improve official statistical systems.

The Code of Practice for European Statistics (EC, 2017) defines the basic principles of the institutional framework within the European Union. In addition to the measures to ensure professional

independence, it addresses the need for coordination and cooperation for the preparation of EU-level aggregate statistics, as well as comparability, methodological and data consistency within the Union. In order to produce statistics, it requires tools – authorization to collect data and access to resources. It expects appropriate quality management, data protection, impartiality and objectivity from its members.

The code also covers statistical processes, in which it expects well-founded methodologies that take into account international standards and classifications, match definitions, as well as preliminary testing of data collections, transparent, public methodology, metadata, and regular self-checking. Keeping data provider burdens at a reasonable level and cost effectiveness are key aspects.

The most important chapter of the Code for our investigations sets out expectations and standards for statistical products. These are:

- relevance: data production in accordance with user needs and priorities, monitoring of user satisfaction;
- accuracy and reliability: accurate and reliable mapping of reality with checks, validations, and appropriate sampling procedures;
- timeliness and reliability: statistical data are published on time, in accordance with publication calendars;
- coherence and comparability: statistics can be compared at different territorial levels, chronologically, and it is possible to link different data sources through consistency; the entire process of data production complies with international standards and is based on international classifications and definitions;
- accessibility and clarity: publication of data in an impartial manner, together with metadata and guides, in a format that is understandable to the public, and access to microdata for research purposes is ensured.

RACER is another set of criteria for effective indicators widely used (EC, 2009a). Indicators should be: relevant (to the objective), accepted (by stakeholders), credible (transparent, and confidence is placed in it by stakeholders), easy (in terms of data sourcing and elaboration) robust (high quality of data covering scope, representativeness).

In terms of statistics, the UN's defining document is the Generic Statistical Business Process Model (GSBPM) (UNECE, 2019), which takes us through the demand specification, the planning, the development/testing, the data collection, the data preparation, the processing, the information preparation and the information process. This is the uniform statistical process model used by statistical offices across the world to regulate their activities. Three main tasks are connected

horizontally to the production process: quality management, statistical data management and metadata management.

As seen, the quality of a measurement system in a professional sense depends primarily on the quality of the data production process behind the indicators. This process ensures the characteristics expected of statistical products in the Code. Indicators that meet the requirements are those that are worth for further investigation. As a next step, the composition and balance of the indicator systems and/or composite indicators created from them can be examined.

2.8.3 Typology of measuring systems

Measuring systems, i.e. sets of indicators, enable a deeper understanding of the details of a phenomenon and the monitoring of its changes. They are often combined in such a way that various composite indicators are produced from the indicator systems: if it is a sub-area, then a dimension indicator, if it is a summary of the entire set of indicators, then a key indicator or index is formed. The overall purpose of the indicators is to measure change. The measurement systems do not have a purpose in their own right, they monitor the achievement of some external goal set by policy or by public expectations of the society or other interest groups.

On the one hand, the typology of measurement systems may follow the typification of indicators, for example, there may be a set of indicators that measure directly or indirectly, or a normative and descriptive system. The criterion of a normative measurement system is the availability of target numbers, while this is not a requirement for a descriptive system (Heink et al., 2010).

Change is triggered in the society from two directions, and this is followed by the typology of measurement systems (McDowell, 2017). First, the need for change may arise from policy need and from the accompanying incentive system, called the top-down approach where specific indicators – often accompanied by target numbers – are defined for concretely formulated policy goals. On the other hand, a broad demand for change formulated by social or economic actors can be expressed in public opinion, this is called a bottom-up initiative. These goals are often less specific, so in most cases no specific target numbers are indicated when measuring the social or economic phenomenon. International organizations, civil organizations, and advocacy associations often put the related measurement systems in shape. In the first case the output indicators are in focus used to monitor the direct results of the policy measure, while in case of bottom-up development outcome, even more so, the impact indicators can be the most important, showing the broad social and economic change. While research was previously focused on multi-purpose, unique indicators, recently indicator sets are gaining more and more attention. It is particularly popular in areas where international comparisons are relevant, and where complex phenomena are to be presented from multiple perspectives (Scott et al., 2014).

Measuring prevention is atypical in the sense: we can't see it, we can't know, if it has happened (household surveys are based on self-declarations, or the reduction of the amount of waste may not be attributed solely to prevention). In addition, if prevention may be clearly identified as cause of waste reduction, one may not be sure that the specific action is regular, not accidental, or one-off (Sharp et al., 2010). There is, however, an increasing need to translate prevention efforts into numbers.

2.9 The role of environmental policies in waste prevention

The prevention efforts are formulated and decided upon by the environmental – more precisely the waste – policy. This subchapter attempts to clarify the theoretical background of environmental policy formation, to put waste prevention measures in a policy context.

The environmental economists are focusing on internalising externalities to achieve a better, fairer market mechanism in terms of valuing the used natural resources. Environmental policy is to adjust the shortcomings of market mechanisms, as well as to set goals and take measures for their achievement. The main tools for environmental policy are the direct norms and the indirect economic intervention tools (Kobjakov, 1994). The norms may form goals, set criteria usually for technologies or for materials (e.g. drinking water quality), or immission and emission cut-off values are set. Immission cut-offs are to keep good quality of the environment, while emission norms limit the output of damaging materials. The regulatory tools are the following with some relevant examples (Table 8):

Table 8 -Tools of environmental policy

Norms (direct regulation)	
prohibition	prohibition production and sales of certain single use plastic products (EU Single Use Plastic Directive)
permission	all economic activities related to waste are strictly subject to permissions, licences
norms (including monitoring and sanctions)	no emission norms are set for municipal waste; such limits are usually linked to waste management activities contracting for public waste managements service is mandatory for all real estate owners
Economic policy tools (indirect regulation	
taxes and fees	landfill tax to divert waste from landfilling product fee to be paid after polluting, avoidable products (e.g. plastic bags) deposit fee put on packaging waste to promote returning of recyclables by citizens
subsidies	in the framework of EU co-financed operational programs all waste management plants were modernised, including sorting of recyclables, composting units, presorting facilities of MSW, etc.
market creation	emission permit system does not exist in the field of waste

Source: own compilation based on Kobjakov, 1994

Good examples of economic policy tools for waste reduction are (Bizjak et al., 2020):

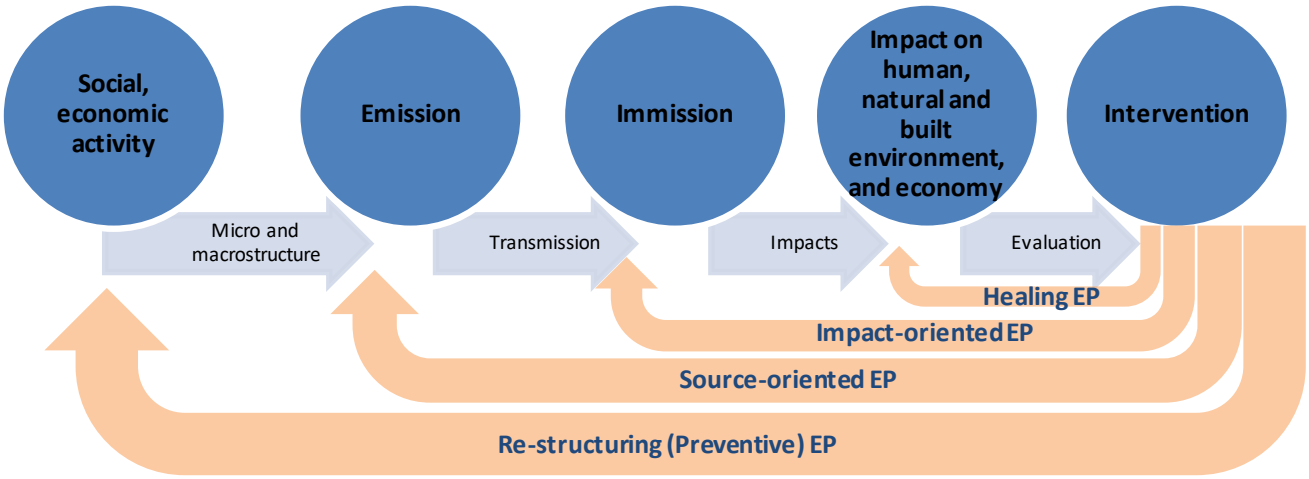
- Not only landfill, but incineration fee is also introduced in Catalonia to support waste management sector in moving upwards the waste hierarchy.

- Pay-as-you-throw system introduced in Contarina (Italy): waste fee paid by households on the basis of the generated mass of waste.
- Tax discount of food donations in Milan (Italy), and reduced VAT on reparis in Slovenia and the Netherlands.
- Sweden shifts tax from labour to resources (income tax decution on repairs and maintenance work).
- Extended producer responsibility scheme set in France for furniture and reuse targets as well, beyond the widely applied EPR for the increase of recycling of plastic packaging, paper, glass, metal.

Four models are usually distinguished when it comes to environmental policy (Nagy, 2012). In the French model the state dominates, direct and indirect tools are actively used. The English model builds upon the involvement of stakeholders, with regulations based on negotiations and compromises. Volunteer undertakings or the Best Available Techniques (BAT) are the typical products. The German model involves professional organisations in developing the regulation, while the American style environmental policy is the combination of the French and English model. The state calls upon the opinion of stakeholders then sets strict regulation as the borders of the playground where free competition can take place. Given the fact that waste prevention of MSW is heavily relying on households rather than waste management sector players, and is based on and atypical processes the involvement of stakeholders seems to be necessary. It might not be accidental, that the most comprehensive analysis of waste prevention methods was run in the UK.

According to the point of intervention in the pollution chain 4 types of environmental policies may be differentiated (Kerekes et al., 1996) (Figure 20). The "healing" environmental policy is correctional. It takes action when the pollution happened, and it already has an impact on the environment (e.g. reduction of damages of illegal dumping). The impact-oriented policy focuses on improving the quality of the environment leaving immissions intact (e.g. making a landfill safe). The source-oriented environmental policy is the most popular, its main goal is to reduce the emission of harmful substances (e.g. in case of waste, putting limits on incineration emissions). The re-structuring environmental policy goes back to the origins and applies major changes that shift the entire economy and society to a more environment-friendly operation.

Figure 20 - The pollution chain and intervention points of the environmental policy (EP)



Source: own compilation based on Kerekes et al., 1996

A research was carried via statistical analysis on environmental policies influence waste treatment (Marti et al., 2021). The Sustainable Governance Index (SGI) produced by Bertelsmann Stiftung for 41 EU/OECD countries evaluating national policies. The SGI has an Environment pillar including the subindices 'global environmental policy', 'multilateral environmental agreements' and 'Kyoto Participation and Achievements'. In each case the level of participation and the level of compliance with goals set was observed. Based on that 4 clusters were set up: cluster 1 including countries with medium participation and compliance to the three above mentioned fields. 10 EU-countries, Canada, Australia, UK and Iceland fell in this group. Cluster 2 countries had medium participation and low compliance levels, mainly non-EU countries. Cluster 3 did not have EU Member, the US, Turkey and Israel formed this group showing low participation and compliance with international environmental goals and agreements. Cluster 4 was made up of Eastern European countries except for Belgium. These countries are medium in participation and high in compliance. Finally, Cluster 5 categorized countries with high participation and medium compliance. These countries are generally the oldest EU Members, Norway and Switzerland. The waste generation performances of all countries were put besides the above evaluation. The medium-high environmental policy effectiveness corresponded to medium-low waste generation, with a medium-low policy effectiveness showed medium-high waste generation.

Defining the waste prevention policy characteristics above, comes the question of who and how shall implement the policy? The EU-level is giving the framework of the regulation, but details should be rolled out in the Member States. The principle of subsidiarity means that the policy decisions should always be made at the lowest level of public administration. At the same level where the policy

is going to have effect, and the level where the adequate knowledge of circumstances is given. This leads to the responsibility of local governments. Not only do they have to develop local environmental policy programs on a mandatory basis, but as a cross-cutting, horizontal topic, elements of resource savings should be built in every other policy. Regarding the implementation, they have to implement the national and local level environmental policies by local tools and measures. Local governments have two types of duties (Farkas, 2021): first, they are local authorities responsible for enforcing law. Second, local governments have to act with due diligence, demonstrating that they shall protect the public good, the natural resources. Public policies fail to be effective when the public good cannot be seen directly, and is difficult to understand (Kerekes et al., 2018). Thanks to public services the waste is removed from the vision of households via waste collection systems, the public good does not seem to be threatened. If there is no perception, no political attention is paid. Nonetheless, if waste prevention is viewed as a series of local community actions, which can be very much seen, and goodwill of the local government can be built by them – on the cost and work of participating households – the option seems politically more viable.

It is essential to link environmental policy and monitoring. Indicators have three basic functions for the environmental policy: they give information on environmental problems, support policy development, monitor effects of policy response, and one additional goal is to raise awareness (Smeets et al., 1999). These may appear in the form of descriptive indicators (see DPSIR indicators), performance indicators measuring performance against targets, and efficiency (or intensity) indicators give information on the extent of environmental pressure.

There is no doubt, that waste prevention expecting new patterns in production and consumption calls for re-structuring in the environmental policy. Waste prevention means reduction of demand or choice of alternative products (e.g. package free products). Alternative products come together with alternative technologies (e.g. bulk distribution or reusable packaging) (Bartus et al., 2014). A demand of a product is always accompanied by materials that the consumer does not demand: this is the by-product of waste. This is the form, how emissions are generated. Waste prevention thus means no emission is wanted.

3 The research “gap”, the added value of the research

The significance of waste prevention appeared in the EU legislation more than 40 years ago in the Waste Framework Directive of 1975. Albeit it is a priority field of waste management since 1998, the elaboration of the policy measures is missing for more than two decades, only lists of measures and collection of best practices are available (EC, 2009b). The mandatory waste prevention programmes did not bring solution either.

The 2018 amendment of the Waste Framework Directive (EU, 2018) deals more in-depth with prevention as a consequence of earlier ineffectiveness of the EU policy. It clearly sets out the framework of prevention policy development: "In order to ensure a uniform measurement of the overall progress in the implementation of waste prevention measures, common indicators and targets should be established." (Preamble (29)). "The Commission shall adopt implementing acts to establish indicators to measure the overall progress in the implementation of waste prevention measures" (Art. (10) 7.) "By 31 December 2024…The Commission shall also examine the feasibility of setting other waste prevention measures, including waste reduction targets. To that end, the Commission shall submit a report to the European Parliament and to the Council, accompanied, if appropriate, by a legislative proposal." (Art. (10) 7.)

This amendment to the Waste Framework Directive was preceded by the 2014 report of the European Environmental Agency (EEA, 2015) analysing Member States' waste prevention programmes. As a prospect, it states that "Indicators for analysing progress towards waste prevention objectives, as well as the effectiveness of specific measures, could be central research area in support of efforts to move up the waste hierarchy."

Not only the EU policy is calling upon waste prevention measures and indicators, but the UN Sustainable Development Goals (SDG), adopted by Agenda 2030 (UN, 2015) by 189 countries, also addresses the issue. The SDG Goal 12. "Ensure sustainable consumption and production patterns" is one of the most controversial goals. It is basically the undertaking that should primarily be borne by economies of well-being (Graczka, 2023) through rationalisation of production and consumption, other goals are rather focused on the progress of developing countries. This goal includes the target (12.5) stating: "By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse". The indicator (12.5.1.) officially assigned to this target is: "National recycling rate, tons of material recycled". The methodology was developed among the last ones in 2020 and the indicator is classified as Tier II by UN Statistical Division meaning that methodology is adopted, but no data is available (i.e. that more than 50% of signatory countries cannot provide such data). Recycling rate is the only indicator in case of this target. Again, this proves that waste prevention exists as a target, but there is no clear definition, there are no consensual measures and indicators, so policy makers at UN level rather not deal with the monitoring issue at all. This, however, must be put right over time.

Almost every literature reviewed on municipal waste prevention refers to the lack of clear and comparable waste prevention monitoring as a given circumstance. The review confirmed that there is no standardised indicator or set in use, and that waste prevention is contextualised in multiple domains (waste management, material use, zero waste, sustainable development). In the monitoring

methodology research two approaches could be articulated: first, developing indicators sets usually based on available data, second, developing composite indices closely related to theory, but often lacking data. O Zacho et al. (2016) has found that within the domain of waste prevention, the least addressed topic in the scientific literature remains monitoring. Waste prevention and reuse play minor role in countries, compared to recycling, and for a better policy approach the transformation of waste management to integrated resource management is called upon, together with context sensitive incentives, the necessity of policy-mixes and need for policy coordination along the value chains (Wilts, 2016). The most frequently used MSW (municipal solid waste, used as synonym for municipal waste) generation indicators are inappropriate for evaluating the effectiveness of prevention measures (Salhofer et al., 2008), monitoring faces the problem of missing methods, and lack of data availability (Zorpas et al., 2013).

4 Research design and methods

4.1 The research questions

Main question: **"How can waste prevention be monitored in the European Union?"**

Supporting question 1: **Which social, economic, and environmental factors affect the waste prevention?**

Supporting question 2: **How does waste prevention appear in the EU and Member States policies?**

Supporting question 3: **Which are the commonly used waste prevention indicators?**

Supporting question 4: **Are there other, more appropriate indicators for the measurement of waste prevention?**

Potential factors which have impact on waste prevention examined are in the hypothesis.

The successful execution of the waste prevention programmes (required by the WFD, Art. 29) relies on how these programs can be filled by concrete actions directly linked to the reduction of waste (excluding recycling) but taking effect on production and consumption before the waste status. Currently, there are no standardised methods for prevention, it seems inevitable to identify and define at least the most important ones at an international level. The methods vary from country to country (Corvellec, 2016) as they are characterised by different social, economic background and knowledge level, and obviously this leads to diverse levels of environmental performance. The 'toolkit' (WFD Annex IV) from which countries or regions choose their ideal mix is the same for all member countries. A waste prevention policy measure can be assessed effective, if it has distinct, direct, measurable, positive impact on the amount of MSW avoided.

Comparability of data relies on a harmonised methodology for data collection and processing. Ideally, comparability should be provided at local levels (LAU 1-2) for national decision-making and at NUTS 1-3 levels for EU policy-making, but the absolute minimum is the national level aggregate.

Measurement criteria is developed in detail during the research, based on documents of international standards. Ideally, the objective is to define indicators covering the process of consumption and waste generation giving more detailed information on waste avoidance. In case of EU-funded grant projects, the output is often measured solely, e.g., in case of an awareness raising campaign the number of actions, leaflets distributed, or the number of people reached, etc. are recorded. Local campaigns, however, give good, but not enough basis for the measures, if output and MSW generation is combined. The measurement shall be assessed effective, if it is conform to the current European Statistical Systems' prescriptions, and it expresses the direct connection of a waste prevention action and the amount of municipal solid waste avoided.

Savings in natural resources, the increase of productivity in production and effectiveness of consumption, and in some cases the rationalisation, i.e., reduction of their volume may lead to the prevention of waste. Indicators measuring these fields could contribute to more detailed and concrete legislation and policy measures at the international, national, and local level. It is crucial to identify the places of the developed indicators in the international and national strategies, as waste prevention is cross-cutting in terms of policy fields (Wilts et al., 2016). Economic incentives and sanctions to promote prevention should also be reviewed.

The accountability of the environmental policy requires so far non-existing waste prevention indicators for monitoring performance based on standards. Defining concrete, measurable actions reduces the political risk (Wilt, 2018) of decision makers committed to waste prevention. Appropriate indicators do not only serve as monitoring and feedback to policymakers, but in the political communication the topic of zero waste could be addressed with less risk if data and measurement methods are available to prove performance.

4.2 The hypotheses

The main question is how can waste prevention be effective in the European Union? The answer to that shall be descriptive. Hypotheses based on the research questions are as follows:

- Main question — No hypothesis (descriptive answer expected)
- Supporting question 1 — See hypothesis in Table 9
- Supporting question 2 — No hypothesis (descriptive answer expected)
- Supporting question 3 — No hypothesis (descriptive answer expected)

- Supporting question 4 See hypothesis in Table 9

The main question of the research has no testable variables but describes a situation that has not been described before. As there is no testable variable for that, there is no testable hypothesis either. The same stands for Supporting question 2 describing the appearance of waste prevention in the EU policies going down to local level.

Supporting question 1 is based on statistical analysis observing casual relations among demographic data and waste generation, which requires the setting up of a hypothesis. The same stands for the Supporting question 4: "Are there other, more appropriate indicators for the measurement of waste prevention?", as in this case in search of new or complementary indicators the relation should be examined with the dependent variable. It is assumed that raw material consumption and household consumption may have an effect on waste generation.

The dependent variable is the mass of municipal waste generated per capita.

To understand the mechanism of waste prevention, and to identify the effective measures factors should be examined which supposedly have effect on the level of avoidance. Wide range of socio-economic indicators have effect on the waste generation (Kawai et al., 2016).

The null hypothesis (H_0) states for all of the Models that there is no casual relation among the following independent variables and the dependent variable. Meanwhile H_1 hypothesis is that there is casual relationship between the independent variables and the dependent variables of the Models below.

Table 9 - Null hypothesis for indicators

Model	Group	Domain	Testable variable	Why is it part of the model?
Model1	Supporting question 1	Population	Median Age of population	Supposedly, as people age they accumulate goods in their lives reaching saturation as getting older, in addition, children in the household generate lot of waste (nappies, outgrown clothes, toys, lot of damages, etc.)
		Population	Average household size	The size of the household has positive effect on the amount of MSW generated, but less falls on per capita.
Model2	Supporting question 1	Consumption/ Population	COFOG (classification of functions of government): Education	Government spending education, leads to higher level of education, increasing consumption, knowledge and consciousness.
		Consumption/ Population	Mean consumption expenditure by degree of urbanisation, cities	Consumption expenditure of population living in cities is particularly important they are the main waste generators, and waste increases as consumption increases.
Model3	Supporting question 1	Consumption/ Population	Real gross disposable income of households	The income level defines consumption level

		Consumption/ Population	Consumption footprint[1]	The higher the consumption footprint, the higher the amount of waste generated.
		Consumption/ Population	Gini coefficient[2]	The level of wealth distribution has an effect on waste generation, the higher inequality could lead to higher waste generation with wasteful consumption.
Model4	Supporting question 4	Material use/ consumption	COICOP (classification of individual consumption by purpose) total per capita	As consumption of all purposes increases waste generation is expected to increase.
		Material use/ consumption	Raw material consumption per capita	Increasing material consumption probably leads to increasing waste.
		Material use/ consumption	Recycling per capita	Recycling may increase waste generation having a 'pull' effect.

Regression analysis shall be carried out with these small models with few variables, to understand the linkages between the variables. The model size is adjusted to the small size of the sample (EU-27 data).

Effective policy measures and monitoring has an overall effect on the waste avoidance and should reflect the linkages to be revealed among these factors and MSW avoidance.

4.3 Methodological choice

In geographical terms the scope of the research is the European Union and Hungary. The EU is a major consumer and producer of the world, having huge ecological footprint outside its borders (see example: Palm et al., 2019). It does have a responsibility in implementing its waste prevention concept, instead of transferring environmental problems to regions with weaker environmental regulation. The implementation of and effective Union-level waste prevention policy would have significant effect given the key role of the EU in global economy. Members States should also stand as role models to developing countries, rationalising consumption and production could ease tensions between the North and South. This is an actual issue, as waste prevention is not only a goal set in the EU, but it is one of the targets of the 2030 Agenda for Sustainable Development adopted by the UN General Assembly. The EU is also a deliberate choice for its supranational entity with common environmental policy mandatory for Member States. This means, that Member States are obliged to harmonise their legislation with EU law. Waste is dominantly regulated by directives in the EU which set the framework including strict targets for waste management. The delays in achieving the targets

[1] Consumption footprint is developed by the EU Joint Research Centre, and includes 16 impact categories and five areas of consumption (food, mobility, housing, household goods, appliances). Impact categories comprise resource use of fossils, minerals and metals.(EC, 2024a)

[2] Gini coefficient of equivalised disposable income is defined as the relationship of cumulative shares of the population arranged according to the level of equivalised disposable income, to the cumulative share of the equivalised total disposable income received by them. The equivalised disposable income is the total income of a household, after tax and other deductions, that is available for spending or saving, divided by the number of household members converted into equalised adults; household members are equalised or made equivalent by weighting each according to their age, using the so-called modified OECD equivalence scale. (Eurostat, 2024a)

(e.g. recycling, landfilling) are subject to infringement procedures against Member States. For this reason, the legislations on Member States closely follow that of the EU. This gives the reason why the document analysis follows the legislative hierarchy.

In contrast, the UN Agenda 2030 is a non-binding resolution, consequently less effective in implementation. Environmental policies are closely linked to the concepts of neoliberal institutionalism (Saryal, 2015) gaining lot of critiques nowadays. Global environmental problems, however, can only be solved in collaboration of nations, with appointed institutions responsible for coordination and supporting implementation. Key players are states and non-state actors, such as NGOs or supranational organisations, whereby the EU is one of the best examples being signatory of international agreements, playing key role in international environmental politics.

Hungary is a choice due to physical, financial limitations of the empirical research. Observing the efficiency of the EU and harmonised local waste prevention policy, Hungary as a Member State should provide relevant data.

The scope of the research is limited to municipal solid waste. Although municipal solid waste represents 10% (2021) of the total waste generation according to Eurostat, the generation is continuously increasing since the negative effect of the financial crises passed. It relates to the largest number and most heterogeneous composition of actors and preventive actions. Even though the industrial waste production is much higher in volumes, it remains relatively homogenous with lower number of waste producers, than households in case of MSW. In consequence, municipal solid waste is the greatest challenge to reduce.

There are two types of approaches in classifying waste streams within the EU. The European Waste Catalogue (EWC) is a statistical nomenclature which is substance-oriented, while the List of Waste (LoW) classification is rather for administrative purposes, authority operations. LoW categories reflect the economic activities and the typical waste types generated by them. Data reporting of Member States is based on EWC (see Annex III for the scope of municipal waste based on LoW codes, that is later converted to EWC). Municipal waste includes (Eurostat, 2016) mixed waste, separately collected paper, paperboard and paper products, plastics, glass, metals, food and garden waste and textiles, but also other types of waste as batteries, e-waste, etc., if those are generated by households or units producing similar waste to households. Municipal waste also comprises bulky waste, street cleaning waste, litter containers' waste and green waste from public space maintenance. By definition (Eurostat, 2016) it is generated primarily by households, but also small businesses, commercial units, services, offices, and public institutions (e.g. schools, hospitals, government buildings), if the substance is similar to that produced by households. To this green waste of public green area maintenance companies is added. The collection may be the traditional form for

mixed waste, and separate collection methods which mean either collection at waste yards, public containers, take-back systems (derived from producer responsibility) or door-to-door (collection). All of these provide source separation, which delivers much higher quality waste, usually for less cost respective to separation at waste management sites.

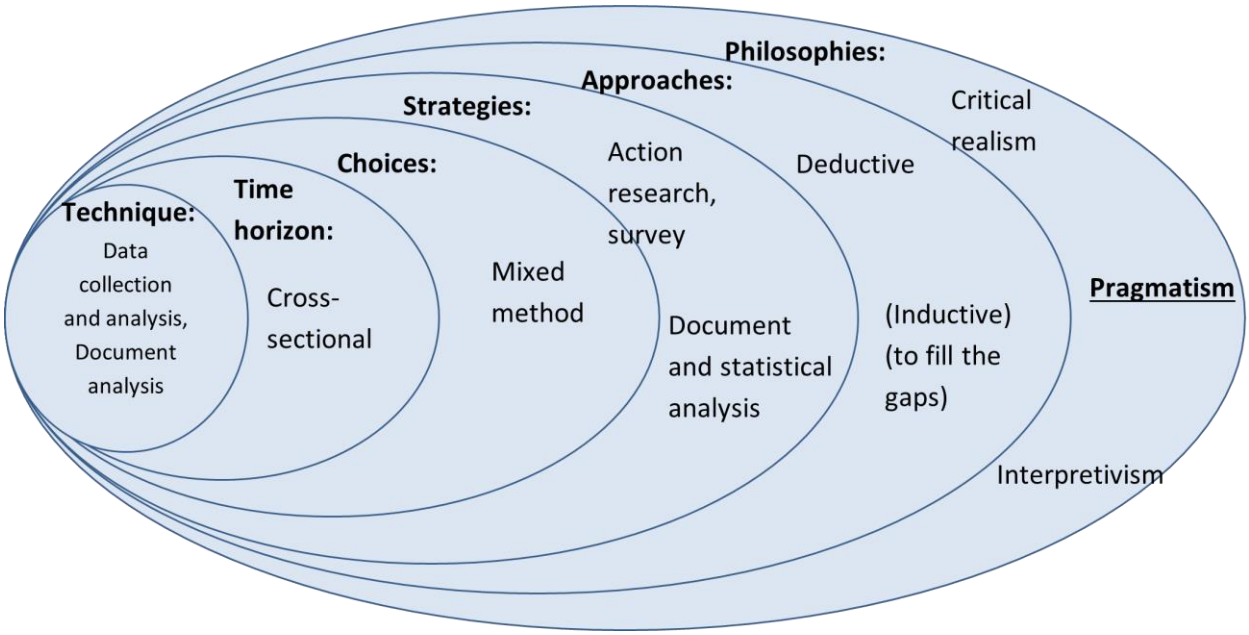
First undertaking of the thesis is to collect the waste prevention methods as environmental policy tools, because this field lacks systematic approach. There is also a need to clarify the relation of resource efficiency (and savings) and waste prevention – these terms overlap but have different policy documents due to different emphasis.

The research philosophy, defining the approach and research design, is described by the research onion model of Saunders et al. (2009). (Figure 21), aiming to apply objective or subjective views depending on the research question. Objectivism applies to waste prevention policy and statistical analysis, but the general ontological approach is critical realist (Bhaskar, 2010), while the implementation and impact of the policy, as well as the bottom-up input and innovation is observed from an interpretivist standpoint. Critical realism states that the reality is objective and exists independently from the human knowledge. It is against the anthropocentric philosophies, and pro to the bioenvironmentalist approach (see below). We need to understand the plains of human's material interactions with nature, the social interactions between people, the social structure, and the stratification of the embodied personality. This philosophy seems to fit the entire topic of waste prevention: the first plain is the consequence of other plains' problems. The human interactions – politics – determine the waste situation, and social injustice, inequality added to the problem. The social structure is something that needs to change – the consumer society must find new values, the primacy of economic, monetary approach should change, which should be supported by individual motivations and actions. Critical realists work for solutions by developing alternatives and keeping the unity of philosophy and practice (being responsive to the latter). According to Bhaskar we do not create society, but we can transform it, which is important because the human and social factor is dominant in waste prevention relative to waste management technologies, as pseudo-alternatives. Compared to other waste management tools, i.e. landfilling, disposal, recycling, which have dominantly objective, clearly measurable processes and outputs, prevention heavily depends on social and educational backgrounds, individual and collective motivations, attitudes, the availability of community fora, etc. To understand such aspects, subjective elements should be approached with empathy – were interpretivism gains ground. Waste prevention, or from another approach sustainable production and consumption, are in the intersection of the fields of sustainability: environment, society and economy. Beyond the social elements discussed above, waste prevention has

environmental and economic aspects, which may be objectively measured by life cycle assessment or life cycle costing.

The paradigm is a way of observing phenomena, leading to an understanding, an explanation. According to the classification of Burell and Morgan (Saunders et al., 2009) this research and the judgement is mixed, but rather radical, and less regulatory type in approach. The approach suggests the need of radical changes, a shift in today's consumer society in the mid-term. At the same time, the research attempts to contribute to the development of a regulatory framework which adheres to the above. The research approach is interpretive and functionalist at the same time. Besides understanding individual and collective motivations, the research focuses on objective, rational explanations as much as possible.

Figure 21 - Research onion



Source: own compilation based on Saunders et al. (2009)

As regard to the statement of values, it is necessary to set the axiological background of the researcher, to be particularly conscious about the filter used to understand phenomena. This is also important for sustainability. It implicates three often concurring fields (economy, society and environment), and the differing preference list of these may end up in evaluating phenomena with outcomes sometimes contrary to each other – waste prevention is a typical case of such. The researcher's priority is the following: environment, society and economy, believing in the ultimate setup of sustainable development where environment is the outermost set giving boundaries to society and economy. The set of society relies on the environment, but itself is providing sources to the economy. Economy relies on both environment and society.

Clapp et al. (2011) created four categories of environmental worldviews based on tools of political science, economics, development studies, environmental studies, political geography, and

sociology: the market liberals, the institutionalists, the bioenvironmentalists and the social green approach. The researcher primarily follows the bioenvironmentalist approach integrating large parts of the social green views as well. The starting point are the biological limits of the earth to support life, the carrying capacity – this is the main principle of bioenvironmentalists. Social greens see the social and environmental problems inseparable, focusing on problems of inequality and globalisation, offering local solutions.

The goal of the researcher is to contribute to the pathfinding towards the green economy, and to some extent integrate the concept of degrowth and the field of ecological economy in relation to dematerialisation. Infinite economic growth is out of question, a balance is sought were needs of individuals and communities are satisfied, at the same time, regeneration or increase of natural resources is made possible, by conscious, resource-light production and consumption.

The research approach is deductive and inductive at the same time. As expected, major part of the research shall be characterised by deduction: theory building followed by data collection and testing. The topic of waste prevention has a modest literature, and the research tradition is rather inductive, focusing on monitoring and analysing specific local actions, awareness raising campaigns, local statistics, or specific examination of waste streams. Generalisation is missing and is the challenge of this research.

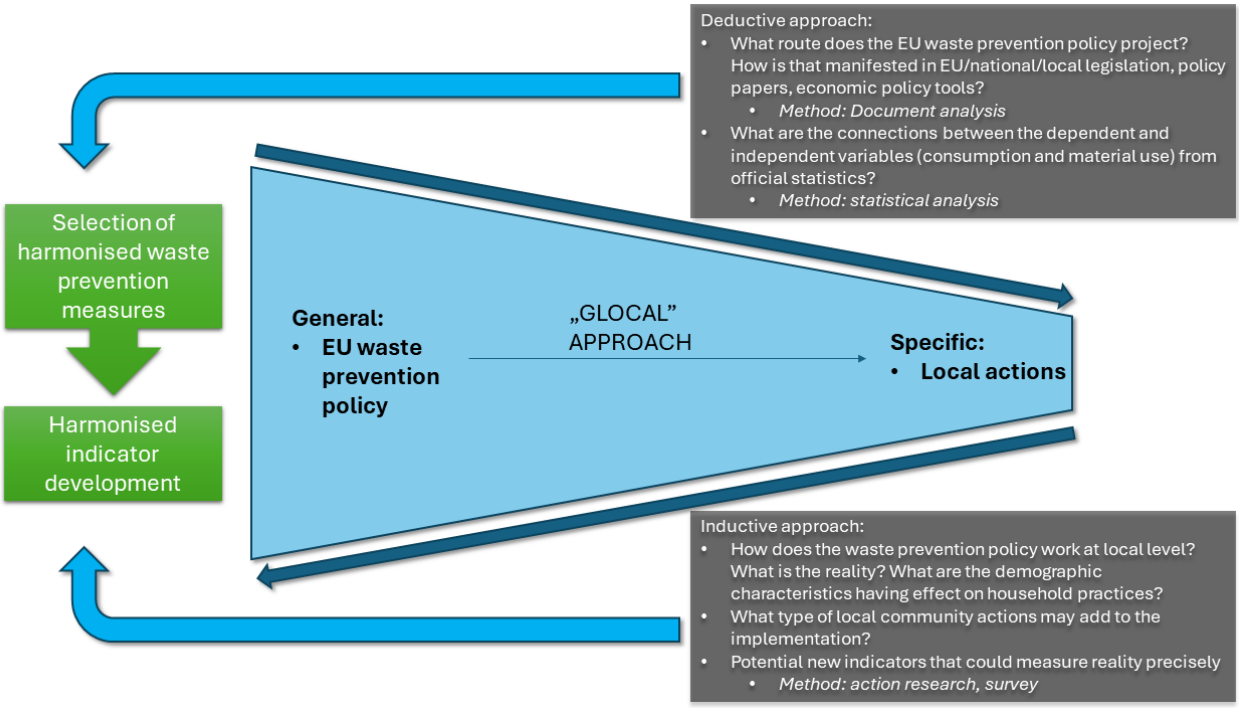
An inductive logic shall be necessary for testing the practice and gaining input on the policy-formulation of locals, citizens. This is the point when the human irrationality is expected to be revealed. Several case studies are collected mainly from secondary sources (e.g. best practice collections) and a specific event of a settlement aiming at community development of a local zero waste plan. Conclusion given by these are possibly used to develop generally applicable actions and measurements.

The purpose of the research is explanatory and evaluative: it aims to understand the links between waste prevention as dependent variable and social, economic characteristics of states as independent variables. It also assesses the impact of policies and include innovative elements with the final objective to draw up a well-functioning indicator set, measuring appropriate waste prevention measures and adequate for comparative analysis of countries.

The research strategy and methods are based on dual perspective (Figure 22): a top-down and a bottom-up approach. Top-down approach focuses on the policy objectives of the EU and follows them through the legislative hierarchy to Hungary. This gives a picture on how the waste prevention goal appears in different documents. The study covers the Waste Law (Act CLXXXV of 2012) and primarily its implementing measures, the National Environmental Programme, the National Waste Management Plan, and the National Waste Prevention Programme, furthermore all national strategies

where the prevention appears. The mandatory National Waste Prevention Programmes – including the most specific policy targets and actions in case of Member States – are also analysed. These documents are primary targets of documentary analysis. There is a broad variety of implementation levels within countries of the European Union, however, the national level planning is mandatory. On the other hand, the systemic change requires close coordination across the levels of government (Santonen, 2017). It is crucial to interpret national strategies at the local level.

22. Figure – Dual (top-down and bottom-up) concept of the research



Source: own compilation

Part of the deductive approach is to map factors having impact on waste prevention through a quantitative analysis. To maintain comparability within the EU, Eurostat database shall serve as the basis of statistical analysis. Existing relations shall be tested by correlation and if the correlation is significant regression shall be the next method of analysis. The sample size is relatively small, as data of EU-27 (2020) Member States shall be tested, this means that large number of variables cannot be entered into the model. The solution shall be setting up multiple small models. The outcome shall be confirmed by the fact, that even though the sample is small, but the data used represents millions of people, and is reliable. Given the relatively consistent data and that volatility is not typical at this level of aggregation one year shall be chosen: the most recent, with the most data available.

The bottom-up examination focuses on how the implementation of the waste prevention policy takes place and its impact in real world, as well as collecting practices working in real life appropriate to integrate them in the policy tools. Research method involves local government, citizens and other stakeholders in common thinking and community action in the selected settlement. The method shall

be action research, as there is deal made that following a workshop with stakeholders, and a population among citizens of the chosen city, Zsámbék, a Zero Waste Strategy shall be prepared by the author for the city. In other Member States taking research action is physically limited, however, best practices of other countries have value added, and shall be collected from relevant documents and literature.

For this reason, the research strategy integrates two different approaches with two different research instruments, all of them primarily answering the question of "why" and "how". These examinations shall lead to a comprehensive understanding of the waste prevention policy's implementation, the gaps, the efficient parts and the malfunctions are identified, and a set of generally applicable tools (by all Member States) are developed together with proposals for indicators for monitoring.

It is an objective to understand adverse and common interests. This is supported by the ongoing discussions due to the researcher's job responsibility with stakeholders, such as the Ministry of Energy Affairs, the new waste concession holder (Mol Zrt.), the local government officials, business representatives, NGOs and other experts of the field and the responsible policymakers. This provides first-hand information on the topic. Continuous flow of information is also provided at the EU-level from discussions held in the Waste Working Group of the Eurostat, the working group discussion, and workshops within the Eionet expert network run by the European Environmental Agency. European Environmental Bureau and Zero Waste Europe as an EU-level umbrella organisations of expertise are also appropriate source for background information.

According to the above, mixed-method research will be applied. The multiple data types – qualitative and quantitative –, and different methods for analysis is necessary for triangulation to validate research findings by using independent sources. The qualitative data is also used to fill in the gaps of quantitative data, as it is assumed that below national level the existence of waste prevention plans, strategies or other regulation shows variety, causing difficulties in comparability. In this case, qualitative data collection may be appropriate for the research.

As the first step of the development of the indicator or indicator set the top-down and bottom-up approach experiences including policy and legal characteristics, and local level actions, good practices shall be taken into consideration. The task is to conceptualize the indicator or set of indicators, by specifying the rationale (specific policy/strategy vs. general concept), the purpose (e.g. monitoring, benchmarking, controlling), the scope (multi-topic vs sectoral), the establishment procedure (unilateral vs participative), the target audience (politicians, policymakers, researchers, general public) and the geographic level (local, regional, national, international) (ESTP, 2018).

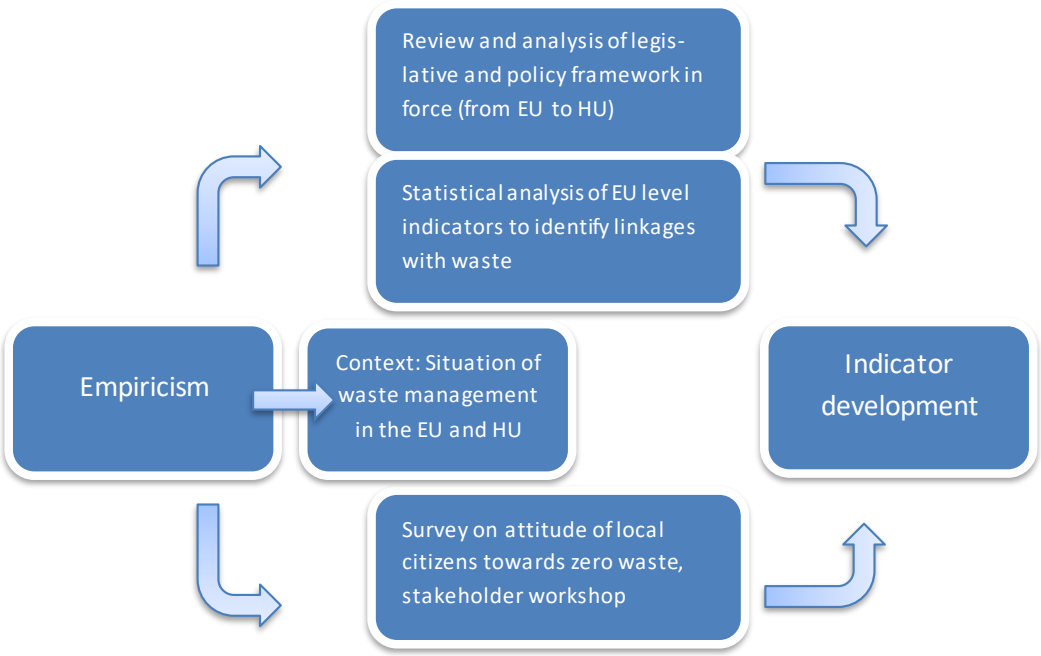
The selection criteria of indicators are based on the compliance with statistical principles, the quality of data and the compliance with the policy tools. Target audiences and users are also important in identifying the indicators and in communicating them in the appropriate way.

A dual approach is planned in the indicator development that should lead to feasible measurement. From one side, the research shall be intentionally limited by cost-effectiveness and quality data availability by relying on official statistics. On the other hand, as part of the inductive approach monitoring should also be linked to the local waste prevention actions in policy development. The probability of developing directly applicable indicators with this method are low – solely due to cost reasons –, but from a policy aspect information sourced from the point of action should have considerable effect on the final, acceptable indicators. Locally developed indicators may also gain grounds as future proposals requiring development of data collection and processing system to produce national aggregates.

5 Empirical research

The empirical research has two directions as presented in the previous chapter (see Figure 23 for more details), but as a first step waste prevention should be put into context by presenting the waste situation in the European Union and Hungary.

Figure 23 – Tasks in the empirical research



Source: own compilation

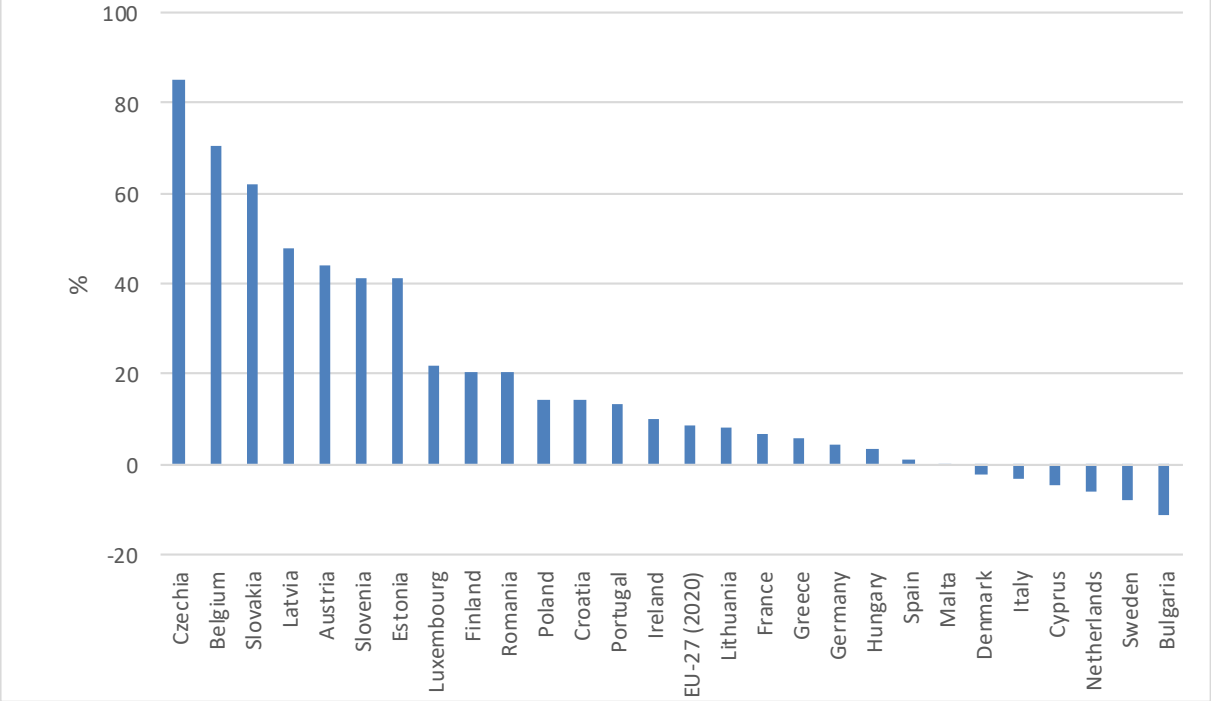
Following that the document analysis and data analysis related to waste prevention policies and economic incentives shall take place. National Waste Prevention Programs of the EU Member States are also analysed, with particular focus on monitoring, and currently used indicators for waste

prevention are discussed. The second part puts forward the outcomes of the Zero Waste Workshop carried out in the settlement of Zsámbék for stakeholders focusing on existing actions, and community and local level initiatives and their methods for monitoring. A survey targeting local citizens knowledge, habits and preferences shall be also carried out.

5.1 Waste situation in the European Union and Hungary

As a first step of the research, we need to understand the waste management and treatment situation in the European Union, which is most convenient by looking at the numbers. To have a view on the change of MSW generation in time, the ratio to the base year, 2010=100 was calculated in case of each country. 7 Member States have experienced decrease in their waste generation, while 20 of them raised their generation of municipal waste (Figure 24).

*Figure 24 – Generation of municipal waste in the EU-27, 2021, % (2012=100)**

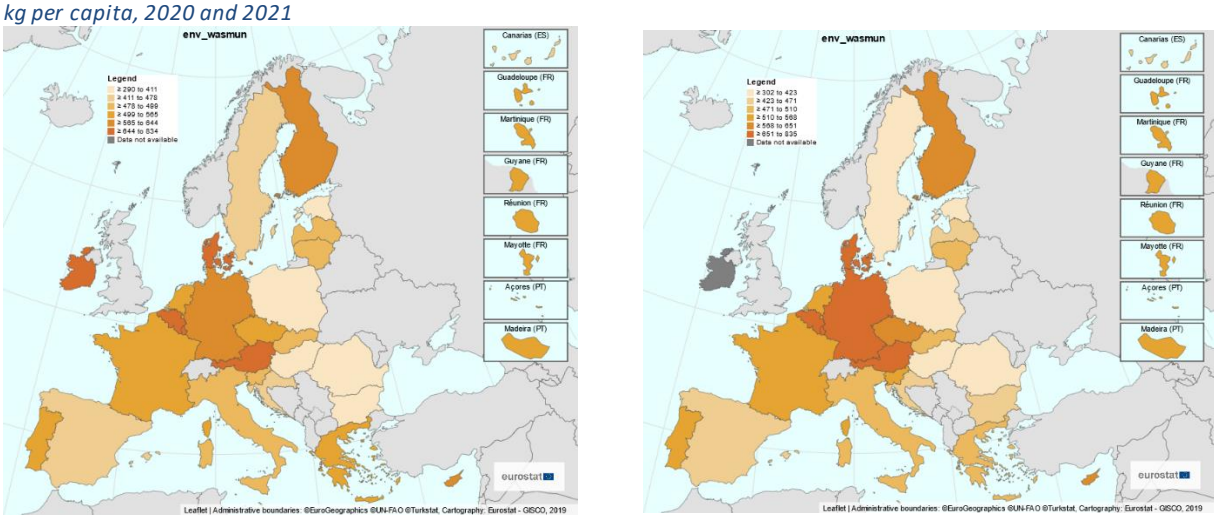


**For Slovakia, Luxembourg, Portugal, EU-27 and Spain – data of 2020, and for Greece 2019 was considered*

Source: own compilation based on Eurostat data (env_wasmun)

It should be noted that the decrease is characteristic for countries relying on tourism. The pandemics probably had an effect on numbers of all countries. Also, the biggest waste generators are in the negative sector of the graph, which could be associated with the local policies' commitment towards waste reduction. The Eastern Member States are rather concentrated among those facing intense growth in waste generation, unlike Hungary.

Figure 25 – Municipal solid waste generation in the EU-27, kg per capita, 2020 and 2021



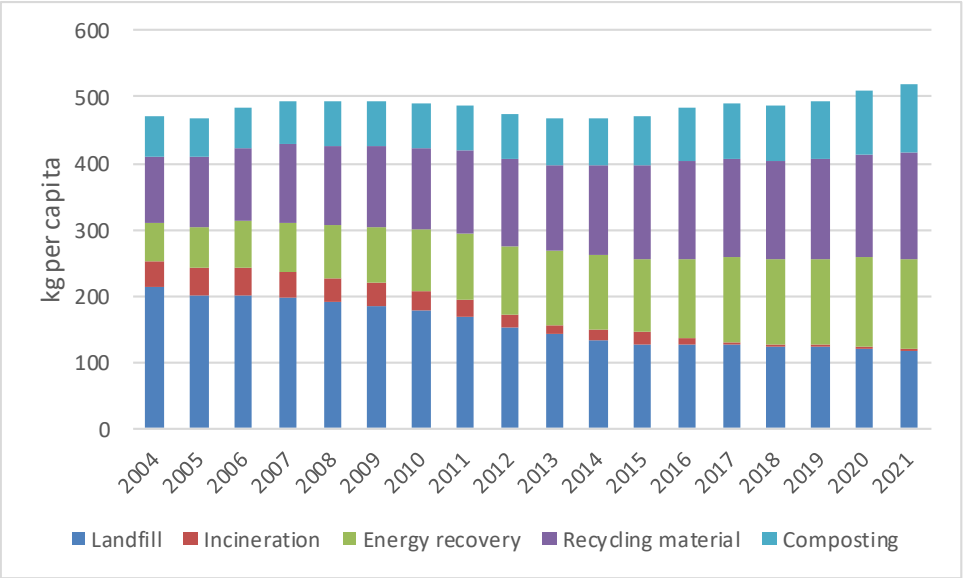
Source: Eurostat, 2021a

Besides the dynamics of the changes is waste generation, the current situation is also important for comparison. It is clear that the most significant waste generation is associated with the most developed Members States, while CEE Member States and lately acceded countries – even though intense in growth – are rather moderate compared to them (Figure 25).

In spite of the usefulness of the waste generation as an environmental pressure indicator, international comparability is not fully assured because of inconsistent national definitions of MSW and unreliable data on MSW generation per capita (Kawai et al., 2015). There are inconsistencies in MSW data, particularly before the Regulation (EC) No 2150/2002 on waste statistics was adopted, creating a framework for harmonised Community statistics in this field. Only from 2004 it became compulsory for Member States to report regularly – every two years (except for MSW reported annually) – on total waste generation and treatment, but still, reliable statistics in municipal solid waste generation is key issue (Eurostat, 2019). Even today the term of municipal solid waste covers different waste streams, data collection and elaboration methodologies from country to country within the EU. Hungary has integrated EU standards in 2004 for the waste management sector.

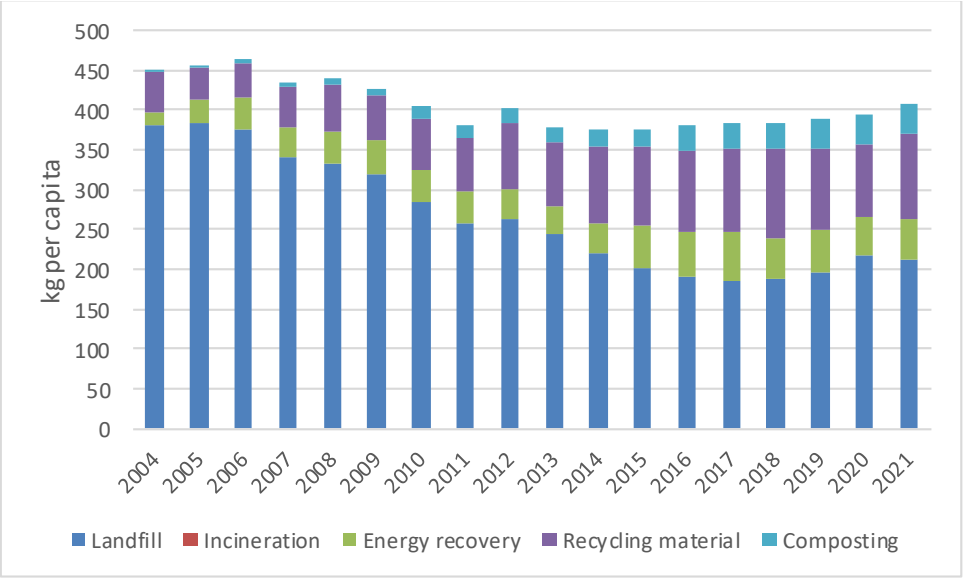
In 2021 the MSW generation per capita in the European Union was 519 kg – demonstrating a 52 kg/capita increase since its lowest point (2013) in the past ten years. Similar path is seen in Hungary reaching 408 kg per capita in 2021 following a slow but steady growth since 2015 adding up to a 32 kg/capita increase (Eurostat, 2021a) (Figure 26 and 27). Parallel to the recap of the economies an increase in MSW generation was experienced. These simultaneous changes with the uptake of the economy are indicating the lack of decoupling. Following the crises of the past years, the recap of the EU economies is likely to further boost waste generation creating a growing gap between environmental policy priorities and the reality.

Figure 26 – Waste treatment in the EU-27



Source: Eurostat, 2021a, env_wasmun, own compilation

Figure 27 – Waste treatment in Hungary



Source: Eurostat, 2021a, env_wasmun, own compilation

The income elasticity of non-hazardous (i.e. municipal and packaging waste) in the EU might go under one in the medium term, but it is not negative (Mazzanti, 2008), suggesting that decoupling cannot become reality. A growing consumption is expected, and even, if recycling rates rise the environmental pressure will further increase for the growing waste generation.

5.2 The regulatory background and financial incentives

5.2.1 The waste policy of the European Union

The key legislative document is the Waste Framework Directive (2008/98/EC). In 2008 the primary aim of its thorough revision was to feature waste prevention. This legislative document defines and regulates prevention and pins down the priorities ranked by the waste hierarchy. The

WFD includes a list of examples for prevention activities admitting, that the list is not comprehensive (see Annex IV). The list covers measures having effect on the framework conditions relative to waste generation including the promotion of resource efficiency, R&D for cleaner production, and the most important element for this research is the development of appropriate indicators for prevention at all levels. The second group of examples refer to the design, production, and distribution phase less relevant from local governments' point of view. The third category covers consumption and use phase. The promotion of prevention means payment for packaging, awareness raising campaigns, eco-labels, and consumer information, the integration to public and corporate procurement, and finally, the promotion of repair and reuse centres with all types of measures (including education, logistics, etc.). This is the priority category for local governments where they can play a key role providing incentives for individual and community actions, and infrastructure for prevention activities.

Another important regulation affecting prevention is the new Waste Shipment Regulation recently adopted (2024/1157). As a basic rule, countries should solve waste management based on the principle of proximity. This means that each country should manage local waste locally. The fact that the European Union is the largest exporter of non-hazardous waste for recycling all over the world (EC, 2024b) shows the significance of the topic. In 2014-2016 there were numerous amendments made after the scandals of all kinds of illegal shipments (e.g. e-waste in Nigeria, ship dismantling in Bangladesh, etc.). The regulation primarily focuses on making shipments transparent, which is crucial, because as long as illegal shipments exist, there is no pressure towards waste prevention.

Another set of regulations refer to the end-of-waste status – of iron/steel/aluminium, copper and glass –, which is crucial in identifying the limits of scope of waste legislation. These regulations define the criteria for waste to become product again (e.g. secondary raw material); from that point the material it is excluded from the scope of waste legislation. What is still missing is defining the beginning of waste status. The borderline appears between prevention and preparation for reuse, but the lack of defining reuse operations properly causes difficulties in prevention. This is because reuse is part of prevention: a second-hand product does not enter the waste status, so its sales is basically operation of prevention. Whereas preparation for reuse is about a product first becoming waste and then mended to become a second-hand product again. The basis of decision currently is the intent: whether the owner intended to give the product for reuse, or to dispose it as waste. This is, however, hard to define subsequently.

There are directives setting the conditions of waste management operations such as incineration and landfilling, cut-off values are set for industrial emissions and for port reception facilities (these play an important role in shipments); these all follow the priority list of the waste pyramid.

Some waste streams (e.g. car wrecks, e-waste, etc.) are also regulated separately due to the notable differences in their characteristics and their management. These often include quantitative targets on recycling (e.g. in case of car wrecks min. 85 per cent should be recycled, or in case of e-waste Hungary has an obligation to collect 4 kg per capita annually for recycling), but all of them refer to prevention as a priority, usually lacking concrete measures.

5.2.2 National level regulatory framework

How do the above regulations appear in Hungary's national waste regulations? The first Waste Management Law (Act XLIII of 2000) was put into force quite late in Hungary in 2000 urged by EU environmental requirements. Official data collection started from 2004. As a consequence of the WFD revision in 2008, Hungary also had to demonstrate its deeper commitment towards waste prevention which ended up in adopting the new Waste Law (Act CLXXXV of 2012).

A series of decrees were designed to support implementation. The main topics of these are public service provision, special regulations on single waste streams, waste management sites, documentation, data provision, waste management planning, permission processes and sanctions – each of them conform to the waste hierarchy, mentioning prevention were appropriate, but major part of them not setting concrete targets or measures on prevention. Besides the 37 government decrees 24 ministerial decrees and 4 municipal level decrees are due in 2019. At the time of the adoption of the Waste Law only 11 of these were adopted, and even today, there are decrees that are either missing or not being revised, not adjusted to the new law. More than 300 amendments were made to the Waste Law since it has entered into force, so the regulation is not stable causing lot of confusion on the waste management market, not to mention the total restructuring of the market several times in the past 20 years.

The other law closely related to waste prevention is the Product Fee Law (PH, 2011). The WFD introduced the concept of 'extended producer responsibility' (EPR). It is based on the 'polluter pays' principle, and it declares that producers as generators of waste are not only responsible for managing the waste emitted by them – as earlier according to the original WFD, before revision –, but are also obliged to deal with the environmental impact of all phases of the production, in other words, they are made responsible for waste prevention in production. The concept of EPR is very much supporting prevention, as the legislators intend to rise prices of polluting products by tax, diverting consumption towards more environmentally friendly items. In Hungary, the EPR means that producers are responsible to recollect waste streams particularly polluting the environment (e.g., e-waste,

medicines, etc.), but it also means that producers are obliged to pay the so-called product fee on polluting products, which covers the costs of state-run waste separate collection. An additional government decree (80/2023) was adopted based on the EPR expectations of the EU containing the detailed regulation of the EPR system entered into force from July 2023, which is about the deposit fee and take-back system to be operated by Mohu Zrt, but financed by producers or first importers. Retailers take part, provide the space for the machines.

5.2.3 The EU policy documents

The 'historical' policy programme paper for waste prevention is the Environmental Action Programme (EAP), which was first adopted in 1973. In the 7th EAP (EU, 2013) one key priority was to increase resource efficiency in the EU. It included a strong declaration on achieving a structural change in production, consumption, and innovation, to reduce the resource use, among others to prevent waste. This means that it is not enough to reduce the resource use to the extent of cost saving, but we should push further, and change deeply embedded patterns of the economy. Structural change requires, at the first place, assignment of money value to environmental externalities. The latest adopted 8th EAP (EU, 2022) reinforced the objective of "advancing towards a regenerative growth model, decoupling economic growth from resource use and environmental degradation, and accelerating the transition to a circular economy".

The EU2020 Strategy (EC, 2011a) was well-known as it is the core strategy for the EU. One of its three key priorities was sustainable growth. It tackles waste prevention from an economic point of view and through resource efficiency. It declared that investing in greening the economy and resource rationalisation shall lead to a competitive advantage of the European community.

The so-called "Flagship Initiative: Resource Efficient Europe" (EC, 2011b) was launched under the auspices of the EU2020 Strategy. It aimed at decoupling economic growth from growth of resource use, which is a crucial concept also in waste prevention. At EU level it fostered mobilisation of financial sources, and framing of market-based incentives; at national level the Strategy proposed to use regulation, standards, taxation, subsidies and procurement to guarantee reduction of resource use. A more detailed document entitled "Roadmap to a Resource Efficient Europe" (EC, 2011c) was also prepared in the topic, which set a milestone envisioning that by 2020 waste generated per capita should have been in absolute decline, this did not prove right, as the numbers are still increasing.

The Directive amending the WFD was adopted in May 2018 (EU, 2018), including the reform of the Waste Package with a focus on circular economy priorities. Initially, there were prevention targets included in the proposal, however the final wording did not contain such, most probably, because of the lack of measurability, and the contradictory forces of consumption and production rationalisation vs economic growth. The Packaging Directive (EU, 1994) and the Directive on Waste

Electrical and Electronic Equipment (EU, 2012) also mention prevention as first principle, but no binding measures are found.

One form of unrolling the Flagship Initiative was turning towards the concept of circular economy, part of which is waste prevention. The first Commission communication in the topic was entitled "Towards a Circular Economy: A Zero Waste Programme for Europe" (EC, 2014a). As it can be seen, even the title includes the concept of zero waste, the concept prioritising waste prevention. The related action plan was adopted in 2015: "Closing the Loop – An EU action Plan for the Circular Economy" (EC, 2015). Both documents were subject to strong lobbying resulting in looser targets, less restrictions on waste generation vs giving more space to recycling and recovery and business profits realised through those activities. At the beginning of 2018 the "Circular Economy Monitoring Framework" (EC, 2018a) was set up to give feedback on progress to policy-makers. As mentioned above, the waste generated as proxy indicator is included, all others are rather partial indicators for waste prevention.

The ultimate product of the circular economy policy is the "European Strategy for Plastics in a Circular Economy" which was a reaction to China's ban on waste import from January 2018. This affected severely the European Union, as 87% of its recyclable plastic waste was headed towards China earlier (Velis, 2014). Recent market data still show substantial plastic exports from the EU. New solutions should be developed, like reducing the plastic consumption – this was framed in the European Plastic Strategy (EC, 2018b) phasing out the production of some plastic products (e.g. straws, single use cutleries) and setting other restrictions. The analysis of this document was important to get an overview of measures. The strategy has set four main goals: first, making recycling profitable, by improving recyclability of plastic products and packaging, by improving the quality of separate collection and launching pledging campaign among recyclers and producers for offering and taking up plastic as secondary raw material within the EU. Driving innovation and investment and spurring global change were also among the goals. There was one goal directly linked to waste prevention: it aimed at curbing plastic waste. This led to the Directive on single use plastic products (EU, 2019a) setting out a roadmap with concrete targets by:

- 2021 - ban on production of plastic cutlery, plates, straws, drink stirrers, cups and food containers made of polystyrene, cotton buds and balloon sticks, as well as oxo-degradable plastics (market placement is not banned yet to let stocks run out);
- 2021 - cups, wet wipes, sanitary pads, tampons and applicators and tobacco products with filters should have clear labelling on their plastic content, recommended disposal methods and environmental risks should also be mentioned;
- 2024 - lids and caps made to stay on drinks' containers and bottles of up to 3 litres;

- 2025 - plastic bottles should be made of at least 25 % recycled plastic, and at least 77 % of plastic bottles of up to 3 litres should be collected separately;
- 2026 - EU countries should cut consumption of single use plastic cups and food containers compared to 2022;
- 2029 - at least 90 % separate collection of plastic bottles of up to 3 litres;
- 2030 - plastic bottles made of at least 30 % recycled plastic.

It is to mention that fishing gears and marine litter were also important issues during the development of the strategy, but these do not affect land-locked countries like Hungary. Overall, the plastic regulation is a milestone in waste prevention for listing concrete products to be phased out, applying deadlines and measurable targets. The shortcoming of the regulation is that it remains weak regarding the most sensitive field in plastic waste: the single use beverage packaging produced and wasted in huge amounts avoidable. The requirement is only to increase its recycled content and with the latest possible deadline within the strategy's timeframe. The EU and Member States build upon the producers and plan to have the above list implemented and financed via extended producer responsibility (EPR) schemes.

The role of waste prevention was further strengthened by the European Green Deal (EC, 2019) approved in 2020, continuing to prioritise the economic growth decoupled from resource use in 2019-2024, requiring a new circular economy action plan which "will prioritise reducing and reusing materials before recycling them". The New Circular Economy Action Plan (EC, 2020a) has a dedicated chapter on enhancing the waste policy to support waste prevention and circularity. Besides projecting a sustainable product policy focusing on design, it expresses the target to halve the (non-recycled) residual waste by 2030. This is also one of the priorities of the Zero Pollution Action Plan. And this is the document that required the revision of the Monitoring Framework for the Circular Economy.

The 8th EAP (EU, 2022) running until 2030 has the objective of "advancing towards a regenerative growth model, decoupling economic growth from resource use and environmental degradation, and accelerating the transition to a circular economy". This objective clearly requires the development of prevention tools, and this is underpinned by two other key objectives out of the six: "pursuing a zero-pollution ambition, including for air, waste and soil and protecting the health and well-being of Europeans" and "reducing environmental and climate pressures related to production and consumption". One headline indicator is total waste generation (kg per capita) for measuring the target of "waste prevention: significantly reduce the total amount of waste generated by 2030". This target was set by the Circular economy action plan and the Zero pollution action plan, COM(2021).

5.2.4 The national level policy documents

Basic document of the Hungarian environmental policy is the "National Environmental Program". The latest in force was the one covering the period of 2014-2019 prepared by the Ministry of Agriculture. The chapter on improving resource savings(!) and efficiency dealt with prevention issues. It is worth noting that the title of the chapter included not only efficiency, but also saving of resources giving stress to reduction of its use. The "5th National Environmental Program (2021-26)" (TIM, 2022a) was adopted with multiple years of delay. The program has dual approach through sustainable production and consumption. Regarding production, the key players are the government for providing an enabling and motivating legal framework promoting the shift towards sustainability, putting stress on the use of environmental labelling and environmental business management systems. Obviously, the main tasks are assigned to the producers. The consumption side is more diverse in terms of players. The government should widen the knowledge of consumers for environmentally conscious choices. Local governments, citizens, NGOs, the church, and the media also share responsibility in increasing consciousness. In the chapter of waste management reduction the objective of food waste reduction and the obligations derived from the Single Use Plastic Directive are included. However, quantitative targets are not set for specific measures, only for recycling. The indicators proposed are resource-productivity, total waste generated, and waste treated.

The "National Waste Management Plan (2014-2020)" was part of the "National Environmental Program", but the Plan for 2021-27 only includes reference to it as a basic policy document and is a separate document. The preparation of the "National Waste Management Plan" is an ex-ante condition from the EU to sign the Partnership Agreement and enter the new programming periods, enabling funds for Hungary. The same stands for the earlier, and the current National Waste Management Plan (2021-2027) (ITM, 2021): the documents contain a thorough situation analysis, but the planning part is moderate not going very much into details. The structure of the plan follows waste streams. Instead of being applied to each chapter as in case of all other waste management methods, waste prevention is isolated in an independent chapter, called the "National Waste Prevention Plan", which is obligatory since 2013 for EU Member States. The notions of waste minimisation and prevention are consistently mixed up in the document, probably on purpose (as other Member States also happened to do so).

The action plan includes the reduction of food waste being obligatory for EU Member States and focuses on loosening the regulation of "best before" labelling and quality that could make progress in food preservation, as well as corporate food donations. The setting up of county-level foodbank network is considered. However, when it comes to the description of implementation, the entire topic of food waste is dismissed.

A prioritised waste stream is construction and demolition (C&D) waste, reaching 98% of recovery in Hungary in 2020, according to data reported to Eurostat. The action plan promotes the rehabilitation of brownfield sites, proposes to establish a coordination body for matching demand and supply. Separate collection of demolition waste is emphasized, together with qualification system for secondary materials. It also calls for a preference system favouring clearly separated C&D waste by lower fee for management, and opening new takeover places is deemed important. The extension of the grants for concrete panel buildings is also considered (this is not mentioned in the action program, only among the measures). A progressive measure could be the introduction of obligatory recycled percentage in state or local government run constructions.

Reuse is the third topic covered by the Prevention Plan. The list of measures is centred around the establishment of reuse centres' network with a strict quality management system as condition to the permit. The identification of criteria and the social-based distribution is the task of the government. Businesses and government or local government could also engage in such operations, financial sources should be allocated to this measure, and communication campaign should be run. The network should be given professional support and coordination. The development of the deposit fee system is also mentioned, but no further information is given among the measures.

Green procurement strategy is expected according to the plan. This is on its way for more than a decade in Hungary, but it is clear that this objective is so weak, that green procurement rate as an indicator in the Circular Economy Monitoring Framework does not have available data at the EU level either.

The sustainable production and corporate operation are planned to be promoted through the quality management and environmental certification systems, the support of R&D and eco-design, the development of a CSR assessment system, the boosting of industrial symbiosis, and the saving of food waste by making the regulation on 'best before' quality more flexible.

As for the awareness raising communication campaigns, webpages, networking, event organisations and the introduction of waste prevention to the national curriculum are prioritized.

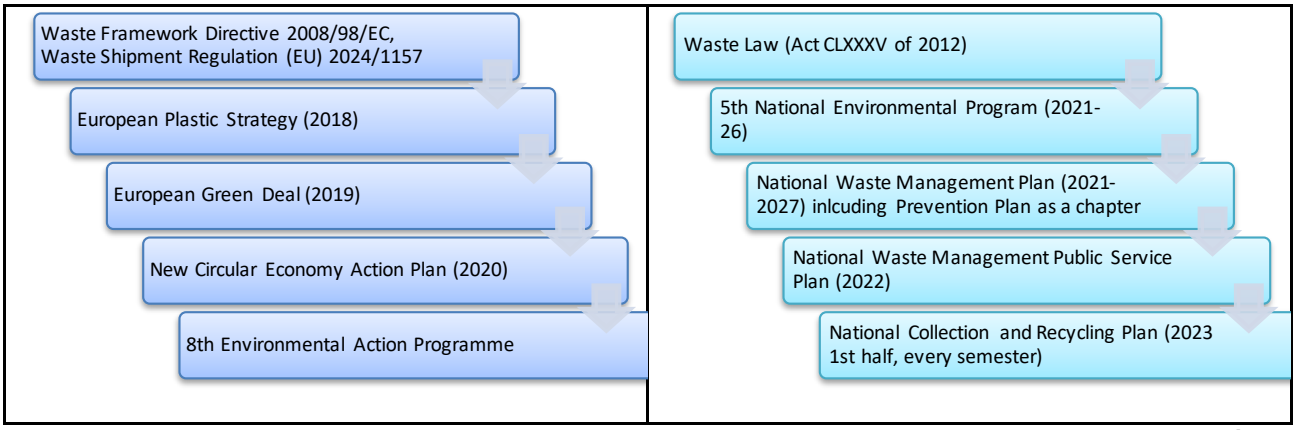
Due to the change in interpretation (residual waste reduction instead of prevention), the waste prevention chapter focuses on binding (mainly recycling) EU targets: the European Commission's circular economy package of 2015 calls for a reduction in food waste from 30% by 2025 and 50% by 2030, 70% of construction and demolition waste should be recovered by 2020 (including backfilling operations). For reuse the same target applies as for recycling, i.e., the municipal waste recovery targets should include reuse and recycling as well, although Member States did not count on reuse earlier. From 2023, it became obligatory to report on reuse even though this reporting face numerous statistical difficulties significantly lowering the reliability of data. These are the main drivers for the

goals in the National Waste Prevention Program. Other than that, the action program is not always consistent with the measures proposed (particularly in food waste). Shortcoming is that responsibilities are not assigned, nor budgets allocated. Though, it was pinned down that financial sources will be available from the landfill tax, the product fee and EU sources.

The Waste Law prescribed the territorial planning of waste management, as was earlier. The planning – including waste prevention – was previously assigned to local municipalities following the principle of subsidiarity, but it was found that the fragmented planning does not enable the country to run an effective waste management system. Later, the regional environmental protection authorities became responsible for planning, but no territorial plans were prepared even though it is required by the Waste Law, the "National Waste Management Plan" and the EU WFD. One of the plans existing is the "National Waste Management Public Service Plan (2022)" (ITM, 2022) published by the Ministry of Innovation and Technology which covers territories applying public service providers' operational territory as geographical unit. Due to the gradual centralisation of waste management public service this covers all important aspects of waste management. As of waste prevention some tasks of public service providers are listed: development of waste management system elements related to prevention, reuse centres (in the form of extending services of waste yards), promotion of home and community composting through local programs and acquisition of tools; awareness raising communication campaign; reducing hazardousness of collected waste. This means that public service providers – interested in increased waste generation for keeping up their market – are made responsible for downsizing their market by convincing citizens to waste less. This is a paradox situation. In addition, the "National Waste Management Public Service Plan" has no clear connection with other policy documents. The other existing plan sets the annual quantitative targets and the subsidy levels for recycling every six months: this is the National Collection and Recycling Plan (2023 1st half) (TIM, 2022b) updated regularly by the line ministry. In terms of measurable targets, it has nothing to do with waste prevention, however, the exact amount to be spent on waste management and awareness raising is stated here.

As a summary of finding regarding policy documents and legislation Figure 28 shows the list of documents in force:

Figure 28 - Legislation and policy documents commanding waste prevention in the EU and in Hungary – Chronological (not legislative hierarchical) order



Source: own compilation

5.2.5 Policy actors in the European Union

The highest-level decision making in the field of waste prevention is assigned to the Council of Ministers and within that to the gathering of Environmental Ministers: the Environmental Council.

The Commission is responsible for proposing new policies, and following the adoption, it ensures implementation. Policy preparatory work is basically done in DG ENV involving the European Environmental Agency, and often contracting consulting agencies. The operation of the European Commission is supported by the expertise of the Directorate General for the Environment (DG ENV). The Juncker Commission had a strong business competitiveness approach regarding waste issues, environmental considerations had less space. One of the first actions of the Juncker Commission was to withdraw the proposed ambitious circular economy policy paper of its predecessors: after reworking it, the new policy lost waste prevention as a primary focus, instead, recycling and recovery as a business model became favoured. The Commission led by Ursula von der Leyen is keen on green policies, one of the first documents put forward was the European Green Deal highlighting the cross-sectoral approach. The topic of natural resources, environmental consciousness, however, appeared in a whole new scenario in the past years. The COVID lockdown has made people feel their exposure to the elements of nature, the vulnerability of economic structures and the supply system. The Ukrainian war following has put environmental issues back to the end of the priority lists, but the energy crisis has brought the issue of scarcity of natural resources in the forefront of public discussions, and it made people directly experience the economic consequences of scarcity. In this new scenario, energy supply has become key, but other resources are not so much in the spotlight (except for Hungary experiencing serious droughts).

The European Parliament is the co-legislator. The Parliament was earlier following the concept of Europe becoming the leading force in environmental protection. In this sense, MPs were more pro-environment. Today, this ambition is weaker and lobbying forces of the industrial sector – in case of

waste, the management companies involved in recycling, landfilling and incineration and other companies subject to extended producer responsibility – are having significant effect.

The monitoring of policies is assigned to the Eurostat which is also in charge of publishing waste statistics. Currently, they represent this standpoint, also meaning that they are not holding themselves responsible for reuse or waste prevention monitoring, as it is out of scope. These are statistics not covering waste. For this reason, the methodological development of reuse and waste prevention statistics was assigned to the European Environmental Agency (EEA). The reuse reporting is legally covered by the Commission's implementing decision (2021/19) (EC, 2021); however, Member States are struggling with the methodology. Regarding waste prevention, a proposal from EEA was put forwards on indicators (2023) later presented.

5.2.6 National actors of the waste policy

Primary expertise of waste policy was in the Ministry of Agriculture, as in 2010 the independent Environmental Ministry ceased operation, and its tasks were assigned to the Ministry of Agriculture. Since then this ministry was responsible for all strategies on waste. It was the one to prepare the new Waste Law for adoption, to develop the "National Environmental Program" and the "National Waste Management Plan", it was also the main body for collecting waste data for statistics, and was also responsible for directly managing recycling activities and achieving the EU quantitative targets.

After banning the producer responsibility organisations founded for the coordination of recycling by producers, the Ministry of Agriculture has founded the National Waste Management Agency in 2011, the sole recycling, state-owned coordinating body. It ceased operation in 2014 and the staff was moved to the National Environmental Nature Conservation and Waste Management Department of the National Environmental Authority, which then became part of the Pest County's Government Office with significantly less capacities.

A confusing situation developed as the domain of public service within the waste management was transferred to the Ministry of National Development, which was preparing its own annual National Waste Management Public Service Plan. Under the supervision of this Ministry a state company with the one and only responsibility of invoicing waste fees to households (NHKV Inc.) was founded. The Ministry was then renamed Ministry of Innovation and Technology, then of Technology and Industry, ultimately of Energy Affairs. From mid2023 a concession has been granted to Mol Zrt., the Hungarian oil company for managing public service of waste management to meet EU targets. The company founded its affiliate Mohu Zrt., currently responsible for operating the new EPR scheme since 2023. According to work discussions they are also considered in pushing reuse data much stronger for increasing country performance.

Players of waste management market regularly express the problem of not being able to follow changes. The regulation and the institutional framework also changed at a pace that causes problems in the market. Beyond that, there is a strong financial squeeze as on the cost side landfill tax is introduced, but the service fee was maximised due to the political will to reduce household utility costs. This caused bankruptcy of some public service providers with tasks taken over by the National Directorate for General Disaster Management. Today the cross-financing of geographical areas has brought balance.

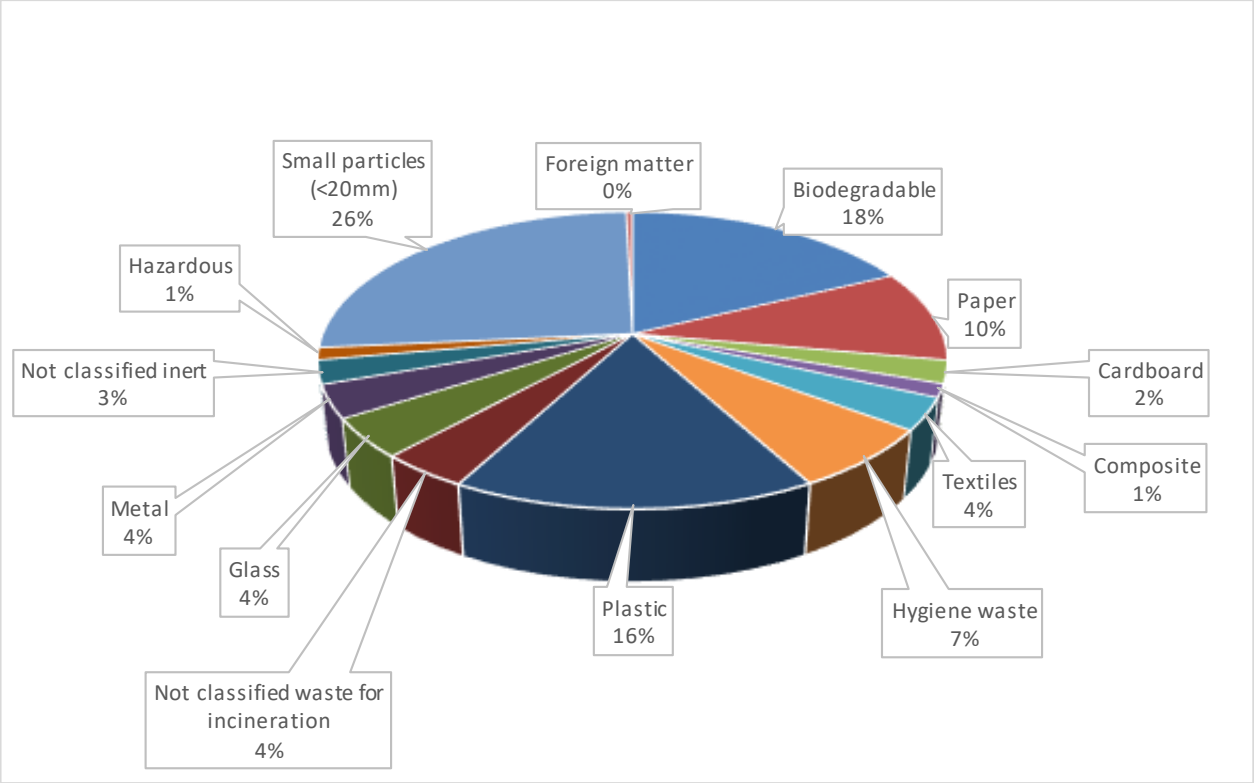
As of monitoring, the key player currently is the Ministry of Energy taking over the electronic waste information system (OKIR- EHIR) from the Ministry of Agriculture. This is the system were individual waste generators and managers are obliged to regularly submit the data from their operation. They also have to report to the Hungarian Energy and Public Utility Regulatory Authority responsible for licences and regulating fees. The public service providers are also requested to annually report data to the Hungarian Central Statistical Office.

It is clear, that waste prevention does not belong to any of these ministries in practice. Planning is made by the Ministry of Energy Affairs, but the problem of being out of scope in legislative terms hampers the development. A joint work of the Ministry of Economic Development and the Ministry of Energy Affairs would be necessary in order to introduce waste prevention, i.e. sustainable production and consumption aspects in the market of Hungary.

5.2.7 Waste composition analysis

Waste composition is a basic information for waste prevention planning, as we need to have information on the waste streams for defining the point of intervention. The waste analysis was not compulsory, but it is indispensable for waste policy planning as it shall form the basis of the fees of the new EPR scheme, as well as the assessment of the separate collection system according to the National Waste Management Plan. The action program of the Plan includes the regular municipal waste analysis to be financed from EU funds and national resources. The annual waste analysis became compulsory from 2022 due to an amendment made to the Hungarian Waste Law, however, it is not made public. The last public analysis was made in 2017-2018 (ITM, 2018), with the outcome in Figure 29.

Figure 29 - Municipal waste analysis in Hungary (2017-18)



Source: own compilation based on ITM, 2018

The diagram unambiguously demonstrates why food waste and plastic are at the forefront of latest legislative discussions. As an EU target, biodegradable waste should be diverted from landfills as those do not harm nature but do take up large proportion of the space in landfills, and significantly contribute to GHG emmissions. For this reason, composting and biomass use for biogas is crucial. There is a theoretical discussion going on regarding the classification of composting, as the product for sale has a varying quality depending on the input. Until some type of standardisation does not take place, the compost cannot become a product, thus there is no economic incentive for its production, and no demand for it on the waste market.

The community or offsite composting is clearly material recycling, but home composting is questionable: it may be viewed as recycling (and the reporting standards enable this with a formula), but the composted bio-waste in this case practically does not leave the site, does not enter the waste management system. This said, it can be viewed as waste prevention. Plastic waste is clearly addressed in the new Directive. Substantial development could be achieved by promoting the open or closed deposit fee systems for refillables, not primarily for recyclables.

5.2.8 Financial sources for waste management and prevention in Hungary

The basic waste management public service activity is financed from the waste fees collected from waste generators. This fee is centrally determined and is capped by the target of utility cost reduction. On the other hand, the landfill tax was introduced recently increasing the cost of the waste

management actors, but without enabling them to transfer this cost to the final consumer due to the utility cost reduction. The dramatic reduction of financial resources in the sector caused paralysis in hundreds of settlements leading to the Directorate for Disaster Management charged ad interim by waste management taking focus far away from prevention. According to an EEA study (Wilts et al., 2015), it was communicated that part of the landfill tax shall be spent on waste prevention (313/2013 (VIII.28) Government Decree). It was stated in the State Budget, that 18.386 bn HUF is expected to be the income from landfill tax in 2022. The landfill tax is 6000 HUF/tonnes after waste disposed (D1-D5 and D12 operations).

The state-managed recycling activity for the achievement of recycling targets is financed from the product fee as mentioned in Chapter 3. 25% of the cc. 75 billion HUF (OGYH, 2017) in 2018 is spent on this activity, out of which only a symbolic amount is dedicated to prevention campaigns and none for waste prevention conceptual development. About 85 billion HUF was expected to be the State revenue from product fee in 2022 (Varga, 2021). However, only cc. 25 per cent of that is spent on covering costs of waste management and a minor amount on prevention, the rest flows into the central budget without heading. According to the National Waste Collection and Recycling Plan (2023 1st half) 821 million HUF could be spent on awareness raising for the first semester – 7% of the total waste management costs, which is an EU commitment. The total budget financed from product fee is 11.7 bn HUF.

Large proportion of Hungarian investments are co-financed by the Government and the European Union. Technological development of waste management was funded by ISPA earlier. In the past programming period (2007-2013) the "Environment and Energy Operational Programme" (EEOP) financed large scale regional waste management developments under Priority 1 which gave 47% (827 bn HUF) of the total EEOP spending (Bártfai et al., 2016). In case of these large projects, communicating waste prevention was only a symbolic objective, awareness raising focused on recycling. It was controversial to expect waste management companies living from waste to communicate about prevention. Priority 6 of Sustainable Lifestyle and Consumption represented 1.2% of the total EEOP spending, resulting in a 21.9 bn HUF total priority budget. The 'passive participation' as output indicator was 115%, the 'short term participation' as output indicator was 68% and the 'long term, active participation' as performance indicator of these awareness raising campaigns added up to 494% relative to targets (Tóthné Kiss et al., 2015). This undoubtedly shows the effectiveness of these campaigns, while the expenditure structure demonstrates the disproportionate division of funds between waste management and prevention, although the latter is higher in the waste hierarchy.

In the programming period of 2014-2020 the main funding source for waste management is the "Environmental and Energy Efficiency Operational Programme" (EEEOP) under Priority 3. Large scale waste management systems are further financed, but there is an increasing focus on separate collection and recycling and some highlight on reuse. Awareness raising is marginal as in case of the previous programming period, but the decoupling of technology development projects from prevention-focused awareness raising shall help in being more efficient. 400 bn HUF was planned to be spent on Priority 3 which includes waste management and remediation, which is a middle-sized budget among priorities of EEOP (NFM, 2014) including the separate campaigns.

In the framework of "Economic Development and Innovation Operational Programme" (EDIOP) Priority 3 targets increase in the competitiveness of small and medium-sized companies (NGM, 2014a). Within this priority only activities related to recycling and recovery were supported, innovations leading to waste prevention are not.

The Territorial and Settlement Development Operational Programme was performing weaker from a prevention point of view. Under Priority 1 municipalities were eligible to funds targeting waste management methods at the bottom of the hierarchy: besides recycling, landfill and incineration. Recycling has a dedicated budget of 20 million EUR, and the same amount was targeted towards landfilling and incineration, none towards prevention (NGM, 2014b).

Regarding central EU funds, the biggest Research and Innovation programme of the EU was Horizon 2020. One of the major research areas within the program was "moving towards near-zero waste at European and global level". Horizon 2020 dedicated more than 3 million EUR (EC, 2018c) to "Climate action, environment, resource efficiency & raw materials" including waste prevention.

5.2.9 Economic policy measures promoting waste prevention

Economic instruments of waste prevention originate in multiple policies: the first driver is rationalising production and consumption; the second driver is to make waste management move up the hierarchy. EU policy adopted by Member States made a provision for national fiscal policies to support shifts towards waste reduction. The tools are the following:

- Promoting Eco-design and Taxes on Production (Upstream taxes)
- Downstream Taxes (on Waste Management)
- Subsidies
- Pay-as-you-throw (PAYT) Schemes
- Sanctions
- Partial or Complementary Economic Consideration for Waste Prevention
    - Shifting Production

- Deposit Refund Systems
- Illegal shipments and incineration – obstacles to prevention.

Promoting Eco-design and Taxes on Production (Upstream taxes)

Waste prevention in production means the selection of eco-friendly, recyclable raw materials, a resource efficient production technology with least waste possible – efficient planning of material use considering durability and repairability, and quality control of production –, minimised and reusable (inverse logistics) packaging for distribution.

Obstacles to the spread of eco-design good practices are numerous. Basic concept of environmental economics applies to this case: externalities are not included in the prices failing to demonstrate the social and environmental costs of current products and technologies. The marginal private cost of waste disposal consists of the extra costs of the equipment and the opportunity cost of the land that are needed for collection and disposal. The marginal external cost consists of negative impacts, like noise, litter, dust, unsightliness, air, and groundwater pollution. The marginal social cost is the sum of these two (Porter, 2004). To the point that occurring costs are not integrated, no measures shall be effective, but become regulatory constraints to the market. In other words, market mechanisms may be supporting the change, if the prices would reflect externalities. In the reality of imperfect pricing the EU level regulation – texted in the Eco-Design Directive (EU, 2019b) – could not be other than weak. It only covers electronic and electric appliances and energy labelling, but does not define rules for other types of efficiencies (GHG, material), as it would contradict actual mechanisms of national markets.

Greening products and production technologies are obviously competitive, if they induce cost savings through resource efficiency. Cost saving is relevant both on supply and demand side, and the timeline when return and cost saving occurs is also an important factor from a competitiveness point of view. However, when eco-design goes beyond cost-optimisation and requires long-term investments, or large investments contradicting to short-term profitability or utility expectations (as core drivers of consumer society), it is not viable anymore for players. Transforming the entire production line to introduce a new eco-friendly raw material, as a supply-side example, or buying a relatively expensive eco-product that shall save costs only in the future (e.g. solar panels), or has no immediate, tangible advantages to a person (e.g. eco-friendly washing powder) respective to the 'original' competitors, will not make the entire market shift towards eco-design, as the only decision parameter is the price or cost. Political stability and long-term incentives could increase propensity to investing in eco-design. If competitive advantage cannot be made direct – as it effects the person's well-being indirectly through the protection of environment – cheaper prices can stimulate demand.

How can the price lower, while external costs are also to be included? The price can be lowered relatively by increasing the price of products that are not eco-designed. Economic governance promoting the shift to eco-design operates in line with the 'polluter pays' principle, levying taxes on environmentally damaging products making them more expensive for consumers relative to their environmentally friendly competitors and serving as an income to cover public costs rising from externalities. This corresponds to the requirement of the environmental policies maximizing social welfare (Walls, 2004).

'Producer responsibility' in the earlier version of the WFD covered the responsibility of the producer to manage waste occurring due to the production and the release of the product to the market. In lot of countries product tax or product fee is levied to cover costs of waste management and to enforce producer responsibility as they are officially paid by the producer. Weakness of this mechanism that implicitly it is finally paid by the consumer in the price of the product, thus means less motivation for producers until they can transfer the cost to consumers. At the same time, the consumers' level of awareness and knowledge is far from being able to make responsible decisions on pro-environment consumption (e.g. no information is directly available on the product fee content in a price, not to mention environmental impact assessment). The producer responsibility concept was further developed during the revision of WFD in 2008 resulting in the principle of 'extended producer responsibility' (EPR) (2008/98/EC, Art. 8.). Almost all OECD countries apply the principle of EPR today. EPR goes further stating that producers should be made physically and financially responsible for the environmental impacts their products have at the end of a product life (Walls, 2004), but this goes beyond take-back of waste, the primary aim of EPR policy is upstream – production phase – waste minimisation. Related paragraphs of the WFD are, however, not imperative only permissive weakening the effect.

Additional tools for upstream waste reduction are the EPR combined with recycling subsidies and/or with 'advanced disposal fee' (Glachant, 2004) included in the price of the product, covering costs of waste management in advance. The tax is paid by the consumer, but it appears to be settled by the producer creating less rejection. Advanced disposal fee is another solution for source reduction which could be based on the weight of the product. Key problem of introducing any kind of tax related to waste reduction is the risk of illegal dumping (Fullerton et al., 2004). Therefore, it is widely accepted to combine measures promoting source reduction and subsidies related to optimal waste management (i.e. increased recycling, deposit-scheme funding in recycling).

Other measures like green procurement, central funding of eco-design innovations and basic research, patents and intellectual property rights are also appropriate for promoting the structural change.

Downstream Taxes (on Waste Management)

Well-known form of downstream taxes is the landfill tax introduced by most of EU Member States, imposed on the weight unit of garbage landfilled, to be paid by the landfill operator. Optimally, the cost is transferred through the line from the waste management company to the collector ending up at the producer of the waste (households or organisations). The additional cost aims to make landfilling more expensive supporting the diversion of waste from landfill towards upper categories of the waste hierarchy. This proves to have a significant effect according to the assessment of the Italian landfill tax, the oldest regime introduced in the EU (Nicolli et al., 2013).

Another example is that of Norway (Martinsen et al., 2004). Following the introduction of the landfill tax, they found that the incineration level significantly increased, which is not the policy preference. This leads to the concept of incineration tax, as diversion from landfill did not prove to be successful in waste reduction, as a single tool it only distorts the waste management system.

Both forms of taxes are part of the green taxes which – beyond diverting waste from disposal – create funds to substitute state income from employment related taxes (Bartus, 2006). They contribute to a structural change including the internalisation of external social costs of waste management, as well as shifting the source of revenue from employment to environmentally damaging industries. Reducing burdens of employment is essential in a green economy.

Subsidies

The "Guidelines on State aid for environmental protection and energy 2014-2020" (EC, 2014c) of the EU defines the forms and fields of subsidies permitted. These include subsidies covering all operations of waste management and the entire waste hierarchy.

Subsidies on green products may create the same situation as the product fee (EPR), lowering the price of environmentally friendly products respective to traditional, more damaging competitors.

Additionally, subsidies on combined heat and electricity (CHP) producing incineration of municipal waste may be obtained as a form of power generation, and due to the estimated 50% biodegradable part of the municipal waste (Renewables Directive) for which it may be considered as renewable or green energy eligible to subsidies. This is ironic as biodegradable is just the wet part of the municipal waste least preferred by incinerators for its low calorific value. The best fuel for them is the so-called residue derived fuel (RDF, paper, textile, plastic pieces of waste), which are the most effectively recyclable waste streams.

Subsidies are also provided for waste management of coal and nuclear power generation, which do not support competitiveness of renewables, nor do they help moving upwards on the waste pyramid. The amount of state support approved in EU Member States to decommissioning and waste disposal was 4330 M EUR in 2012 (Alberici et al., 2014).

Mining subsidies have important impact on waste prevention. First, a general environmental consideration is to create "price" for a raw material, as it is not a product. This price should include the cost of mining externalities. These are manifested in a contribution to the State as raw materials and minerals under the surface is property of the State. If an operator pays very low contribution not covering the real costs, it is a form of direct state aid (Szabó, 2006). On the other hand, the price relations between secondary and primary raw materials are crucial in economic decisions on production and is the same from an environmental point of view.

Pay-as-you-throw (PAYT) Schemes

According to the 'polluter pays' principle the waste management fee should be paid by the waste producers (households and organisations). The design of the tariff system is essential in the effective economic governance and waste reduction. The fee should cover the entire cost of waste management, including future monitoring of landfills (for 30 years), etc. Core issue is the inclusion of external costs, which in 2006 were estimated to be between 5-20 EUR/tons of waste EU-wide (Bartus, 2006). In 2022, this would add up to 7.05-28.21 EUR[3].

Fees traditionally are determined either on a flat-rate basis or included in other municipal taxes. In apartment buildings, the fee may be integrated into the common charges. If waste prevention is an objective, the pricing model should be volume sensitive contrary to the traditional methods (Graczka, 2011). A waste producer may be strongly motivated in reduction, if it must pay more for larger amounts of waste.

'Pay-as-you-throw' schemes are designed to move waste producers up the waste pyramid. Fees may be based on the volume, and within that category two types are differentiated: first case is when the waste is weighted, this is precise, but costly, as all collector vehicles must be equipped, and all waste bins should be identified by RFID or bar codes (e.g. Denmark). The second type of pricing system is based on frequency of collection. Price depends on how often the bins are emptied (e.g. parts of Hungary). This is far from a precise 'pay-as-you-throw' system, and because of public health regulations – prescribing obligatory regular collection – is not effective in prevention.

Sanctions

Sanctions usually appear in two cases across Europe: illegal dumping and mixed collection of waste where compulsory separate collection is expected. Key question is the waste producers' willingness to pay for waste management services. If the psychological threshold is passed by the waste management fees, fly-tipping shall appear. This is the primary reason why policymakers fear to use pay-as-you-throw systems. The solution is a combination: any measure increasing the waste

[3] calculation based on Harmonised Index of Consumer Prices, Eurostat, PRC_HICP_AIND, 2015=100

fee should be coupled with other subsidies (recycling-reuse-prevention), or with sanctions. Penalties may be raised, but they shall only have an effect, if monitoring and control is strong enough, this is hardly the case in Europe, especially in CEE.

Inappropriate separate collection is fined in some countries (e.g. Germany). There are cases, when the not clearly collected separate waste is not taken away (e.g. Barcelona), in others the entire apartment building or single households may be penalised (e.g. Germany, Denmark)[4]. As of January, China set extremely strict trade rules for the cleanness (meaning the proper separate collection of waste streams) of imported waste, this issue should be managed urgently in Europe. This does not add directly to waste prevention, although it contributes to waste minimization which is also important.

Partial or Complementary Economic Consideration for Waste Prevention

There are further issues that should be considered at EU level to support Member States' waste prevention aspirations.

Shifting Production

As mentioned above, a move towards eco-design is essential in waste prevention. This is, however, a regional and a global problem. The shift of production should happen globally stimulated by global regulatory agreements, i.e., if it only happens in one Member State or only in the EU, it shall distort competitiveness in all cases. Long-term investments for the shift may override cost saving opportunities given by resource efficiency concluding in higher product prices. If the EU introduces a new imperative regulation supporting eco-design and resource efficiency, it may face the relocation of multinational companies to other regions in the world or will make the production more expensive without guaranteeing the purchasing power and demand on the other side.

Deposit Refund Systems

Take-back systems are prominent instruments in waste reduction. It may be used for both recycling and reuse. Consumers usually mix the two types, although there is significant difference in their environmental burden. Take-back system for recycling is usually part of the extended producer responsibility to collect waste after their products. This was more general among EU Member States (e.g. Denmark, Sweden, Germany, Hungary, Croatia and Spain)[5], with the new regulations on EPR entering into force this became a widely used instrument.

The economic governance promoting the reuse-based deposit refund system strongly supports waste prevention, particularly by inverse logistics. These systems are designed to take back packaging

[44] According to Zero Waste Europe members' workshops, 2014-2015; see Bussgeldkatalog.org for Germany
[5] According to Zero Waste Europe members' workshops, 2014-2015

(e.g. beer bottles in Hungary) avoiding the generation of waste. Consulting producers in Hungary running the largest deposit packaging systems (Varga Pincészet, Dreher Sörgyárak)[6], there was consent in two issues. First, they agreed that based on their calculations, the reusable packaging is cheaper for them to operate, than to apply single use versions. Second, the main limitation of the spread of deposit refund system is the lack of unified packaging and motivation of retailers. Due to the globalized markets standardisation of packaging (e.g. bottle designs) should take effect at least on EU level, if not on global. The amount of the refund should also be motivating for consumers and for retailers, and widespread network of collection points is also essential.

Illegal shipments and incineration – obstacles to prevention

The EU adopted its Circular Economy Action Plan, however, experts agree that currently the common market is not circular, but linear with large amounts of waste ending up in developing countries. As long as the option is given by regulation to do so, the loop will not be closed. The first hit came from China in the beginning of 2018, when it banned import of waste. 87% of Europe's separately collected plastic waste ended up in China (Velis, 2014), but major part of other waste streams such as paper and e-waste also leave the EU. This means that radical and urgent changes are required within the borders of the EU to close the loop in reality.

The illegal export of waste is still quite significant, leading to the support of illegal waste management sites like the ones for plastic in China, textiles in Pakistan, ship dismantling in Bangladesh or e-waste recovery in Nigeria. The new Waste Shipment Directive sets stricter rules on waste delivery and export, the effects of that are awaited.

An analogue situation should be mentioned here: the advanced part of the EU has huge incineration over-capacities. If they are able to absorb the waste from other EU countries (like waste of Naples burnt in Sweden then Austria), the upward movement on the pyramid towards prevention is counteracted.

In general, if investments and regulation in developing or developed countries (not only advanced countries of EU, but more incinerators are to be built in the CEE region) provide and increase the end-of-pipe capacities, no prevention shall take place, as there is no constraint to reduce.

5.2.10 Remarks on different levels of policy

Remarks on the EU level policy

Typical dynamics of the EU policy forming in the field of waste policy are the EU institutions setting ambitious targets – usually favouring waste prevention measures –, but Member States

[6] Discussions held as representative of Humusz Waste Prevention Alliance with representatives of companies of Varga Pincészet and Dreher Sörgyárak in 2015.

responsible for implementation and budgeting (László & Galambos, 2018) and waste management interest groups as well as EPR-obliged companies' lobbying activity usually bargain down the prevention targets. This was the case during the Commission communication on Circular Economy, the Circular Economy Action Plan and ultimately, during the latest Waste Package Revision.

Due to the strong business approach in the Commission and the strengthening business orientation in the Parliament, the European level policy tends to avoid any structural change in production and consumption to lower the level of waste generation. The only extent to which waste prevention is considered, is the passive form: as long as the resource use reduction leads to cost savings waste prevention is welcome. When it needs additional efforts and investment (active form), it is neglected.

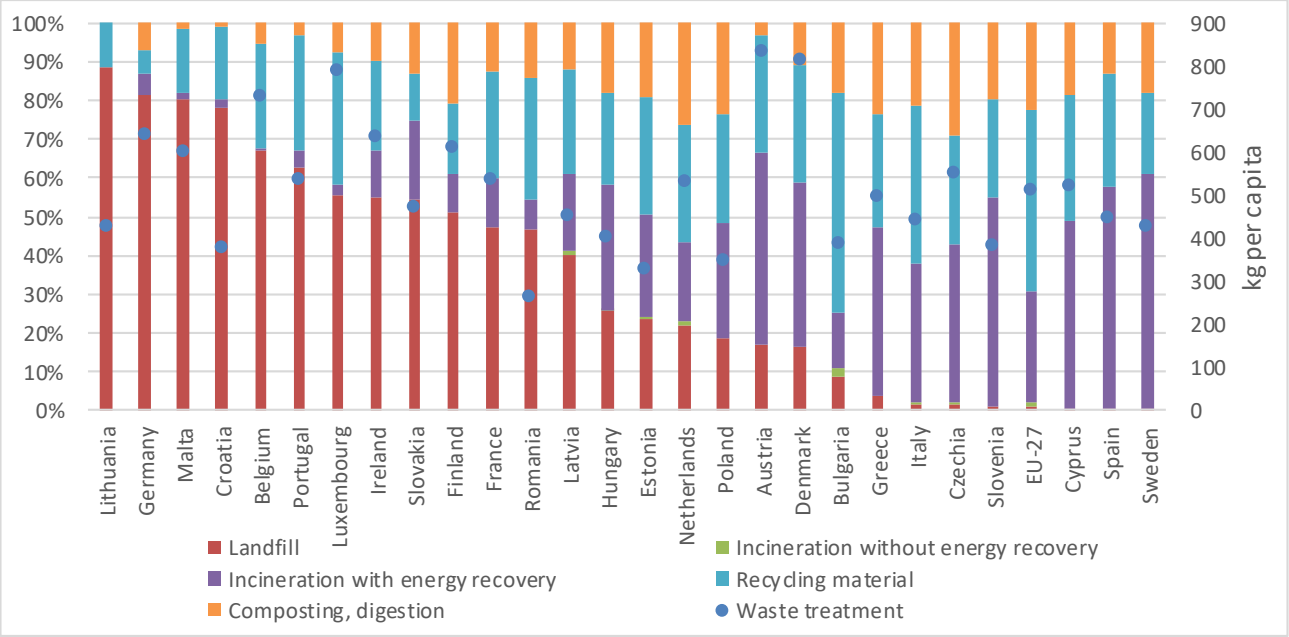
Binding regulation (directives) and quantitative targets are motivating. It can be seen in the Hungarian policy as well that avoiding infringement procedures can be a strong driver in the performance of waste management. Such targets could intensively promote prevention as well in all Member States.

Statistics are a permanent problem, whilst from a waste prevention aspect, it is crucial to have a clear view on current waste generation and trends. Data provision is incomplete; national definitions and metadata are often different from each other, in some cases agreed definitions are completely missing on the EU level (e.g. reuse reporting). A common problem is that in case of recycling statistics not the effective, finally recycled amounts are reported, but only the collection for recycling. No adequate measurement of preparation for reuse and waste prevention exists. To strengthen statistics standardisation is needed and a strict supervision of data providers to increase trustworthiness of numbers. The timeliness of waste statistics is also disputable, as national data provisions suffer delays, and comprehensive reporting occurs only every second year.

Remarks on the regional level trends

Countries having similarities with the Hungarian waste situation. CEE countries are facing the same advantages and disadvantages, exceeding the performance of the South-Eastern European countries. The statistics of CEE deteriorate, but also enhance the performance of the EU15. As a positive contribution, the amount of waste produced per capita is lower than that of the advanced countries (due to lower production and consumption levels). On the other hand, the waste management is dominated by landfilling and lower levels of recycling are typical (Figure 30), and no organised form of reuse or waste prevention is existing, the latter not even included in waste management statistics.

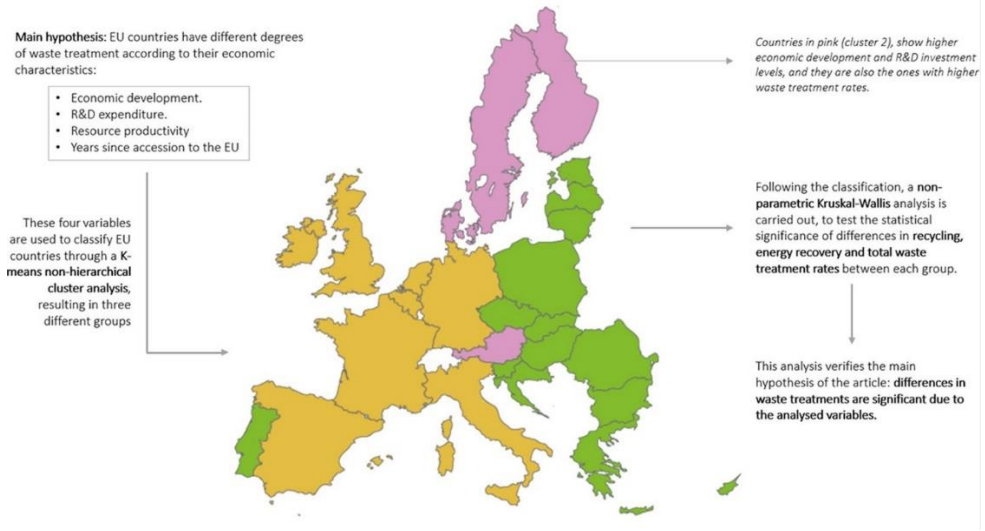
30. Figure - Municipal waste treatment operations and waste treatment per capita, 2020



Source: own compilation, based on Eurostat, env-wasmun

According to López-Portillo et al. (2021) EU Member States can be classified into 3 clusters (Figure 31) based on the real GDP per capita, R&D investment per capita, years of EU membership and resource productivity. The first cluster with highest values for years of EU membership and resource productivity have intermediate values for waste treatment rates. The second cluster does not only perform highest in real GDP and R&D investment, but is the leader in waste treatment rate, with strong energy recovery. The 15 countries of the cluster 3 have the lowest values for economic indicators above and for waste treatment.

Figure 31 - Clusters of waste treatment



Source: López-Portillo et al., 2021, p 7

CEE countries have problems with the EU quantitative targets, as they argue that it is more difficult to achieve those targets with an economy less advanced respective to the Western part of the

EU. According to recent intents of CEE countries the reduction of landfilling is planned to be solved by redirecting waste towards incineration with energy recovery, instead of increasing recycling, reuse, and prevention. Following the advanced Europe may lead to dead end in certain cases: it is clearly acknowledged that today the old EU countries suffer from significant overcapacity of incinerators, diverting recyclable materials towards incineration, as these have the highest calorific values (plastic, paper), best for incinerators. The CEE region should rather focus on developing recycling capacities, and further moving up the waste hierarchy, especially that China has left the oligopsonistic market as importer creating a huge vacuum. This is also underpinned by the LCA findings of Gentil et al. (2011) stating that shifting low-tech waste management (typically the CEE regions, with high level of landfilling and low rates of recycling) towards waste prevention leads to much higher gains than in case of high-tech wste management (in Western EU countries).

Remarks on the national level policy (of Hungary)

From a policy approach, the Ministry of Energy works on planning waste prevention, but as it can be viewed in Figure 7, the waste status ends at preparation for reuse, so prevention is in practice out of scope of the Ministry's Waste Departments when it comes to implementation. This contradiction should be dissolved by authorising a responsible institution able to cover all aspects – production, consumption, waste – of the prevention problem, and implement plans already developed. As a first step, policy documents should be harmonised in this field, excluding or putting waste minimisation targets in the second row, next, clear and measurable targets should be set, third, implementation of plans should begin.

Data collection should become more transparent and of better quality, the methodologies should be standardised to avoid current inconsistencies.

Currently, there is no territorial planning in the country, leading to the lack of regional and local waste prevention plans and programs. Public monitoring and transparent performance are also important to be able to follow achievements by people who should be involved as individual and community players in waste prevention and management. Territorial, or settlement level planning is crucial: there are issues, such as product design that are logical to be standardised at EU or national level. As prevention has little to do with waste management, the territorial public-service-provider-based breakdown is not appropriate. Community (e.g. community composting, or swaps, repair cafés, etc.) and individual actions can be best supported at the settlement, or neighbourhood level. Today however, local governments are on a forced trajectory with responsibilities of waste management assigned to them, but without any tools, as the legislation dismissed all of them, still prevention is terra nullius, no one is taking up responsibility. Following local capacity building at municipality level expertise, local governments should be again involved in planning and implementation as

institution with best knowledge about the local situation. Environmental authorities – the Government Offices – should also be empowered to be able to present adequate supervision and sanctions.

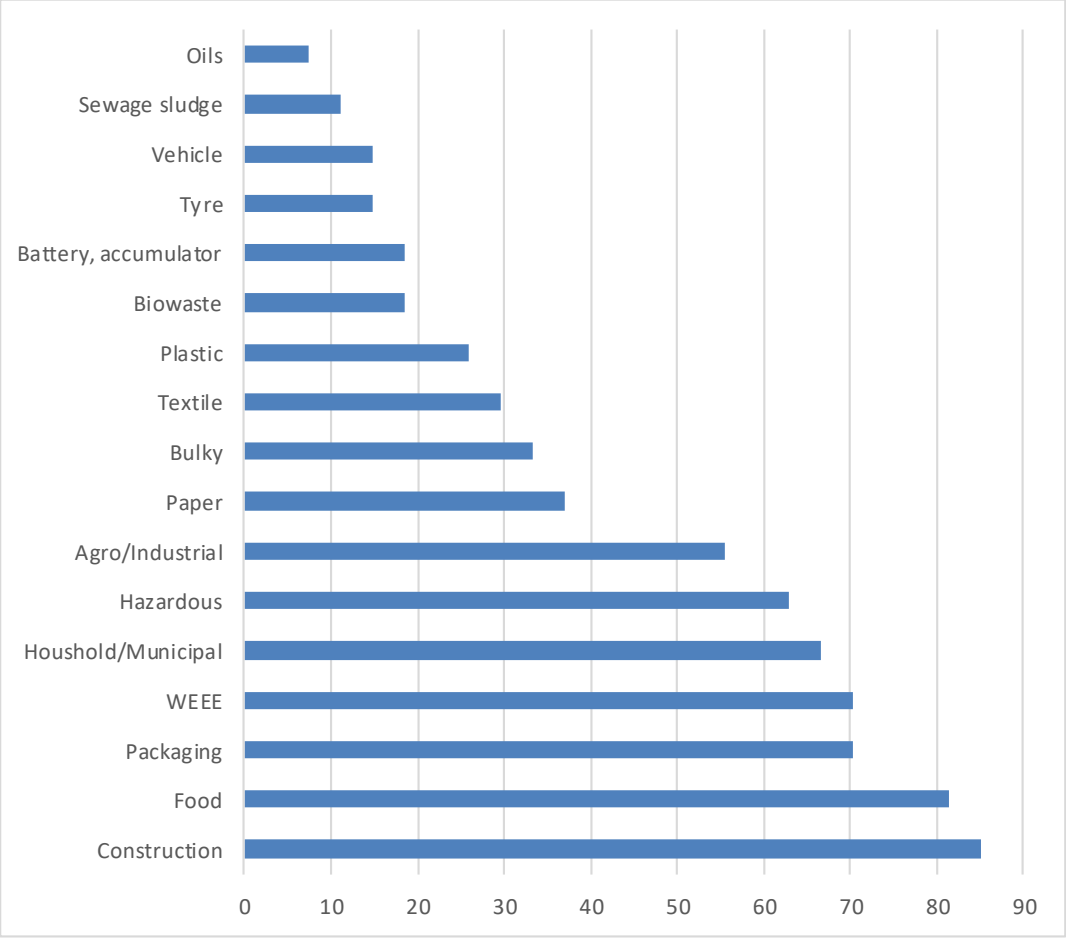
Large scale technological developments characterised waste management in the past decades which was inevitable to catch up with EU safety standards, although overcapacity is being created in many regions. The "hardware" is given today, even if there are fall-backs due to the continuous restructuring of the waste management sector. However, the lack of "software" is soaring, i.e. the household awareness raising and the business incentives regarding the waste reduction are completely missing. The improvement is important, as this can be a first step in people's willingness to take individual responsibility in the solution of waste problems, leading further to prevention and to an affordable implementation of waste management policies.

5.2.11 National Waste Management Programmes across the European Union

According to the WFD "Member States shall determine appropriate specific qualitative or quantitative benchmarks for waste prevention measures adopted in order to monitor and assess the progress of the measures and may determine specific qualitative or quantitative targets and indicators…" (WFD, Article 29 (3)). The national waste prevention programmes were finalised by end of 2013. The 2020 revision of the national programmes (EEA, 2020) has concluded that 9 out of 27 Member States did not set any quantitative target, so the progress was slow, but in the 2023 revision this proportion has improved (Table 6). Commonly used targets are related to the total generation of municipal waste, consistent with 2020 report on waste prevention programmes (Wilts et al., 2015). Packaging waste is also addressed in terms of targets, as the EU Plastic Strategy has put focus on this waste stream. Food waste is also priority as the reporting has become compulsory for Member States from reference year 2020 (EU, 2019c). The inconsistent use of notions of prevention vs. reuse vs. recycling is traced in many national programmes. Given that recycling may counteract prevention, there is a controversy in setting recycling targets, indicators or merely discussing recycling efforts in the national prevention programmes. Landfill targets and indicators do not give any direct information on waste reduction, the decrease may happen parallel to growing waste output, but even faster growing incineration, which is feared in the situation where China has banned import of waste for recycling, while Europe lacks recycling capacities and suffers from overcapacities in incineration. Divergence indicators on landfilling and incineration, as well as the topic of littering has almost nothing to do with prevention. Setting quantitative targets on specific waste types has become much more common. Below are the waste types addressed by countries according to the 2023 Country Fact Sheets (EEA,2023) (Figure 32), which clearly show the EU-driven characteristic of the prevention plans for targeting the waste types with strict EU level regulation including quantitative targets subject to infringement procedures, if the country does not meet requirements. The

'construction and demolition' waste is huge amount in mass and has a recycling target, so targeting it logically leads to high impact. Although construction and demolition waste are out of scope in this document, it is worth mentioning that there are good initiatives on increasing the reuse of dismantled parts. The food waste (EU, 2019c) and the plastic packaging waste (EU, 2019a) are regulated in details at EU level with quantitative targets leading to prominent places in the number of countries dealing with their prevention. The same stands for hazardousness and the separately collected wastes from usually households. The most problematic waste types in prevention in terms of regulation, lagging in Figure 32 are tyres, vehicles, construction & demolition waste, municipal solid waste, and within that textiles and waste form electrical and electronic equipment (Karigl et al., 2022).

Figure 32 - Waste types addressed in the national waste prevention programmes by EU Member States (% of countries)



Source: own compilation based on EEA, 2023a

The updated national waste prevention programmes of 2023 were evaluated (Due et al., 2023), based on multiple aspects (Table 10). One of the main issues with waste prevention is its atypical, heterogeneous feature. Measures can be of many kinds, so classification is a core issue. The following classification is based on the measures listed in the Waste Framework Directive Article 9 (see Annex IV), and specific measure types. The last 2 rows refer to a control whether the countries have set quantitative targets and indicators.

Table 10 - -National Waste Prevention Plans evaluated based on WFD9 and policy instruments (proportion of countries %)

Measures, targets and indicators	Any policy instrument (%)	Type of policy instrument (%)(*)				
		Regulatory	Market based	Voluntary initiatives or agreements	Informative	EPR
Total waste						
Article 9 measures (paraphrased)						
(a) Sustainable consumption models	93	22	41	63	56	4
(b) Encourage resource efficiency, durability, repairability, reusability and upgradability	85	15	11	74	26	11
(c) Target products containing critical raw materials	52	19	0	44	22	4
(d) Encourage reuse and repair activities	93	22	48	85	56	7
(e) Encourage availability of spare parts, instruction manuals and technical information	56	22	0	26	26	0
(f) Reduce waste generation in processes related to industrial production, mineral extraction, manufacturing and construction	81	30	30	63	37	0
(g) Reduce the generation of food waste	89	44	4	85	44	0
(h) Encourage food donation and other redistribution	70	15	7	52	19	0
(i) Promote the reduction of the content of hazardous substances in materials and products	63	30	4	52	15	0
(j) Reduce the generation of waste, in particular waste that is not suitable for preparing for reuse or recycling	63	19	15	41	19	4
(k) Identify products that are the main sources of littering; take appropriate measures to prevent and reduce litter from such products	67	44	15	56	4	7
(l) Aim to halt the generation of marine litter	56	22	4	41	19	0
(m) Develop and support information campaigns to raise awareness	93	0	0	7	93	0
Quantitative targets in WPPs	25 countries of EU-27					
Indicators in WPPs	22 countries of EU-27					

Notes: Blue shading represents the frequency that a policy instrument is used for a particular measure in EU-27 countries. The darker the colour, the larger the number of countries that have a particular policy instrument for the respective measure. Green shading indicates the frequency of a measure addressed in WPPs for any policy instrument.

(*) See Table 3.3 for a description of each type of policy instrument.

WPP, waste prevention programme.

Source: WPPs of EU-27 countries (more information in the waste prevention country profiles of EU countries).

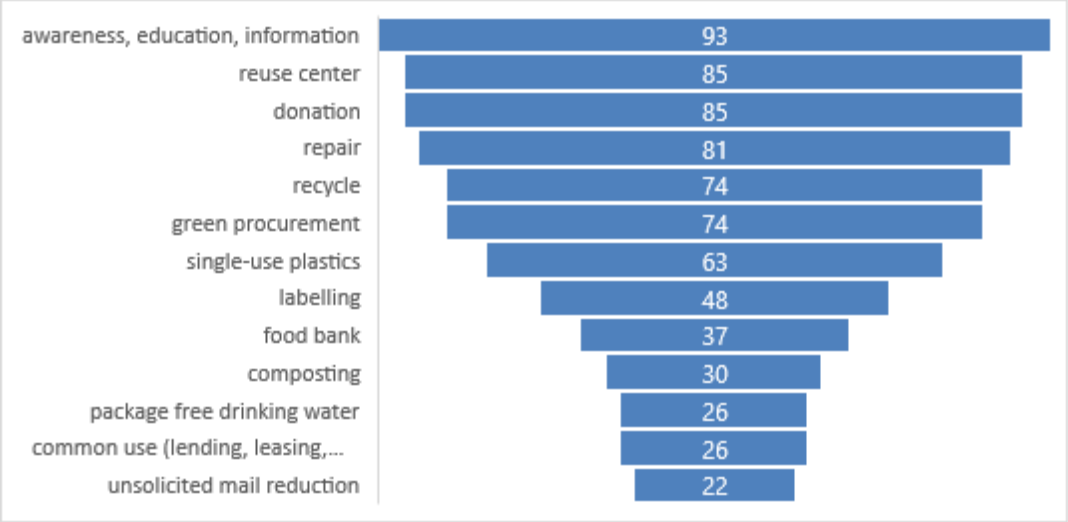
Source: Due et al., 2023, p 42

The above figure gives good guidance on the economic policy tools that are usually applied. The most applied policy instrument is information campaigns, almost all countries have applied them. The effectiveness of these, however, are not in the focus of monitoring. Even if, target or indicator is set, those usually count the number of actions, but do not cover quality. The quantity of measures show

that food waste is a key waste stream, but also, that policy instruments and monitoring methodologies are well-developed. The food waste voluntary agreements target businesses in the value chain of food products, which is obvious as food waste divergence may happen in bulk on the production side. Reuse and repair activities are also important, because the EU recycling targets indeed are recycling and reuse targets, so in case data could be collected in a formal way, it could be added to recycling rates improving the performance of countries. This is why EPR focuses on reusability, repairability. The list in Table 10 follows the exemplary list of WFD on possible waste prevention measures.

The below diagram (Figure 33) is based on the detailed review of waste prevention programmes fact sheets aiming to identify typical measures. The list was not defined previously, but followed the occurrences.

Figure 33 - Typical measures cited in national waste management programmes (% of countries applying them)



Source: own compilation based on EEA, 2023a

It should be pointed out that recycling is mentioned (either as indicator, quantitative target of measure) in 74% (!) of the waste prevention programmes, which should be avoided (see above argument on counteraction). Another difficulty in the assessment are the 'tools' cited in every programme: 'promotion', unclear what that means in practice, development of guidelines, strategies, preparation of studies, setting up fora, working groups. These are very general terms, no concrete output or impact could be measured. The list reflects the review of Due et al. (2023) as awareness raising is also the most important instrument, followed by reuse and later repair. The major part of donation is related to food waste avoidance. In few countries the donation of other products is also mentioned. The food waste/biowaste topic was also covered by instruments such as food banks, composting. The single use plastics and the tap water campaigns all have the same common goal to reduce plastic waste. Green procurement is also in the spotlight which is very important also for demonstration. Labelling refers to two directions of development: some of them focus on food labelling for better understanding of durability terms like 'best before', 'use by', etc. The

misunderstanding of "best before" and "use by" date marking leads to the 10% of food waste (EC, 2018d). The European Farm to Fork Strategy has set the objective to adjust regulation to support waste reduction. Other developments focus on increasing the amount of products with eco-label, or attempt to unify existing eco-labels into few official. Common use, i.e. lending, borrowing, leasing, sharing seem to have further potential in the future developments. Almost one-third of the countries mention the topic, however common use is as important as reuse and repairability. There is no doubt, that these notions could overlap. The reduction of unsolicited mails is a problem in some countries, however the crises of the past years have caused rationalisations in the field of advertising, so this issue is becoming less important. Some other interesting good practices were found like the Austrian Library of Things as a lease centre, the assessing of the quality of compost (the main obstacle for compost to become a product instead of waste), the Belgian baby nappies campaign, the circle house project in Denmark building an entire house form reused, recycled items, the repairability index in France giving consumer information on the degree of the repairability of an item. In Germany the environmental burden caused by online shopping and the sending back of products shall be addressed, Lithuania's best practice is Vinted, an online platform becoming global for selling and buying second-hand items, while Netherlands has a decent number of repair cafés (668) across the country. The certified zero waste accommodation Hotel Ribno is seated in Slovenia. In Sweden there are reuse pop-up stores, while in Denmark a progressive, general concept is to reduce the limescale of the water, as this could increase the durability of products working with water. Slovakia has passed a regulation obliging drink producers to make their products available in single use and reusable packaging. Meanwhile, in Poland municipalities have a zero waste competition.

Regarding the targeted groups almost 90% of the measures addressed companies, business players, 85% of the countries targeted households, municipalities are third place with 63%. Public administration and institutions are the next in row with 59% and 44% of countries addressing these sectors. The waste management companies (19%) and NGOs (22%) are expressively targeted in much less countries, however, the cited good practices are frequently provided by and measures are focusing on them.

The key factors to successful implementation of measures are defined by Karigl et al., 2022: "Legally binding requirements instead of voluntary agreements, and consistent enforcement; sustainable financing of waste prevention measures by establishing markets, new business models, tax incentives, providing funds (public funds, funds established under extended producer responsibility); regular monitoring and evaluation of waste prevention measures including data collection and reporting routines; public institutions as frontrunners in sustainable procurement, taking account of waste prevention criteria; broad regional coverage of waste prevention measures;

consolidation and formalisation of community engagements through the establishment of networks and umbrella organisations; packages of waste prevention measures instead of individual measures". Taxation in force or under planning dominantly refers to VAT reduction, deduction (Germany, Greece, Latvia, Sweden, Denmark, Croatia, etc.) or payback for food or other product donation. Austria issues vouchers for repairing items. Regulatory issues occurring in a lot of countries regarding the quality assurance, the safety of spare parts recovered, also easing the commerce or donation of foods close to deterioration. In some countries the regulatory framework for operating reuse and repair centres has to be set up. The prevention programmes reveal that for keeping the legislation simple reuse activity is being assigned to waste management service providers to found reuse centres at waste collection points of already operating recycling centres. This seems logical from a user point of view, as one can drop its waste and used products at the same place, but service providers are not much willing to change their profiles, if not incentivised.

The further review (Table 11) of the waste management plans followed a narrowed aspect respective to the above. This study focused solely on the indicators related to household/municipal waste (excluding construction and demolition waste), on actions directly targeting households as main generators of MSW, and municipalities as influencers of households and service providers to them, and it also excludes any indicators and objectives related to recycling as that is not part of waste prevention. It included separately collected wastes under municipal waste, if those were taken back for reuse, not recycling. It excluded the reduction in hazardousness due to the scope of the dissertation. The analysis based on country factsheets (EEA, 2023a) reveals great degree of heterogeneity, as there is no standardised format for the national plans, so the structuring of information was challenging.

Table 11 - The subject of indicator sets in the national waste prevention programmes (focus on households, municipal waste)

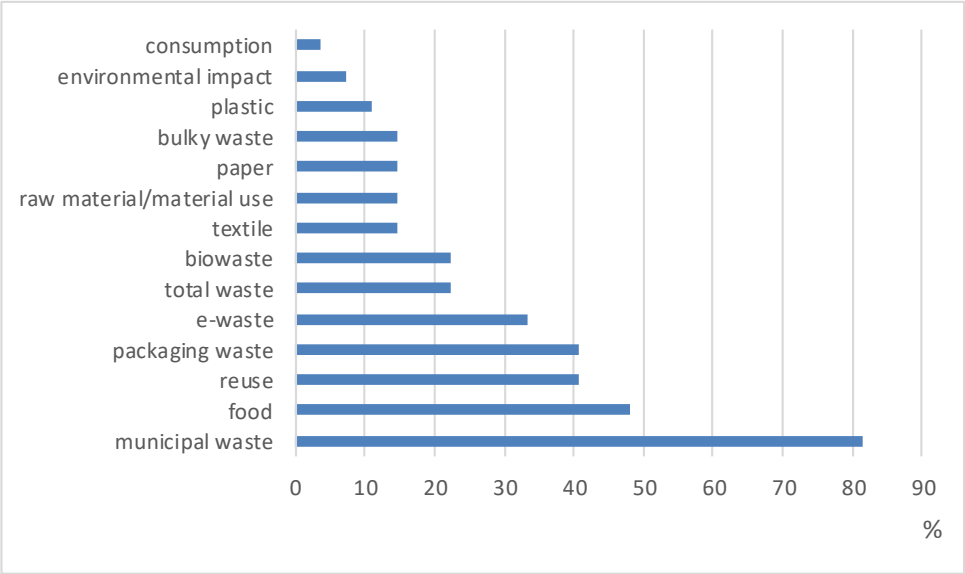
	AT	BE	BG	HR	CY	CZ	DK	EE	FI	FR	DE	EL	HU	IE	IT	LT	LV	LU	MT	NL	PL	PT	RO	SK	SI	ES	SE
municipal waste	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x				x	x	x	x	x	x	
total waste	x					x										x	x				x					x	
packaging waste	x	x					x	x		x		x			x						x		x			x	x
paper				x											x								x	x			
plastic							x					x													x		
food	x	x	x	x						x	x	x			x						x		x	x	x		x
biowaste			x	x	x	x																	x	x			
textile					x	x						x													x		
e-waste		x		x	x				x			x			x						x				x	x	
bulky waste					x							x			x										x		
raw material/ material use	x						x							x						x							
consumption							x																				
reuse	x	x			x			x	x	x	x		x		x						x					x	

environmental impact							x										x										

Source: own compilation based on EEA, 2023a

Contrary to the situation in 2020, in the 2023 review total waste generation as an indicator has lost its prominent first place, today there is a much more diversified picture (Figure 34).

Figure 34 - Distribution of indicators of the national waste prevention programmes based on their subject (% of countries)



Source: own compilation based on EEA, 2023a

Either absolute, or relative indicators (to GDP, GVA, per capita) are set which are meant to be intensity indicators showing how decoupling takes an effect. Almost all waste prevention plans focus on the mandatory targets set by the EU on recycling (and reuse) of separately collected waste, on phasing out single-use plastic products and the reduction of food waste. In addition, reuse is also in the spotlight, as an implementing regulation from the EU has been adopted on mandatory reporting of textiles, furniture, electronic and electrical items and construction materials. These products/waste streams are usually addressed in all prevention plans even though recycling for example has nothing to do with waste prevention. In few countries there is no consistency among applying an indicator and setting the targets (e.g. Finland), none of the proposed indicators refer to food waste, while the quantitative target is halving food waste generation by 2030. Some special issues also appeared among the indicators which are forward looking: Austria, for example, links material use consumption to waste prevention with Domestic Resource Productivity [€/t, Index], as well as Denmark with material footprint (raw material consumption per capita). Denmark and Lithuania measure the greenhouse gas emissions of the waste sector as an impact indicator. A predictor indicator could be the sales of products, the good example is from Denmark, measuring the marketed amount of plastic packaging. Greece, Croatia, Belgium (in separate programmes for 3 regions) and Slovakia have an extensive list of indicators almost covering every so far mentioned waste stream. Considering such details, however, data availability may be an issue. Indicators on information campaigns are included in lot

of countries, where policy-makers understandably refuse to set targets on household actions, and choosing impact indicators, they rather stay on the 'safe side' by applying output indicators of awareness raising campaigns, as this is more controllable. In some countries it is a weak point that households are not supported by accessing prevention services, e.g. reuse centres, sharing services or neighbourhood composting, or the availability of refillable packaging, etc. In these cases, these are randomly available often based on non-profit initiatives.

In general, taking the DPSIR model as a widely used environmental indicator model as basis, major part of the indicators are descriptive, pressure indicators presenting the output of human activity. There is hardly any circular approach, the few cases of drivers, i.e. demographic, material use and consumption data are above mentioned. For the state indicator Lithuania and Denmark presents the only case with the GHG emission of the waste sector even though landilling has a substantial methane emission. Waste management accounts for 20% of the anthropogenic methane emission (Hogg, 2024). Few response indicators occur on policies, incentives.

Applying waste indicators related to other stages of the waste hierarchy than prevention is misleading. The latent convergence towards end-of-pipe indicators stems from path dependencies understood as 'self-reinforcing feedback loops' meaning that once a decision for a system design is made, this is favoured over all other, as well as future alternatives (Wilts, 2012). If we consider the evolution of waste management priorities, they historically follow the steps of the waste hierarchy. For this reason, the financing structure is stuck by the end-of-pipe technologies.

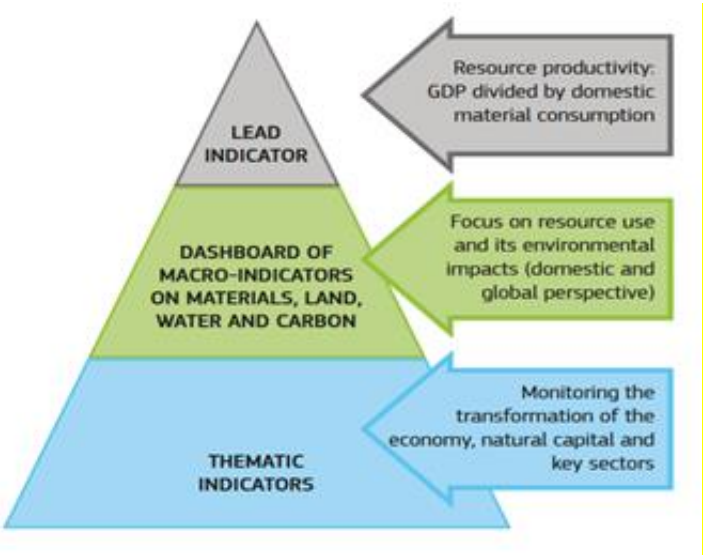
5.2.12 Indicators of waste prevention in use

Even if changed frequently, the EU level indicators of waste prevention to date are not ideal. They are following several aspects, the most typical is the above-mentioned end-of-pipe, another is the material input/output approach. This subchapter covers the Resource Efficiency Scoreboard, the material flow indicators, and the absolute of relative waste generation indicators in the context of the original and the revised Circular Economy Monitoring Framework, also, the problems of using recycling indicators for waste prevention monitoring shall be raised. Finally, the indicators of the Hungarian National Waste Prevention Programme will be analysed.

Resource productivity

The EU Resource Efficiency Scoreboard was linked to the Flagship Initiative: The Resource Efficient Europe within the EU2020 Strategy (Figure 35).

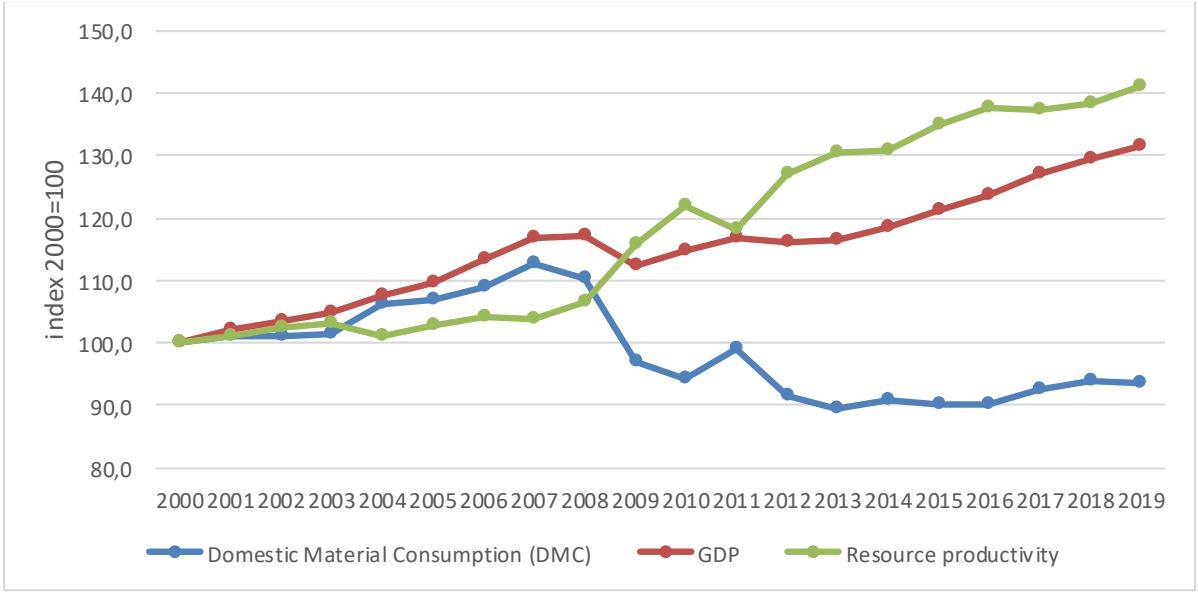
Figure 35 - Resource efficiency indicators



Source: EU Resource Efficiency Scoreboard, EC, 2020b

The lead indicator was resource productivity, which is an indirect measurement of waste prevention. It is calculated by the formula GDP/DMC (Domestic Material Consumption), a relative, intensity indicator. The financial crisis of 2008 led to a sharp optimisation of resource use (Figure 36) (Eurostat 2020b). This crisis – revealing the vulnerability of EU Member States regarding the strong import dependency on materials – contributed to the development of the vision of a Resource Efficient Europe as part of the EU2020 Strategy.

Figure 36 - Resource productivity, Domestic Material Consumption, GDP in the EU



GDP in chain-linked volumes, reference year 2010

Source: Eurostat, nama_10_gdp, env_ac_mfa, env_ac_rp, 2020

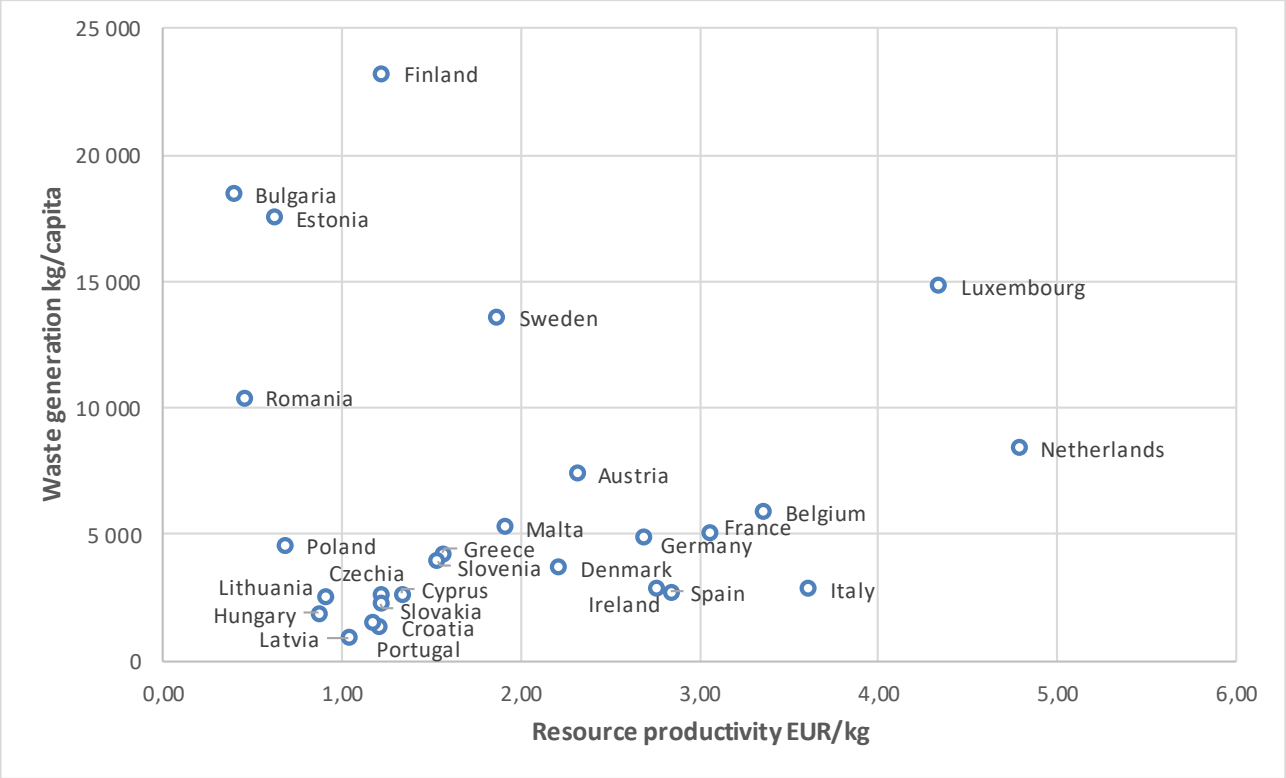
Resource productivity is a so-called decoupling indicator (Fischer-Kowalski 2011, Bringezu et al. 2017) which demonstrates the extent to which the economic growth is independent from the use

of resources. The key concept is to increase added value in production instead of extensive growth requiring more and more natural resources. Resource productivity as lead indicator was highly aggregated, giving good snapshot on the current situation, but obviously simplifying. The second tier is a dashboard of macro-indicators on materials, land, water, and carbon. These focus on the use of specific natural resources and its environmental impact. The third layer is made up of thematic indicators, which measure progress towards key thematic objectives set out in the Roadmap to a Resource Efficient Europe. Waste related thematic indicators are the generation of waste, the landfill rate – both excluding major mineral wastes – and the recycling rate of municipal waste and e-waste. The total amount of waste is particularly included to measure prevention. Eurostat planned to source the Scoreboard on environmental accounts where possible. Reporting on waste accounts is optional to date. The scoreboard is planned to be complemented with footprint type indicators that analyse the environmental impacts through the whole global economic cycle (EC, 2020b). This was particularly important, because according to Giljum et al. the share of raw material extracted within the territory of the EU fell significantly from 68 % in 1995 to 35 % in 2011, illustrating that within a short timeframe two-thirds of the raw materials needed to satisfy European final demand is extracted in other regions of the world (Giljum et al., 2016).

All above-mentioned indicators may form the basis of conclusions on waste prevention, whilst none of them are direct indicators. There is no track on the drivers of resource productivity, whereas this is an important issue for policymakers to understand how incentives should be set. Increase in resource efficiency equals waste prevention only if the following underlying reasons are considered: less use of material by optimisation of and/or cut in production and consumption processes. In other words, if resource efficiency leads to resource saving. If the use of resources is rationalised by substitution, waste prevention may not occur in total (also considered by the LCA model of Cleary, 2010). If resource efficiency increases, because the growth of GDP is more intense than the growth of DMC – the reduction of waste generation in absolute terms may not be valid.

Continuing logic of an existing relation supposed between resource productivity and waste prevention, one could assume a negative correlation. This way it is supposed to be used as a proxy for waste prevention. Figure 37, however, shows no correlation pattern between the two variables in the European Union. Resource productivity rather refers to the level of income of countries (Fischer-Kowalski, 2011). On the other hand, evaluation of municipal waste with a range of variable – population, wages, GDP, and personal expenditure – showed the best correlation with personal expenditure (0,969) demonstrating that waste is expressively growing, if spending is increasing (Coggins 2001). This could be the point where decoupling could be effectively measured: the relation between personal or household expenditure and the generation of waste.

Figure 37 - Resource productivity vs. waste generation among the EU member States (Correlation table)



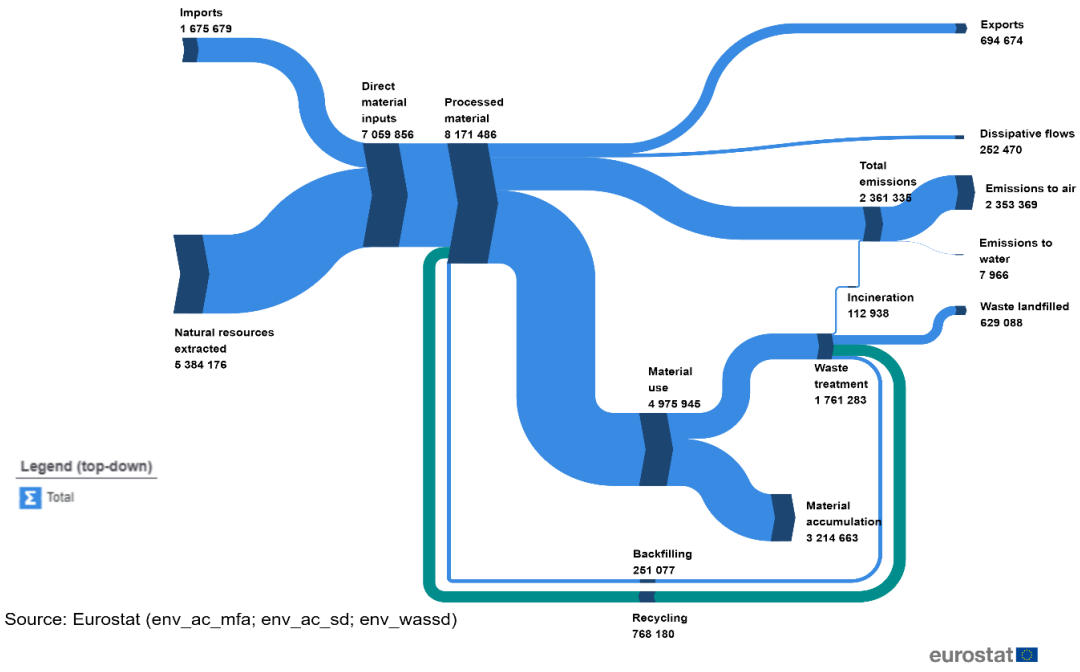
Source: own compilation based on (Eurostat 2020a, 2020b) env_wasgen, env_ac_rp, 2018

Material flow indicators

The material flow indicators (Figure 39) are important basis partly for calculating with the waste of mining, partly for serving as a type of forecasting of future waste. Domestic Material Consumption (DMC) is part of this indicator set, but as mentioned above, the reduction of material use is also indirect statistics as to waste prevention mainly because the reduction may have several reasons.

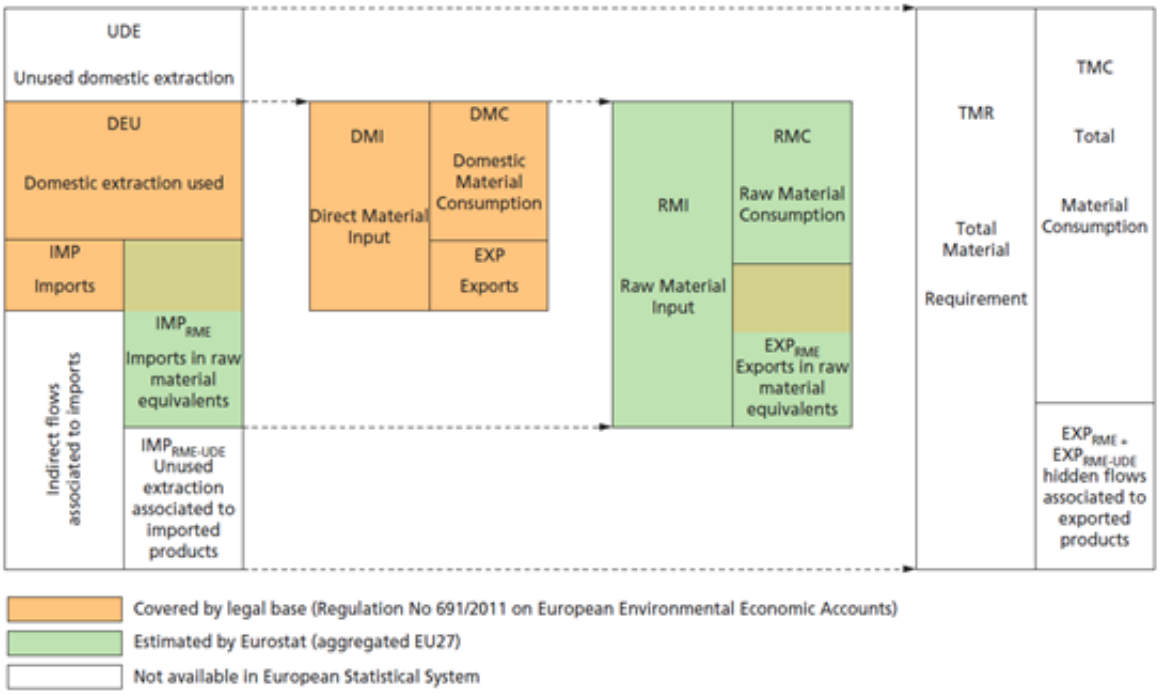
These indicators track the inflow and outflow of materials in an economy, as well as the consumption as discussed in Chapter 2.4.. The basic concept developed is that a country uses material either by extracting the domestic natural resources or by importing material (or as raw material or as product). The material is then either consumed by intermediate and then final consumers or is exported in the form of raw material or product. This logic can be followed in Figure 38 from left to right: import – domestic extraction – consumption – export.

Figure 38 - Material flow (Sankey diagram) (EU-27 (2020), 2022, thousand tons)



Methodology of indicators is gradually improving since the setup of the framework: there are indicators that are already reported, or estimated, but there also missing ones. The most widely used is domestic material consumption (DMC) reported by Member States based on biomass and mining data. The export-import data comes from foreign exchange statistics. Raw material consumption (RMC) is estimated by the EU to the national level. Critical part of this is the measurement of waste (unused extractions) generated by raw material extractions in third countries outside the EU, but which are linked to the imported products (Drahos et al., 2007). Indicators below (Figure 39) follow the same input-output concept as seen on the Sankey diagram.

Figure 39 - Indicators of material flow account (MFA)



* Domestic extraction (DE). Material extracted within the territories of the EU.

Direct Material Input (DMI) comprises all materials with economic value which are directly used in production and consumption activities. DMI equals the sum of domestic extraction and direct imports

Raw Material Input (RMI) adds the Raw Material Equivalents (RME) of imports to DMI.

Total Material Requirement (TMR) comprises all types of input flows.

Domestic Material Consumption (DMC) measures the total quantity of materials used within an economic system, excluding indirect flows.

Raw Material Consumption (RMC) deducts from RMI the export of materials plus the RME of exports.

Total Material Consumption (TMC) adds to RMC the unused extraction related to RMEs of both imports and exports. Other indicators derived from material flow analysis include:

Physical Trade Balance (PTB) shows to what extent domestic material consumption is based on domestic resource extraction or on imports from abroad.

Domestic processed output (DPO) measures the total weight of materials which are released back to the environment after having been used in the domestic economy. These flows occur at the processing, manufacturing, use, and final disposal stages of the production-consumption chain. Recycled material flows in the economy are not included.

Total Domestic Output (TDO) represents the environmental burden of materials use, i.e., the total quantity of material outputs to the environment caused by economic activity. TDO equals DPO plus unused domestic extraction.

Net Additions to Stock (NAS) reflect the physical growth of the economy, i.e., the net expansion of the stock of materials in buildings, infrastructures and durable goods.

Source: EUROSTAT, 2018/Wuppertal Institute: Economy-Wide Material Flow Accounts

Here is the case of Sweden where – a minimum of targets and indicators are set and a research programme was run aiming to identify where and how Swedish consumption has the greatest environmental and climate impact outside Sweden. This highlights the general problem of waste prevention of tracing the waste impact of production and consumption in global context. According to the research, major part of the emissions (>60%) related to Swedish consumption is realised outside of its borders (Palm, 2018). The international life cycle of production implies the outplacement of

waste generation to developing countries with loose regulation and statistics. This practice may result in the underestimation of waste generation in the European Union, showing false development in prevention.

Whereas the Economy-Wide Material Flows Accounts (EW-MFA) is based on domestic extraction of materials in tonnes of gross material, and the exports and imports of products measured in mass weight. This does not include information on the additional material use given the raw material extraction occurring outside the border. As a complementary model the MFA in raw material equivalent (RME) (MFA-RME) was introduced at Eurostat (Schoer, 2023) which attempts to convert the imported and exported products in mass weight in a form including the amount of raw material used during the production. This is the raw material equivalent (RME) which is based on estimations. The MFA-RME includes domestic material extraction by material as well, estimates in the imports and export in RME by material and derived indicators: raw material input (RMI) and raw material consumption (RMC). Figure 40 demonstrates the difference once additional raw material consumption is calculated. The equation for raw material consumption is the following:

$$RMC = RMI - EXP\_RME$$

DE: Domestic extraction (DE)

IMP_RME: Total imports in raw material equivalents (IMP_{RME})

RMI: Raw material input (=DE + IMP_RME)

EXP_RME: Total exports in raw material equivalents (EXP_{RME})

At the same time, domestic material consumption is equal to:

$$DMC = DMI\text{-}EXP$$

DE: Domestic extraction (DE)

IMP: Total imports

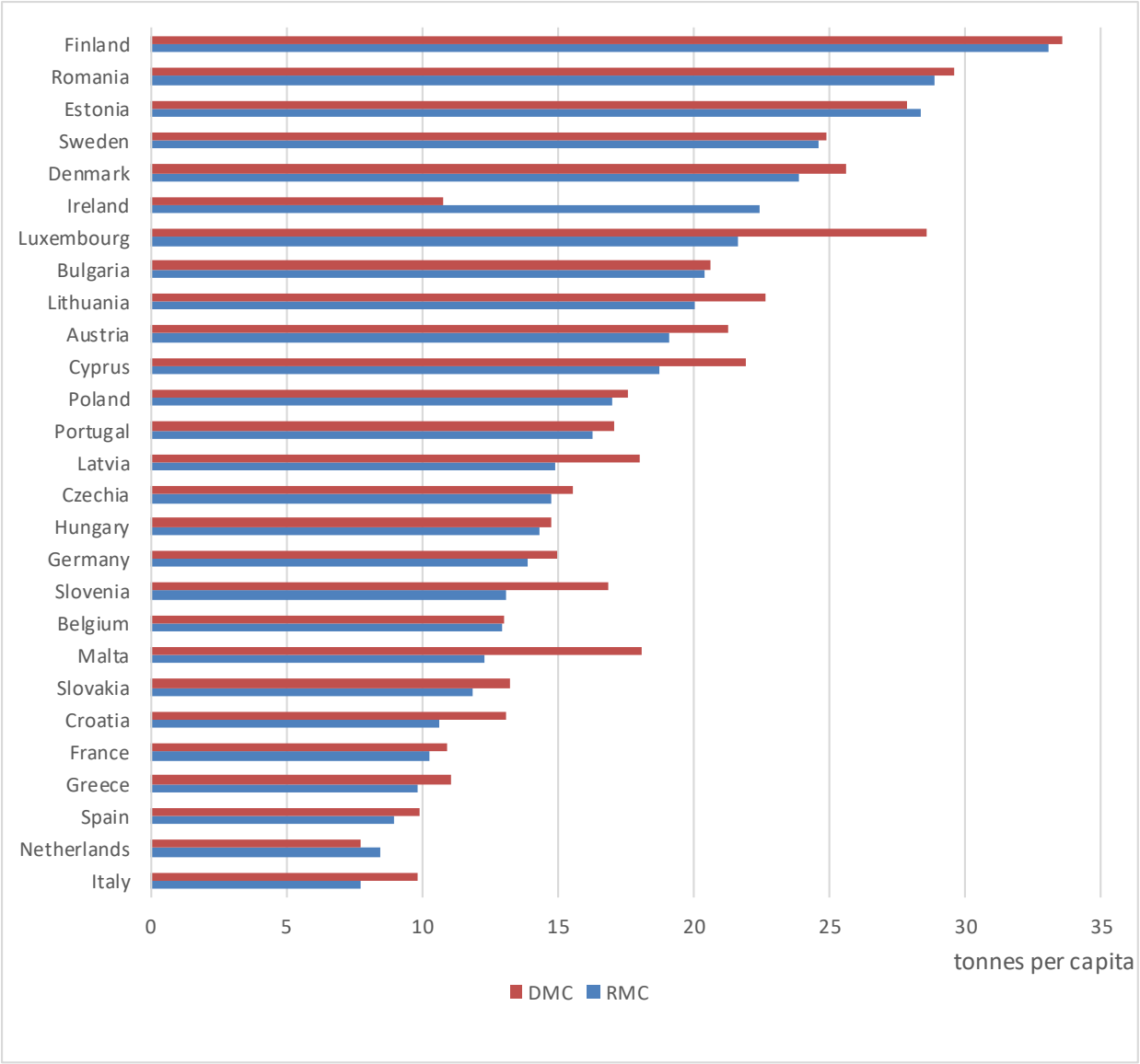
EXP: Total exports

DMI: Direct material input (DMI) (=DE+IMP)

DMC: Domestic material consumption (=DMI-EXP)

The difference between RMC and DMC should be the raw material that was not consumed but was used during production (e.g. spoil of extraction). Given the Swedish example (Palm et al., 2019), the question seems obvious: how is it possible that RMC and DMC are so close to each other?

Figure 40 - Comparison of EU-27 Domestic Material Consumption and Raw Material Consumption (with RME calculation), EU-27, 2020



Source: own compilation based on Eurostat env_ac_rme, env_ac_mfa, 2023

All these indicators would show changes in case of successful waste prevention, ceteris paribus. The reality is not about ceteris paribus: there are lots of causes why these material flow indicators may show variations (e.g. fall-back in consumption for economic reasons or increase in productivity on the production side). Overall problem with MFA indicators is the high-level ratio of estimated data, which may lead to uncertainties, and the lack of breakdowns. Only EU and national level aggregates exist. There is not breakdown based on NACE for the economy, and only the four types of material flows could be observed in disaggregation (biomass, metallic minerals, non-metallic minerals, and fossil fuels). MFA requires additional work to become an effective indicator (set) in terms of waste prevention.

In 2009, the European Commission identified PSR (Pressure-State-Response) indicators for prevention (EC DG ENV, 2009). According to their study pressure indicators are the Material Flow

Account (MFA) indicators – particularly, the Direct Material Input (DMI) –, and the waste generation indicators that may measure the total or only a specific waste stream. The state indicators measure the impact of waste on air, water and soil. While the response indicators measure the effect of prevention policies and programmes.

OECD also identified PSR indicators (see Annex II) for waste prevention consisting of resource productivity indicators such as material productivity, demand-based material productivity, production-based domestic material productivity, waste generation intensity, recovery ratios, and nutrient flows and balances. These are all indirect indicators when it comes to analysing waste prevention, so they should be interpreted with caution. Productivity and intensity indicators cannot show very effectively the direct changes in the use of material, as they are linked to economic performance as discussed in the previous chapter.

Waste generation indicators (absolute and relative)

The indicator system of the Circular Economy Monitoring Framework (Table 12) was adopted in 2018, and was later revised. It aims to monitor the realisation of the goals set by the Circular Economy Package of the EU including waste prevention.

Table 12 - Circular Economy Monitoring Framework - Indicators for waste prevention, i.e. production and consumption

	Name	Relevance	EU levers (examples)
Production and consumption			
1	EU self-sufficiency for raw materials, aluminium (%)	The share of a selection of key materials (including critical raw materials) used in th EU that are produced within the EU. The circular economy should help to address the supply risks for raw materials, in particular, critical raw materials.	Raw Materials Initiative; Resource Efficiency Roadmap
2	Green public procurement (%)	Share of public procurements in the EU that include environmental requirements. Public procurement accounts for a large share of consumption and can drive the circular economy.	Public Procurement Strategy; EU support schemes and voluntary criteria for green public procurement
3	Waste generation	Generation of waste streams related to population, to GDP and to direct material consumption. In a circular economy waste generation is minimised.	Waste Framework Directive; directives on specific waste streams; Strategy for Plastics
a	Generation of municipal waste (kg per capita)		
b	Generation of waste excluding major mineral wastes per GDP unit (kg per thousand EUR, chain linked volume, 2010)		
c	Generation of waste excluding major mineral wastes per domestic material consumption (%)		

4	Food waste (million tonnes)	Amount of food waste generated. Discarding food has negative environmental, climate and economic impacts.	General Food Law Regulation; Waste Framework Directive; various initiatives (e.g. Platform on Food Losses and Food Waste)

Source: EC, 2018e

The relevant indicators are on production and consumption as these measure progress in the pre-waste phase. The chosen indicators cover waste sources only partially on one hand: green procurement and food waste are partial indicators in waste prevention. Whereas waste generation and EU self-sufficiency in raw materials are indirect, and far from precise, if our goal is to measure prevention. There is no available data for green public procurement. The circular economy monitoring framework is criticized not only for its material focus – not measuring other elements of the environment –, but also for not taking into account the conservation of product functions (Pacurariu et al., 2021). Also, the framework covers the raw material integrated in the product, but does not count the time of use, the durability, the reuse.

Most applied indicators for waste prevention are the absolute and relative term indicators. The measurement of the total waste generated (WG), or the amount of specific waste streams generated are absolute indicators. The relative term indicators always create linkage to other indicators, these are: WG/GDP showing resource efficiency, the WG/capita decoupling waste generation from changes in population, the GDP/DMC demonstrating resource productivity and WG(i)/GVA (Gross Value Added) displaying resource efficiency in case of specific sectors. Common characteristic of relative term indicators is that they aim to demonstrate how the economic performance may be decoupled from waste generation, so these are often called decoupling indicators, but at the same time they give false information on the performance of waste prevention policy as they depend on the economy's performance.

The framework for Circular Economy Monitoring (Eurostat, 2023) was revised in May 2023 and includes 5 thematic sections with a total of 11 statistical indicators. The sections are: production and consumption, waste management, secondary raw materials, competitiveness and innovation, global sustainability and resilience. Waste prevention is not named, but section 'consumption and production' includes the pre-waste indicator set. These are:

- Material consumption
    - Material footprints (tonnes per capita)
    - Resource productivity (index 2000=100)
- Green procurement
- Waste generation
    - Total waste generation per capita (kg per capita)

- Generation of waste excluding major mineral wastes per GDP unit (kg per thousand euro, chain linked volumes (2010)
- Generation of municipal waste per capita (kg per capita)
- Food waste (kg per capita)
- Generation of packaging waste per capita (kg per capita)
- Generation of plastic packaging waste per capita (kg per capita)

This list is basically the essence of the past years' indicator developments. It relies consistently on waste generation data of different waste streams which are made relative to the population number, where reasonable to GDP. There is still no data available to date on green procurement. Including material consumption is forward looking, but as discussed earlier resource productivity gives misleading information on waste prevention. The development is similar in case of the headline indicators of the 8th Environmental Action Programme of the EU adopted in 2023 (EEA, 2023b). Under the 'regenerative circular economy' objective one may find Europe's material footprint and waste generation as related indicators.

Recycling indicators as waste prevention measurement

Another concept for overcoming the problem of measuring prevention is to shift the issue towards recycling which is measurable. The UN Agenda 2030 adopted by 179 countries in 2015 includes 17 sustainable development goals (SDGs) with currently 231 indicators (UNEP-UNSD, 2020) "Goal 12. Ensure sustainable consumption and production patterns" includes a target (12.5) on waste prevention: "By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse". The approved indicator (12.5.1) to measure that target is: "National recycling rate, tons of material recycled". The gap between the target and the indicator is obvious and demonstrates the simplification of the problem. Recycling rate has nothing to do with prevention. Rather, recycling attitude is opposite to preventive attitude (Barr, 2007). Ultimately, a secondary – not official – indicator was introduced, i.e., total waste generation, but was later cancelled. In case of indicators belonging to SDG12 major responsibility lies on developed states (Gasper et al., 2019), while this has the most trade-offs when observing interlinkages of SDGs (Pradhan et al., 2017).

Indicators in the Hungarian Waste Prevention Programme

Indicators of the Hungarian National Waste Prevention Programme are two types. General indicators are:

- Total amount of waste generated per year (t)
- The amount of separately collected waste relative to the total generated (%)
- Number of illegal disposals (piece).

The total amount of waste generated is a typical indicator, however, the version related to GDP growth or at least per capita would be more precise. The separate collection rate has nothing to do with prevention as mentioned earlier. This is a good example for how prevention is shifted intentionally towards recycling. Illegal disposal statistics is a data that cannot be empirically collected, it is an estimation at its best. Probably, the reason for including it, is the fear that, if measures are applied that promote the cut of waste in households, that a certain amount of waste may end up in illegal dumps. The collection of illegally dumped waste is also a low hanging fruit from a political point of view: the 'Let's do it!' movement a volunteer-based waste picking campaign is run, and it has attractive, well-communicable outcome. Illegal dumping, nor littering has any connection with waste prevention. Specific indicators are the following:

- Reuse of construction and demolition waste (%)
- Number of licensed reuse centres (pieces), served population (capita)
- Number of products entering licensed reuse centres (pieces)
- Rate of products sold by licensed reuse centres (%) relative to the products entering centres
- Textile, electrical and electronic equipment, furniture, construction materials and products, other products (t)
- Rate of "green" elements of public procurements (%)
- Number of companies introducing ISO140001 (pieces)
- Number of companies introducing EMAS (pieces)
- CSR excellence companies (pieces)
- Companies with sustainability assessment (pieces)
- Number of industrial innovation centres (pieces)
- Students taught about waste prevention (capita)
- Events on waste prevention (pieces).

No doubt, that these indicators go much more in details. The first note is that they hardly cover the consumption side at all. The approach is from the business side. The reuse of C&D waste in the beginning of 2023 does not have any institutional framework, nor qualifying system in place for second-hand construction material. This basically halts reuse. In reality, the private commerce of second-hand construction materials and products exists, but there is no methodology developed to follow up on that. The number of licensed reuse centres and their trade data shall be ideal indicators, once reuse centres and the licence criteria are worked out. "Textile, electrical and electronic equipment, furniture, construction materials and products, other products (t)" is an unfinished sentence, but this was the indicator that the author has personally requested due to the Commission's

implementing act on reuse reporting. This sentence should start by "Amount of reused…". No methodology is yet available for that, but that is valid for basically all Member States. Regarding public procurement, the "green" element is something that does not have precise definition, so the indicator has no sense currently. The number of companies with green quality management system, CSR actions and sustainability reports are useful indicators as proxies, to follow the shift of the production side towards sustainability. These, however, are not specific indicators for waste prevention, nor is the number of innovation centres. The number of students and events are output indicators, but not outcome indicators, students listening to a lesson will not necessarily reduce their waste, although these indicators together with waste generation data could show progress.

The statistical approach of waste prevention may be characterised by uncertainty (Zorpas et al., 2013). A change in paradigm is necessary, because this field cannot be measured precisely by the traditional waste management indicators, given that totally different types of activities lead to prevention. Actors are not the same either. Waste management is the responsibility of public service providers, recycling businesses, etc., whereas prevention is an individual and a community level responsibility. Households, businesses, organisations, academy, public bodies are all responsible in their daily operations. Awareness raising is crucial in this field, and its efficiency must be measured. Examples of indicators may be the awareness raising measures on business, zero waste business units available for the citizens, number of zero waste products, etc. Standardisation of the measurement is also problematic for the different starting points of Member States. In case of a country where separate collection is a widely accepted norm, prevention may need less awareness raising. In case of a less wealthy country reuse may be widespread, with no need for further campaigns. Meanwhile, policymakers and statisticians insist on researching indicators already available to adhere to expectations of comparability, aggregability and economically viable surveys (EASAC, 2016) but which admittedly do not give appropriate or full result.

5.3 Analysis of available statistics

The objectivist top-down approach in the research requires the examination of available official statistics as part of the quantitative analysis described in the chapter on research method. The decision has been taken to develop an indicator set, rather than a composite index. The indicator set gives more sophisticated information, with multiple dimensions. As the data describing the phenomenon is more diversified in case of an indicator system, there is less risk than in the calculation of a composite index, where if a relevant aspect is missed, the index becomes useless.

The model is based on the literature review: the broad conceptual framework is given by the input-output model of Bartelmus (see Figure 14) (Bartelmus, 2003), setting up the relation of natural resources, material use and consumption. The other important framework to build on is the DPSIR

model from Smeets et al. (1999) a casual, circular model identifying stages of the human activities effect on the environment. These are: driver, pressure, state, impact, response. The third element is to choose the list of relevant indicators that could be placed in the casual context of DPSIR, and also to cover the material flow approach. The indicator list seemed to be the most profound in the sets proposed by Zaman (2014) (Table 3), Yano et al. (2016) (Table 1), and Due et al. (2023) (Table 2). All three indicator sets have a lot in common, and these served as a compass for the next step, which was to review the database of Eurostat. Obviously, due to maintaining comparability the search had to be based on Eurostat including data of all Member States. The search brought all together 109 indicators (Annex V) which based on the literature could have relation with waste generation as dependent variable. The domains of the indicators were: waste, consumption, population, economy, education, environment, (household) finances, and material.

The examination of relation involved data of all EU-27 (2020) Member States, but the year had to be decided to run the statistical tests. The selection was based on the data availability: year 2020 turned out be optimal with the second lowest missing data, but the most recent data during the period of 2004-2020. Data availability partly depends on Member States problems or derogations in reporting, or on the frequency of data collection. Pearson correlation tests were made in SPSS for the selected variables, to give a first snapshot on the relations, not only for the second most comprehensive, but most recent dataset of 2020, but also for the year 2015 (lowest missing values) as a cross-check. The test gave similar outcomes for the two years (Annex VI). Yellow colours show in the annex where p value was <0.05, i.e. the relation was significant. Partly, this served as a basis for filtering out the relations that were not significant. The significant relations were grouped, waste generation showed correlation with:

- waste treatment variables (these were included, because treatment and generation data are from separate data reporting, they are not calculated from each other),
- population age indicators,
- material footprint indicators,
- environmental expenditure and performance indicators (government and households),
- the fields of educations,
- GDP, final consumption expenditure, exports and imports of goods,
- COICOP (Classification of individual consumption by purpose) indicators,
- final consumption of households based on durability of goods.
- Two more indicators were chosen assuming some type of relation with MSW generation: consumption footprint and Gini coefficient on income inequality as calculated indicators.

In case of the first, the explanation is obvious as it is a good indicator that links consumption with environmental effects. Whenever income levels are discussed in case of a country, it is not enough the check on the average or the total, but the wealth distribution in the society also has the same relevance, so the Gini coefficient was chosen to tone consumption.

The next step was proving or rejecting the causality among the dependent variable, municipal waste generation and the independent variables. For running a regression the sample size of the 27 EU Member States was fairly small. The GPower examination proved that 2-3 independent variables could be integrated by model. For this reason multiple small models were built up following the above mentioned material use – consumption logic and for identifying demographic characteristics having effect on waste generation leading to the null hypotheses below (Table 13), serving variables mainly for the Driver and Pressure phase of DPSIR model later discussed. The selection of the indicators within the above list was based on including more indicators from the demographic, consumption and material use topics diversifying the models, so that the overlap in their explanatory effect was not too big to get clear picture as much as possible of the specific effects of the one indicators.

Table 13 - Independent variables in models

Model	Group	Domain	Testable variable	Why is it part of the model?
Model1	Supporting question 1	Population	Median Age of population	Supposedly, as people age they accumulate goods in their lives reaching saturation as getting older, in addition, children in the household generate lot of waste (nappies, outgrown clothes, toys, lot of damages, etc.)
		Population	Average household size	The size of the household has positive effect on the amount of MSW generated, but less falls on per capita.
Model2	Supporting question 1	Consumption/ Population	COFOG (classification of functions of government): Education	Government spending education, leads to higher level of education, increasing consumption, knowledge and consciousness.
		Consumption/ Population	Mean consumption expenditure by degree of urbanisation, cities	Consumption expenditure of population living in cities is particularly important they are the main waste generators, and waste increases as consumption increases.
Model3	Supporting question 1	Consumption/ Population	Real gross disposable income of households	The income level defines consumption level.
		Consumption/ Population	Consumption footprint	The higher the consumption footprint, the higher the amount of waste generated.
		Consumption/ Population	Gini coefficient	The level of wealth distribution has an effect on waste generation, the higher inequality could lead to higher waste generation caused by wasteful consumption.
Model4	Supporting question 4	Material/consumption	COICOP (classification	As consumption of all purposes increases waste generation is expected to increase.

			of individual consumption by purpose) total per capita	
		Material/consumption	Raw material consumption per capita	Increasing material consumption probably leads to increasing waste.
		Material/consumption	Recycling per capita	Recycling may increase waste generation having a 'pull' effect.

Regression was made for the *Model1* including independent variables:

- median age of population,
- average household size.

The explanatory level of the model is $R^2 = 0.272$. According to ANOVA the relation of the model to municipal waste generation per capita is significant ($p=0.022$). The variance inflation factor (VIF) should be under 4 as the strictest limit. The VIF values of both predictors are under 4 (VIF=1.021 for both) demonstrating that there is no collinearity. The unstandardized beta for average household size, and median age of population show that there is negative relation with municipal waste generation in both cases, and both variables are significant: $p=0.046$ for median age of population and 0.024 for average household size.

The residual statistics were analysed following the test. The Cook distance was checked for outlier detection, resulting 0.290 remaining under 1, so no outliers were found. Homoskedasticity was also examined via preparing the residuals standardised plot (x = standardised predictor, y = standardised residual) (Annex VII), and no pattern was found to cause skewness or biased results, the variances are homogeneous. The model corresponds to all conditions of regression.

Model2 was set up by grouping other relevant demographic variables:

- COFOG (classification of functions of government): Education (government spending on education),
- mean consumption expenditure by degree of urbanisation, cities.

The explanatory level of the model is $R^2 = 0{,}587$. According to ANOVA $p<0.001$, so the model is strongly significant, with both variables within the model relatively significant ($p=0.069$ for COFOG:Education slightly above the limit, but not far, and $p<0.001$ for mean consumption expenditure of population living in cities. The variance inflation factor (VIF) should be under 4 as the strictest limit. The VIF value for both predictors is 1.054, both being under 4 demonstrating that there is no collinearity. The unstandardized beta coefficient shows positive relation with municipal waste per capita: if the government spending on education and/or the mean consumption expenditure of population living in cities increases, the municipal waste amount shall also rise.

The residual statistics were analysed following the test. The Cook distance for was checked for outlier detection, resulting in a maximum of 0.208 remaining under 1, so no outliers were found. Homoskedasticity was also examined via preparing the residuals standardised plot (x = standardised predictor, y = standardised residual) (Annex VII), and no pattern was found to cause skewness or biased results, the variances are homogeneous. The model corresponds to all conditions of regression.

Model3 included consumption related variables:

- real gross disposable income of households,
- consumption footprint,
- Gini coefficient.

The explanatory level of the model is $R^2 = 0.654$. According to ANOVA $p<0.001$, so the model is strongly significant. The variance inflation factor (VIF) should be under 4 as the strictest limit. The VIF value for the Gini coefficient was 1.013, for real gross disposable income of households per capita 1.059 and for consumption footprint per inhabitant 1.070, all being under 4 demonstrating that there is no collinearity. However, the real gross disposable income was not significant (p=0,086) nonetheless, it is useful to keep it controlled by leaving it in the model. This way it gives the information that it is not relevant from the waste generation point of view. The unstandardized beta coefficients show negative relation of Gini and positive relation of consumption footprint with municipal waste per capita. An elevated consumption footprint causes higher municipal waste generation. Higher level of Gini coefficient (with value between 0-1) means higher level of equality in the distribution of wealth within a country. A more balanced level of wealth distribution leads to higher level of waste generation contrary to what was assumed.

The residual statistics were analysed following the test. The Cook distance was checked for outlier detection, resulting in a maximum of 0.217 remaining under 1, so no outliers were found. Homoskedasticity was also examined via preparing the residuals standardised plot (x = standardised predictor, y = standardised residual) (Annex VII), and no pattern was found to cause skewness or biased results, the variances are homogeneous. The model corresponds to all conditions of regression.

Model3 includes two variables that are significant: the Gini coefficient (p=0.49) and the consumption footprint per inhabitant ($p<0.001$).

Model4 was focusing on consumption and material use including three independent variables:

- COICOP (classification of individual consumption by purpose) total per capita (total individual consumption),
- raw material consumption per capita,

- recycling per capita.

The explanatory level of the model is $R^2 = 0.684$. According to ANOVA $p<0.001$, so the model is strongly significant, but one variable is not significant: raw material consumption per capita ($p=0.917$) is not relevant, the total individual consumption ($p=0.014$) and recycling per capita ($p=0.016$) are significant variables within the model. The variance inflation factor (VIF) should be under 4 as the strictest limit. The VIF value for total individual consumption is 2.170, for raw material consumption per capita is 1.098 and for recycling per capita is 2.077, all being under 4 demonstrating that there is no collinearity. The unstandardized beta coefficient shows positive relation with municipal waste per capita in case of total individual consumption and also with recycling per capita. Consumption increases municipal waste, but as seen recycling also does as expected. This may be because of its pull effect on consumption: if the waste problem seems solved by waste management companies, the individual does not have to pay close attention on reducing waste. This underpins the very different individual drivers in waste prevention and recycling.

The residual statistics were analysed following the test. The Cook distance was checked for outlier detection, resulting in a maximum of 0.284 remaining under 1, so no outliers were found. Homoskedasticity was also examined via preparing the residuals standardised plot (x = standardised predictor, y = standardised residual) (Annex VII), and no pattern was found to cause skewness or biased results, the variances are homogeneous. The model corresponds to all conditions of regression.

The above regressions prove that *Model1-4* are in a causal relationship with municipal waste generation. The variables of the models all have effect on the amount of municipal waste generated per capita, except for two: the real gross disposable income of households in Model3, but is kept in the model to remain under control. The other not significant indicator is raw material consumption per capita. Most probably, due to the limited available sample size (EU 27 countries) this regression model was unable to verify the casual relationship, which does not mean that it does not exist otherwise.

The null hypothesis, H_0 for the below variables in the three models based on their relationship to the dependent variable municipal waste generation per capita are

- median age of population – rejected as the casual relationship is verified;
- average household size – rejected as the casual relationship is verified;
- COFOG (classification of functions of government): Education - rejected as the casual relationship is verified;
- mean consumption expenditure by degree of urbanisation, cities - rejected as the casual relationship is verified;

- real gross disposable income of households – accepted as causal relationship could not be verified with this model;
- consumption footprint - rejected as the casual relationship is verified;
- Gini coefficient - rejected as the casual relationship is verified;
- COICOP (classification of individual consumption by purpose) total per capita - rejected as the casual relationship is verified;
- raw material consumption per capita - accepted as causal relationship could not be verified with this model;
- recycling per capita - rejected as the casual relationship is verified.

A focus was put on driver/pressure type of indicators as forecasting is essential in case of a preventive policy, and these indicators could be adequate for this role.

5.4 Action research in Zsámbék

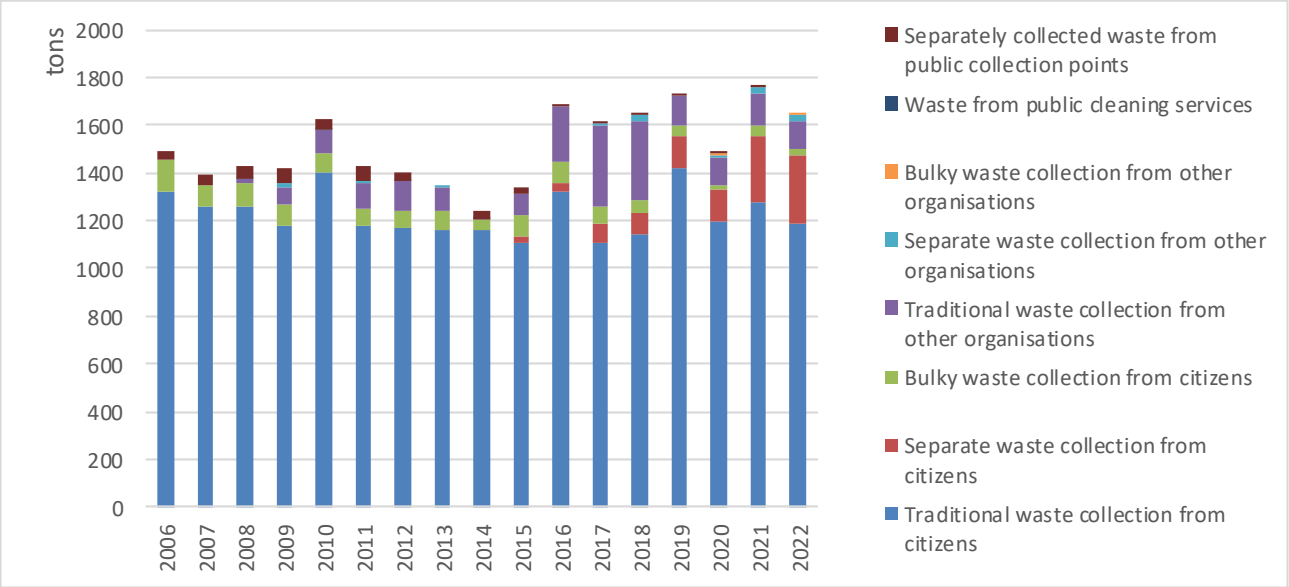
The action research serves as a type of control and reality check of policies, legislation and national and EU level statistics. This part of the research is meant to reveal characteristics from a bottom-up approach of waste prevention, how realistic is the EU/national level waste prevention policy, what are the possibilities and obstacles to improvement? It is an action research as a Zero Waste Workshop was held as a first step with stakeholders in Zsámbék (see invitation poster and photos in Annex VI), which was useful to set the framework, and get information on the city. The second step was an online and in person survey among local citizens on waste prevention. In this chapter this shall be presented. Following the dissertation, a Zero Waste Strategy shall be compiled by the author to support the local government and communities in developing the city's waste reduction capacities.

The city of Zsámbék is part of Budapest's agglomeration, it lies cc. 30 km far from Budapest's downtown. The population is 5,585, the number of dwellings is 1,852, and its area of 3,366 acres lies in Pest County (KSHa, 2024). According the data from the 2022 Census the population is mostly mid-aged: 15% is under the age of 15, 65% of the population is between 15-64 years of age, and citizens older than 64 give 19% (KSHb, 2024). The education levels are relatively high, the population owning high school diploma or tertiary level certificates represent more than 50%. The suburban characteristics is manifested in the workplace of employees: 60% per cent of the local citizens work in other settlements. There are 1,883 households in the city, 55% of those is formed by two adults, 22% is a one person, 12% is single parent household and the rate of multi-generation households has almost tripled since the census of 2011. The rate is fairly balanced among households without children (27.6%), households with 1 (33.7%) and with 2 children (25.1%). Large households with 3+ children

represents 13.5 %. The size of dwelling has intensively increased during 2001-2022: dwellings with 4+ rooms have doubled, representing 53,4% of the total referring to the dominance of detached houses.

Waste collected by the public service provider Zöld Bicske Nonprofit Kft. is increasing, reaching 1,646 tons, 295 kg per capita in 2022, which is much lower than the national average 406 kg per capita. Major part the waste is collected from households. The smaller part is typically the waste similar to household waste from businesses and public institutions, this and the household separate collection gives the bulk of the increase. Meanwhile the separate waste collection is spectacularly increasing in the last few years from households, this cannot be stated about other waste generators (Figure 41).

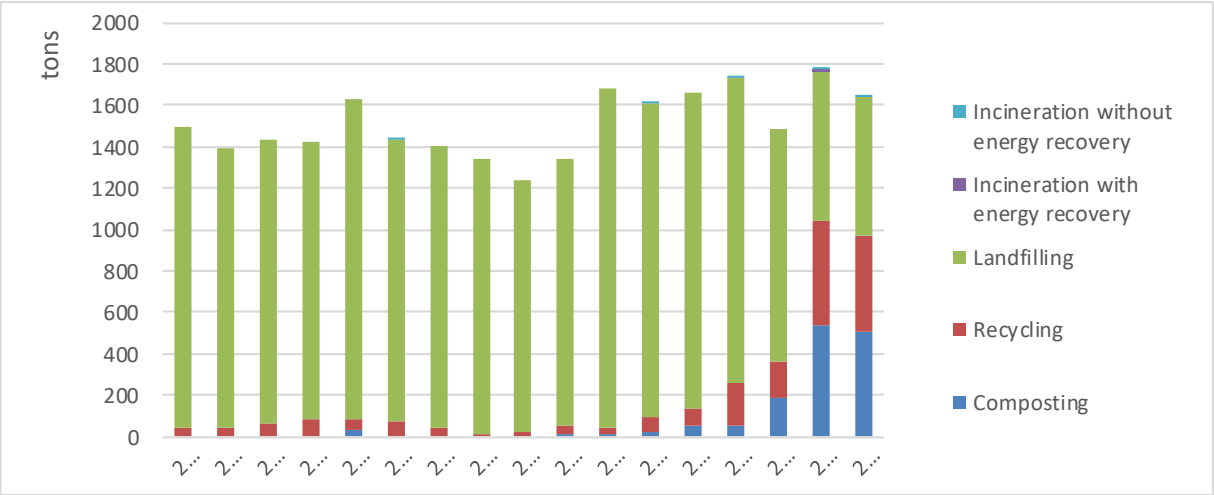
Figure 41 – Municipal waste collection from the city of Zsámbék



Source: Hungarian Central Statistical Office, Information Database, 2024

Waste treated has increased rapidly in the past years, with an even more intensive growth of recycling and composting due the binding EU targets (Figure 42). Incineration is a form of disposal when waste is burnt to reduce its size, however, it has high health and environmental risk. It may happen with energy recovery or without that, for Zsámbék this means hazardous waste incinerator with no energy recovery as a destination of waste. There is still lot to improve in reducing the landfilling rate. This is the point when the life cycle assessment of high-tech and low-tech waste management (Gentil et al., 2011), results could be taken into account, stating that shifting to waste prevention brings significant reduction in environmental burden if the starting point is a low-tech environment. This is the case of Zsámbék, as landfilling dominates in its waste treatment.

Figure 42 - Waste treatment of the city of Zsámbék (tons, 2006-2022)



Source: Hungarian Central Statistical Office, Information Database, 2024

The Zero Waste Workshop took place on 23 April 2023 and was hosted by the Local Government. Participants were the Mayor of Zsámbék, Horváth László, four representatives of public institutions (e.g. schools, retirement facility and urban management company), 2 citizens and the representative of a local environmental NGO, Zsámbéki Ökoműhely actively supporting the research.

The first point of the agenda was a presentation held on the basic terms, the legislative framework and the directions of possible development. These were the reduction of organic waste (food waste, composting), promoting reuse, the reduction of packaging waste and the 'other' category covered actions like sanitary products, construction and demolition waste reuse, incentives for companies, environmental education, waste reduction at mass events and green procurement. The next step was the participants forming small groups and working on the above four topics in rotation. The outcomes of the workshop were organised around the above topic and the collected potential actions are summarised in the below table (Table 14).

Table 14 - Findings of the Zero Waste Workshop

Reducing organic waste
• Food products close to deterioration should be available from retailers (either discounted for buying, or for donation). • Food box (Re-formáló) set up in public spaces where household food surpluses could be left and taken by people in need. • Food surplus of public institutions should be managed, and the regulatory framework should be set to facilitate institutional composting (e.g. retirement home). • Awareness raising of locals on the alternative use of garden waste (e.g. the use of mulch or compost) • Composter distribution action linked to knowledge transfer. • Fairy kitchen (tündérkonyha): common canning, vegetable and fruit dryer, and other preservation techniques of vegatables and fruits in the community house. • Community garden. • Garden waste of companies to be distributed as animal feed.
Reducing packaging waste
• Promoting local farmers, producers – short supply chains: online platform for connecting them to buyers.

• Motivating sellers of the market to give up the use of plastic bags, the re-introduction of the measuring bowls used commonly in the past. • Motivating restaurants to reduce their food waste. • Better separate collection, more knowledge on plastic types. • Tap water awareness raising. • Promoting own horticulture.
Reuse
• Forming reuse communities, even if small ones to exchange products, lend items. • Buy expensive and rarely used machinery together for common use. • Community rental service (the cost-bearer is and issue).
Other important potential actions

• Specific waste streams:
  o hygene products: get to know locals about reusable alternatives, and eco-friendly washing solutions, through health visiting service, in retirement homes or nurseries;
  o construction and demolition waste needs a waste yard (cost-bearing and the regulatory framework is an issue), but also reuse should be priority (e.g. using windows for building greenhouses, other leftovers to build composters, raised garden beds, etc.);
  o bulky waste: waste yard and local swap platform needed;
  o better public waste bins (with top lid).
• Incentives for companies seated in Zsámbék, founding a prize to recognize their efforts and control visits at the companies.
• Environmental education of the citizens (inviting lecturers, provision of communication platform, in local public education institutions, study visit at the waste management service provider).
• Mass events: reusable cutlery, cups, compost toilet.
• Green procurement, setting an example in everyday operation.
• Employing locals to reduce traveling.
• Shelf-market (Polcos Piac): small producers or private sellers renting space on a shelf.

Source: own compilation

The above produced intervention points testify that there is knowledge 'in-house' on waste prevention. There are, however, uncertainties regarding the regulatory frameworks and the cost-bearing was raised numerous times. Although, all over Europe municipalities are responsible for municipal waste, the regulatory framework in Hungary is very centralised, while municipalities are bearing the responsibility of waste management, but they lack tools – those are assigned to the centralised waste management system. That stands for waste, but not for the pre-waste phases of consumption. Here the municipalities have great opportunities to intervene and enjoy the local communities' positive feedback. The least political risk is in supporting grassroot initiatives via a green fund, and if those initiatives turn out to be of satisfaction of the public, the local government may partner in a more organised form. Regarding financing, the local government only plans in public budget, there are however alternative or complementary options. Supporting fundraising from private donators or asking for sponsorship from local companies, or community financing (maybe community co-financing) are also options, and the committed groups of the city may take volunteer actions as an added value.

The workshop was followed by a Zero Waste citizen survey run in Qualtrics between 10/06/2024 and 30/07/2024 online. The structure and questions were based on behaviour, and household prevention measurement studies (Cox et al., 2010, Sharp et al, 2010, Zorpas et al., 2013, Coggins,

2001). The conceptual framework was based on Coggins' (2001) definition of households' responsibility in waste prevention. The first group of questions referred to "What to buy?" by households which partly depends on what is available (e.g. sources for shopping). In terms of quantitative waste prevention the refillable services, using less packaging, avoiding single use nappies, the repairability of products, etc. are determining. The other factor influencing consumer choice is lifestyle, attitudes and awareness which are defined by socio-demographic characteristics or the disposable income. The second topic is related to the question of "What to throw?". The reduction in waste status is guided by the local authorities and depends on the availability of community services such as repair or reuse centres, charity shops, and home composting. According to Cox et al. (2010) the most effective topics to address in household waste prevention achieving highest avoidance is food waste, home composting and bulky waste. According to Zorpas et al. (2013) as mentioned earlier, the main behaviour domains for households in waste prevention were junk mail, reuse, sharing, smart shopping and purchasing choices (e.g. avoiding overconsumption, single life products, buying loose/bulk, food waste prevention, home composting, repair, and others (e.g. avoiding hazardous waste). Almost all of these topics were addressed in the questionnaire (junk mail was not for it has significantly decreased since the crises and the introduction of product fee). In addition, the author has prepared more zero waste strategies for municipalities, so the questionnaire builds on those experiences understanding the main drivers of municipalities, or the most and least preferred forms of prevention in communities. The local government of Zsámbék also requested the insertion of few questions to test planned measures. Based on this there were 4 blocks developed:

- basic demographic data,
- shopping habits,
- knowledge and habits related to waste,
- reuse,
- preferences.

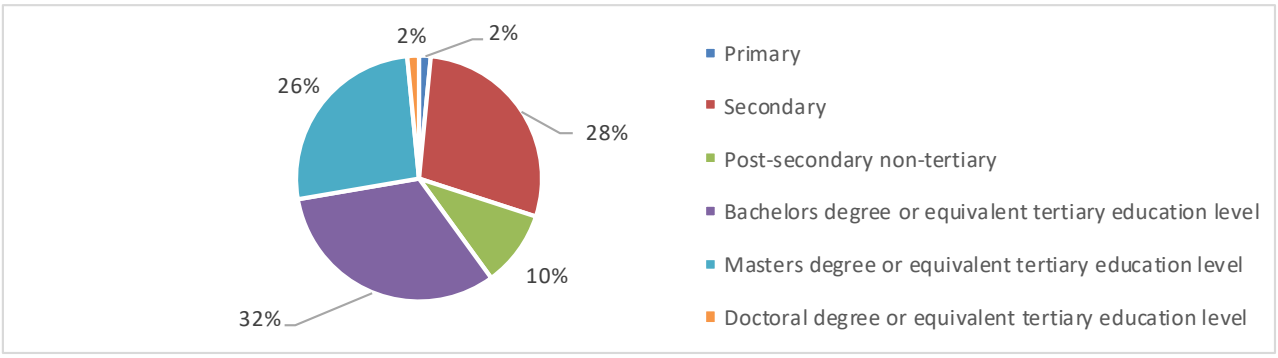
The questionnaire is available in Annex VIII. Advantages of attitude and behaviour surveys in waste prevention are useful because they provide a baseline for monitoring change in the form of both quantitative and qualitative data, the data can reveal participation levels and shifts in behaviour, it gives good basis for information campaigns and action plans (Sharp et al., 2010).

20 questionnaires were filled by hand personally, all others online. A total of 227 questionnaires were started, respondents answering only questions on demographic variables were deleted, 130 questionnaires (=130) remained. Partially filled questionnaires within the remainder are taken into account depending on the availability of the analysed variable. The cleaned sample is 2.32% of the total population of Zsámbék, and is randomly chosen, not representative. Members of the

municipality, the public institution representatives, and the local NGO volunteer was requested to distribute and promote the questionnaire among locals in person and online. Social media, local mailing lists were used for distribution, there was an article in the local magazine as well requesting to have one respondent per household. The questionnaire was reviewed and tested by experts of the Hungarian Central Statistical Office, the representatives of the Zsámbék Local Government, and the local NGO before publishing.

The respondents were aged between 20-81 years, the median age is 43 which is a fairly balanced distribution and a very wide range. 71.4% of respondents were women and 28.6% men, which confirms earlier findings that women are more likely to participate in environmental protection (Steel, 1996). Among the educational level of respondents' higher level is overrepresented (Figure 43), population with tertiary or higher education represent 60% of the sample.

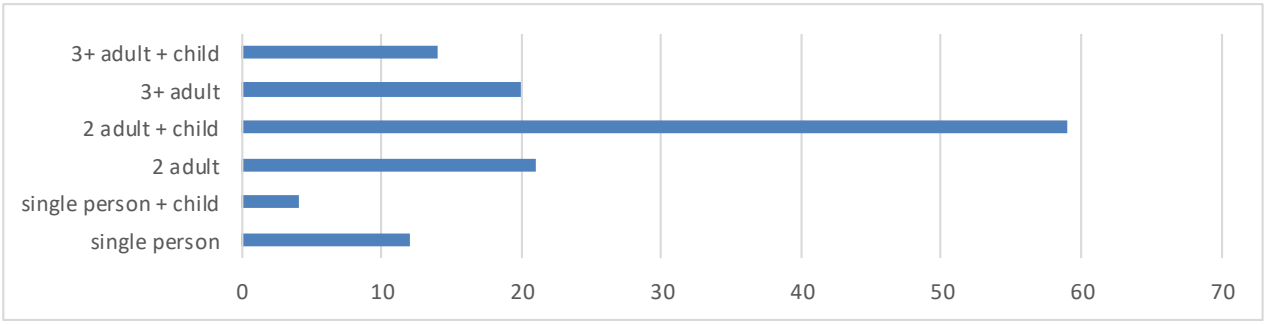
Figure 43 - Distribution of respondents based on their educational level (n=130)



Source: own source

The average household size is 3.4% which is much higher than the Hungarian average 2.3% (2020). The same was demonstrated by the 2022 Census data on Zsámbék. The composition of households show that the adult couple and child/children give major part of the respondents (Figure 44).

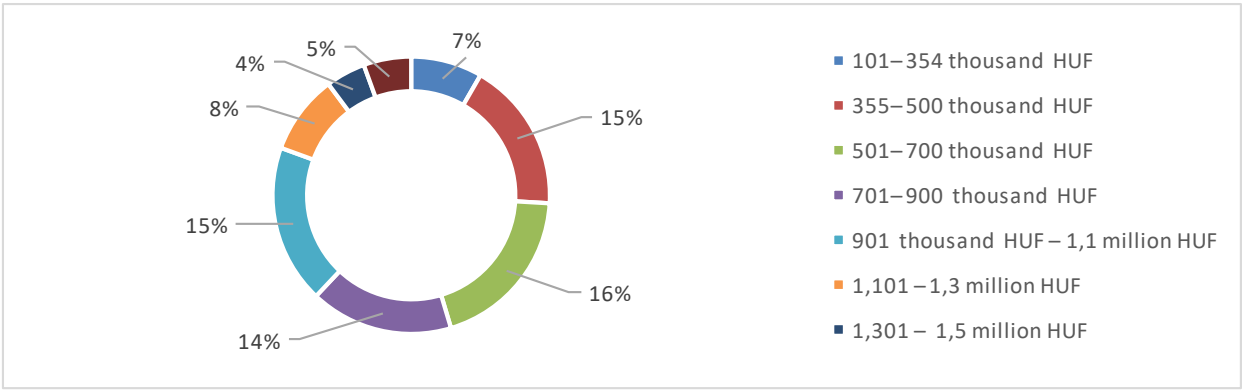
Figure 44 - Number of respondents based on the household size (n=130)



Source: own source

The income distribution of households is the following (Figure 45), demonstrating that the majority of households is evenly distributed among the middle income categories. 60% of the households have a monthly budget between 355,000 and 1,100,000 HUF.

Figure 45- Income distribution of households (n=130)



Source: own source

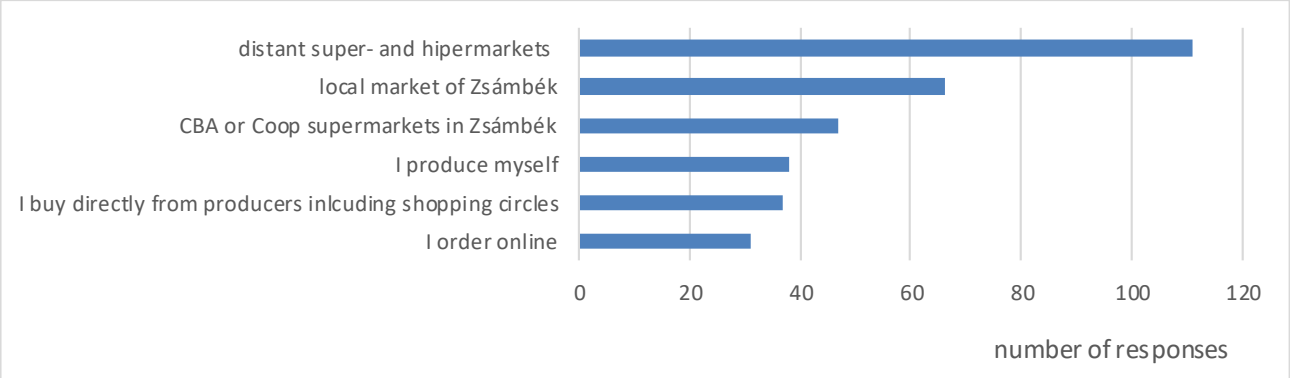
1 respondent lives in a community house, and although 6 live in flats, 4 out of them has garden. All other respondents (124) live in detached or semi-detached houses. The one person living in community house and 2 respondents living in detached or semi-detached houses do not have garden. 41% has a garden between 100-500 sqm, 29% between 501-1,000 sqm and 27% owns larger than 1,001 sqm. This may lead to the assumption that the conditions are given for composting especially that garden waste seems to be substantial.

The most important variables were not only presented with descriptive statistics, but also inferential statistics. The method for testing relations of two categorical variables was Chi-square test, two scale variables by correlation and in case of a categorical and a scale variable ANOVA or T-test was used depending on the number of values that a variable could have, followed by homoskedasticity and normality check.

'Did the consumption in the past 12 months change? If yes, did it increase of decrease?' This showed positive correlation with the size of households ($p=0.034$, Spearman coefficient: 0.186), meaning that with growth of household size the consumption decreased. The consumption's relation to the educational level was positive and significant (Kruskal-Wallis $p=0.012$), but the income level did not show significance. The following question asking whether the waste generation of the household has decreased or increased in the previous 12 months obviously showed very strong positive correlation with the previous question ($p<0.001$, Spearman: 0.752).

Figure 46 confirms that the main source of shopping are the distant super- and hypermarkets either as complementary to other sources or chosen exclusively. This for sure causes significant environmental burden with the traveling and also because of the packaging. As a contrast, the local market at the second place is one of the best choices in terms of distance and packaging, thus waste prevention.

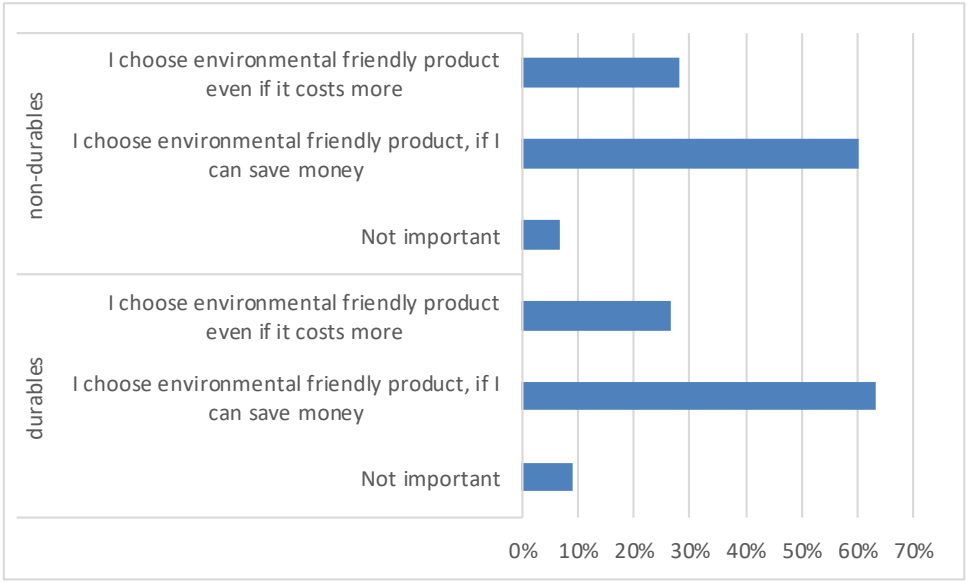
Figure 46 – Sources of shopping of respondents (multiple choices permitted, n=130)



Source: own source

Age, household size, level of education and income level have not shown any significance to the question testing the degree of environmental consciousness in case of durable and non-durable goods (Figure 47). The outcome of the question did not verify the assumption that distinction is made in environmental choices between the categories of goods (e.g. buying repairable items in case of durable goods). The distribution confirms the discussed 'active-passive' form of waste prevention. If savings occur, that is a 'passive' type of environmental protection, it is the positive externality of finances. The active, conscious form of environmental protection, investing if necessary, is much less popular even if there is definitely a positive bias toward environment as the completion of the questionnaire was voluntary. Probably those in the conscious category are the typical committed people of waste prevention.

Figure 47 - Consumer decision of respondents and environmental consciousness (n=130)



Source: own source

The habits regarding packaging choices show higher degree of consciousness (Figure 48). Probably the introduction of product fee on packaging (plastic bags not for free anymore) and the

new take-back system of Mohu recently introduced draw attention on the environmental aspect of packaging.

Figure 48 - Use of reusable packaging (n=130) (multiple choices enabled)

Source: own source

Regarding rental majority of respondents (n=130) do not rent at all (69 answers), raising the question if that is due to the lack of local services or the ownership is more important. This is replied later during the analysis of preferences. Other items were mentioned, such as: baby crib, breathing monitor, canning machine. 41 answers opted on library, 28 on transportation tools, 26 on machinery, 10 on sport and hiking tools and 3 on clothes, costumes (multiple answers were enabled).

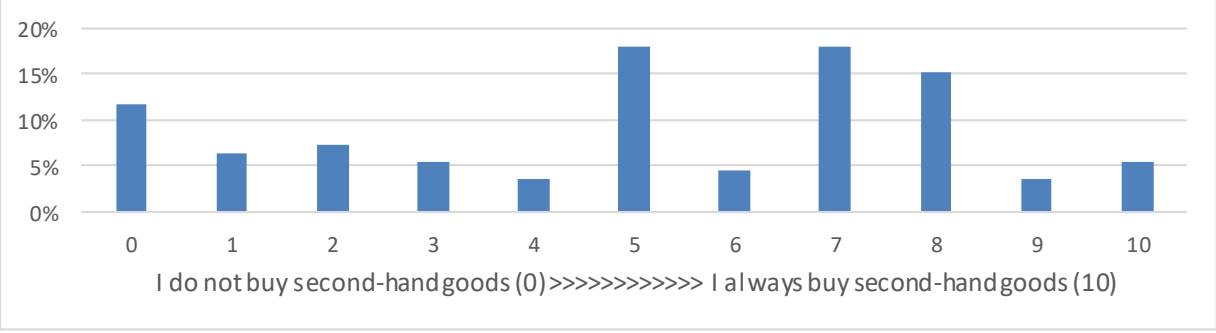
The first block on shopping habits has in general confirmed that pro environmental choices are made, if they are supported by financial incentives. The next block was on waste related knowledge and habits, starting with the question whether the respondent is able to rank recycling and reuse based on their environmental impact, in other words, if they understand the notions right. 57% of respondents (n=116) answered right choosing recycling as the one putting more burden on the environment, 12% answered both equally, 4% chose reuse as more polluter. High level of uncertainty can be detected as 27% of respondents admitted not knowing the right answer. The high level of wrong answers and uncertainty together (43%) confirm the need for information awareness actions.

Although it has nothing to do with waste prevention the next question was on recycling habits to test the sensitivity to waste topic. Generally a very high ratio was the outcome of the responses. Out of n=116 respondents 60 to 90 per cent collects separately depending on waste type. The lowest level of recycling was associated with textiles, and the list in ascending order was: medical waste, bulky waste, waste oil, biowaste, glass, metal, hazardous, e-waste, paper and the top of the list was occupied by plastic (90%) This definitely reflects the availability of services, but also draws attention on how distorting self-reporting can be: the official statistics of the municipality show that 28,2% is the rate of recycled waste (only including plastic, paper, metal and glass). The truth probably lies in between, as among the respondents' pro environmental attitude is certainly overrepresented, but 60 to 90 per cent seem fairly overrated by respondents. This is why the measurement of waste prevention undoubtedly requires also hard data, like the mass of wastes treated, e.g. based on collection round data mentioned by Zorpas et al. (2013).

The respondents (n=116) produce on average 8.84 kg food waste per capita weekly, 460 kg annually. This shows considerable difference from the officially reported country average of 66 kg per capita per year (Eurostat, 2024b). The divergence may partly be linked to the misperception of the amount of food waste generated. However, this type of overestimation may reflect the guilt of respondents. The variable was tested for inferential statistics, and confirmed significant relation with the age of respondents in the form of negative correlation, meaning that older people seem to be more conscious in food waste generation. The education also shows significance, but food waste generation surprisingly does not depend on the income level. Food waste is being composted by 53%, and given to animals by 17%. Food surplus is mostly given to animals (39%), composted (20%), given to known and/or deprived people (15%). In both cases more than quarter (29% for food waste, 27% of food surplus) of the respondents replied that they throw food to the bin. This leaves substantial potential in waste reduction by channelling non-deteriorated food towards people in need or animals, and food waste towards compost. Most importantly awareness raising could help in reducing the overall waste and surplus.

The subsequent block of the questionnaire targeted reuse (Figure 49). The first question (n=111) gave information about the respondents' attitude towards used, second-hand goods. The answers showed very strong positive correlation ($p<0.001$, Spearman: 0.383) with the household size. ANOVA has proved that there is also significant relation with the educational level (Kruskal-Wallis $p=0.003$) and the income category (Kruskal-Wallis $p=0.022$). 12% of respondents turned out to be anti-reuse. In case of the others a neutral or stronger pro reuse attitude is detected. The high level of 5 on the Likert scale is probably due to the general question, as buying of second-hand goods depends on the type of good, but gives good reflection on the positive attitude on used products. An overall 88% of respondents do not reject reuse, which confirms again massive potentials in waste prevention.

Figure 49 - Do you buy second-hand goods?



Source: own source

The drivers of buying used goods is that it is cheaper than the new (42%), the protection of the environment (20%), and the uniqueness (10%). No other drivers were given by respondents, so the

most important ones seem to be covered. 42% is in conformity with earlier findings that pro environment attitude is primarily driven by financial considerations.

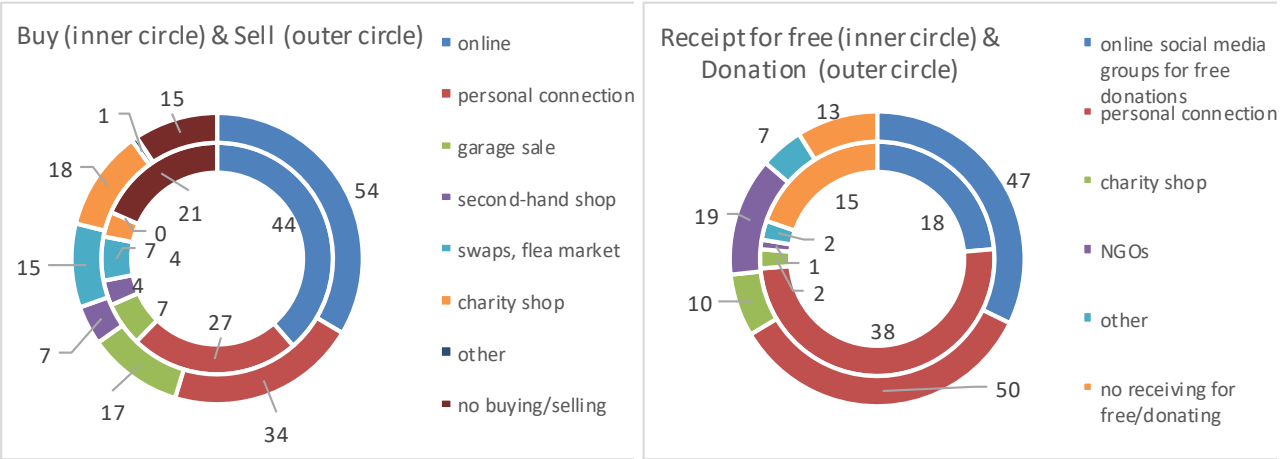
The series of questions regarding the estimation of buying and selling second-hand goods relies on the EU Decision (EC, 2021) requiring reporting in product categories of textile, furniture, electronic and electrical products, and construction materials. Construction material is out of scope, the other categories are included in the questionnaire. The difficulty level of these questions is demonstrated by the reduction in response rate (n=111 going down to n=74). Figure 50 shows the average quantities of used goods in circulation. The numbers are based on estimation of respondents focusing on items of bigger mass: outerwear, large-sized furniture, electronic of electrical goods.

Figure 50 - Average annually circulating quantities of used goods (pcs)

Source: own source

The inward and outward flows are relatively balanced except for the textiles donated revealing the problems of overconsuming new clothes in the world of fast fashion. Regarding the channels of inflows and outflows (Figure 51) the most popular channel is online, the second is personal connections either way. The online commercial platforms are available at national level, but also local social media groups are formed to sell/buy and donate:

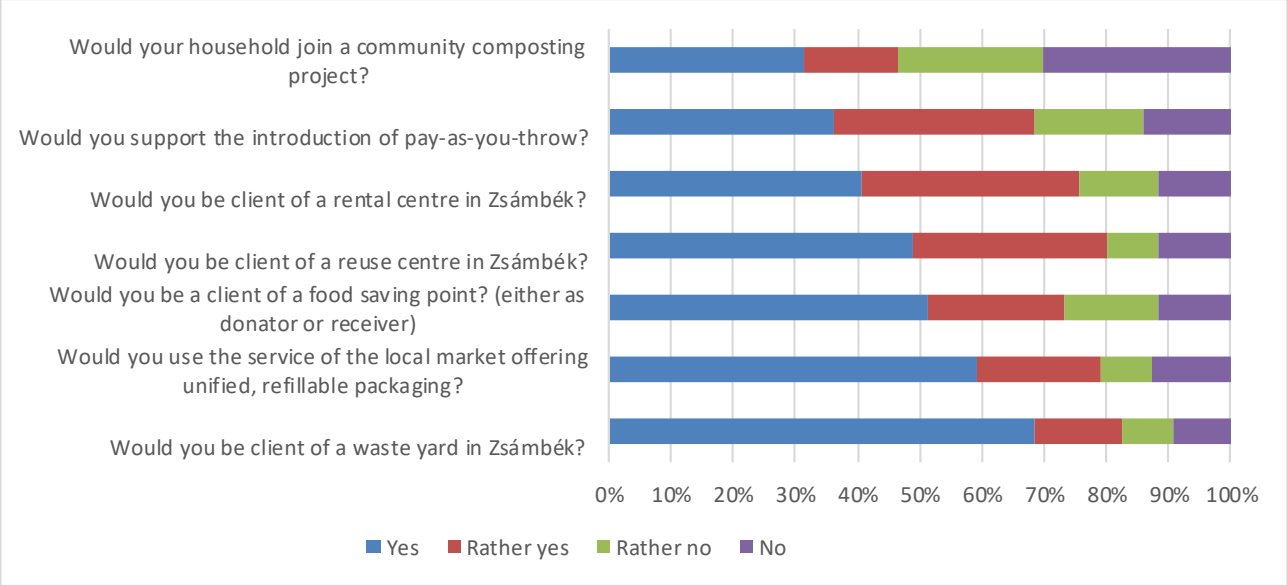
Figure 51 - Inward and outward channel of used good in households (number of answers) (n=86)



Source: own source

Repair seems to be really popular with 8% of respondents (n=86) (Figure 52) ticked all four categories (clothes and textile, furniture, electronical and electrical goods, and other) and around 30-30-30% ticking 1 to 3 product types that they used to repair. Repair of clothes and textiles is at the first place followed by e-goods and furniture. There were valuable answers listing other types of products that is used to be repaired, such as: toys, transportation tools (bikes, motorbikes, cars), home and garden tools/machinery, and composter. There was also a concrete question on the types of repair services needed in the city: 76% would welcome an e-goods service, 70% textiles and shoes repair service, 47% claims that there is need for home tools/machinery services and 28% answered that furniture repair service would be useful. 5% of the respondents stated that there is no need for such services. One additional proposal was a glass service.

Figure 52- Preferences of respondents regarding potential actions supporting waste prevention (n=86)



Source: own source

The most supported action would be the opening of a waste yard, which does not exist today in Zsámbék. This has little to do with waste prevention, but is a very basic expectation from the local community. The order of preferences, however, reflects the end-of-pipe approach. The standardised refillable packaging has also warm welcome, as well as a food saving point. Reuse and rental centres and PAYT are also supported, but a higher degree of uncertainty can be detected, probably due to the lack of knowledge. These centres are not well-known in Hungary, and the personal consequences of the introduction of a PAYT system are also unclear. This needs a lot of communication, awareness raising. Half of the respondents would not join a community composting initiative, this might reflect that they already have the composting issue solved within their own property, as majority of the population lives in detached or semi-detached houses, and almost all respondents have own gardens.

56% of the respondents (n=86) would become customer of a zero waste shop if it were cheaper than the shop they used to go now, and 35% is committed to become a regular customer even, if that is not the case. Only 9% is the responses would remain with the current source of shopping. Some other habits were also analysed which are of significance to waste prevention. The next question addressed the use of nappies and hygiene pads, as these form substantial part of the amount of municipal waste, especially in volume (ITM, 2018). 65% of the responses stated there are nappies/hygiene pads in use in the household, and some are reusable. 17% replied that although these were in use in the household, but none of them were reusable and 17% of households in not relevant to the question. This ratio again shows commitment. The other massive waste producer are the events, and Zsámbék has a lot of mass events. 38% of responses would welcome reusable cutlery and cups, 19% would reject those and 43% does not attend such events. There is a relatively high level of rejection, so the European Plastic Strategy (EC, 2018b) prescribing the ban of single use plastics need sensitising.

The overall conclusion is that there is openness to waste prevention activities, but knowledge is missing which underpins that the main barrier to prevention apart from consumerism is the lack of knowledge (Barr, 2007). For this reason recycling and waste treatment (waste yard) seems to be most attracting, which is of course substantial, but beyond that there is higher level of uncertainty. It was surprising to learn that 43% of the respondents, who are rather pro environment do not know about the existence of a green corner in the local hardware store. The flow of information should be facilitated by creating pro environmental channels, and by supporting the ones already existing, like the local NGO's social media channels, for example. The population of Hungary is traditionally very price sensitive, this is absolute primary in consumer decisions, and the crises and inflation of the recent times, have pushed the population even more towards that direction. The decoupling did not take place in the minds of majority of respondents although this is not a poor city: well-being seems to depend almost exclusively on financial decisions, and the environmental impact having a negative boomerang effect on the quality of life is not integrated in the thinking of the majority of respondents. On te occasion of any action, primarily the financial gain should be very much emphasized. In lot of cases waste prevention leads to financial saving – e.g. choosing second-hand or repairing items, home composting, reducing overconsumption, reducing packaging paid for. This could be a starting point for awareness raising. Committed local environmentalists on the other hand do not need that type of dedicated motivation, but they need knowledge, and they need waste prevention community services to become available. In addition, if the local government would support or partner with civil actions on building zero waste community programs, there would be an added value of boosting local social life, which is crucial in case of a city of agglomeration where citizens often just go home to sleep. The workshop held for stakeholders underpinned the openness of the local government and the public

institutions, however, decisions should not only be made to support mandatory tasks of the country (e.g. increasing recycling rate). The outcome of the workshop and the questionnaire depicts a number of waste prevention actions that could be launched and supported by policy decisions. Such actions should address food waste, composting, reuse and the reduction of packaging, also requiring monitoring to track progress at the city level. These indicators could then be aggregated at national level with the additional added value of contributing to mandatory reporting to the EU.

6 Results: findings and a new indicator set for waste prevention

This chapter answers the research questions starting with the main questions and following up also on the supporting questions. It sums up the most important findings serving as the basis for presenting the new concept for waste prevention indicators.

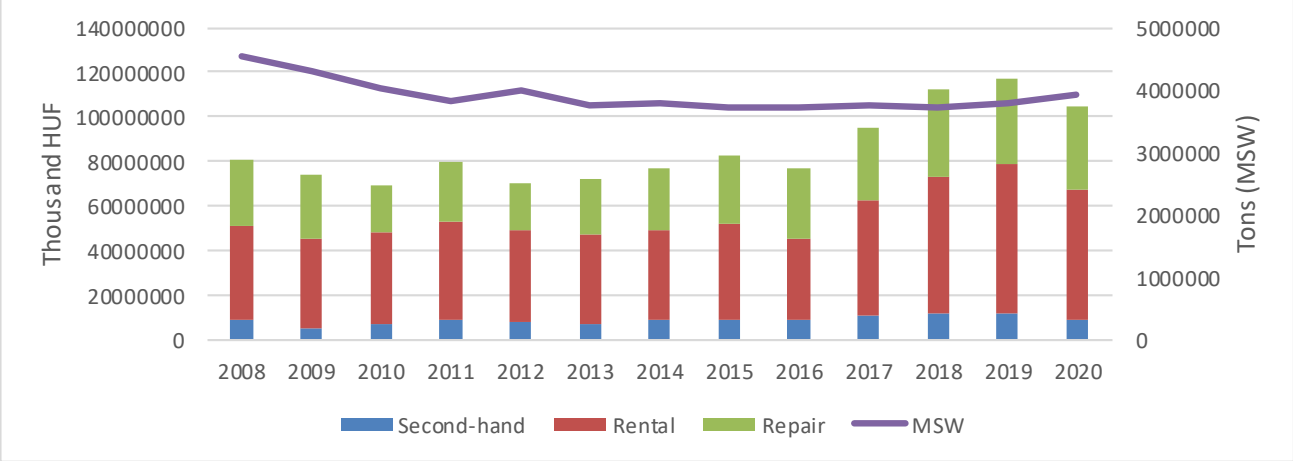
"How can waste prevention be monitored in the European Union?" was the main question of the research. The outcome is that the dual approach in waste prevention is unavoidable. As waste prevention matters on diverse, usually small scale actions difficult to standardise, it is not enough to set top-down targets, especially when monitoring to date is based on national or EU level aggregates, that frequently do not have settlement level disaggregations. Understandably, the European Union expects Members States to report in a standardised format, to be able to aggregate and put forward the outcomes of the joint efforts of the union. Comparability is also important as the single efforts of the Member States should also be recognised. Data collected already by the European Union had to be reviewed to make use of already existing data collection and find statistical relations among them and the municipal waste generation. Indicators had to be observed based on the needs of local governments and communities, the viable waste prevention actions had to be understood and transled into indicators for monitoring. National prevention programmes made enourmous leaps forward in their details respective to the versions of 2013, but there is still lot to develop: a balance should be reached between using waste generation as exclusive monitoring tool, and the other extreme were dozens of indicators were introduced for waste streams having to cope with data availability problems.

Assigning reuse centres to waste management companies running waste yards or recycling centres seems reasonable, as not only this is a convenient solution for the clients, but these companies are already reporting on waste generation and treatment. Giving licence to new reuse centres automatically requiring data provision is also viable, but it is hard to get data for example on the repair of goods by survey. This might be better covered by defining the repair NACE categories. In case of waste prevention not only repair (Due et al. 2023), but second-hand commerce and leasing related NACE groups, and classes may also be taken into account. In the official structural business statistics (SBS) value added, or net turnover data of the following groups/classes are proposed to be

taken into account (referred to as ‘re-sector’ by the author): 47.79 Retail sale of second-hand goods; 77.2 Rental and leasing of personal and household goods; 77.33 Rental and leasing of office machinery, equipment and computers; 77.39 Renting and leasing of other machinery, equipment, and tangible goods n.e.c., 95.1 Repair of computers and communication equipment; 95.2 Repair of personal and household goods.

Three groups were formed from the above ‘second-hand’, ‘rental’ and ‘repair’. SBS GVA data was published for NACE three-digit level until 2020. Following the change in methodology, four-digit level is theoretically available, however data is missing in 2021-2022 in case of many Member States. As appropriate data was not available for all countries, Hungary was taken as an example, resulting in the following diagram (Figure 53):

Figure 53 - GVA of 're-sector' and MSW generation in Hungary



Source: own source

The low sample size does not make regression possible. The three groups strongly correlate with each other (rental-repair $p<0.01$, second-hand-rental $p=0.002$, second-hand-repair $p=0.003$), but show no correlation with MSW probably, because there is an indirect effect mixed with others, and which is also shifted in time (given the basic expectation of extending product lifetime). Given a product that is being reused by many owners, or repaired several times, or rented instead of bought, optimally should manifest in the reduction of waste, as the buying of a new is avoided by each owner.

The development of indicators should serve the top-down expectation and bottom-up reality, and should reveal the casual effects, which would improve the forecasting ability. Indicators should not only be the basis for monitoring of performance, but should contribute to the EU, the national and local government level policy planning where forecasting is essential.

Which social, economic, and environmental factors affect the waste prevention? was Supporting question 1. Based on the regression and also the survey run in Zsámbék demographic characteristics having casual effect on waste prevention action was proved. The average household size and the

median age of population are confirmed by regression model to have casual effect on municipal waste generation per capita. The median age has negative relation – ageing leads to less MSW production which may be related to the slowing down of the accumulation of goods. In addition, households with children have an increased waste production, because of singe-use nappies, food leftovers of children, outgrewn clothes, shoes, change of toys, damages, etc. The average household size is in negative relation with the dependent variable confirming the assumption, that the growing number of household members increases waste, but to less extent per capita, than the average. Obviously, there are lot of goods which amount is not related to the individual, but to the household (e.g. washing machine or other appliances).

The survey has confirmed that gender has an effect (Steel, 1996): women are more likely to participate in environment protection.

The higher education level's relation is not that straight forward, as it partly leads to higher income discussed above. At the same time, higher education leads to higher level of knowledge leading to higher level of understanding environmental problems including waste generation, expectedly leading to more consciousness, but this is unfortunately overdriven by consumption effect in our findings. Higher level of education led to increased consumption according to the survey, in accordance with the regression model confirming that higher level of government expenditure on education leads to increased municipal waste generation.

According to the literature (UN, 2015) the degree of urbanisation also has an effect on the amount of municipal waste generated, the mean consumption of the population living in cities gives good estimation on the municipal waste generation showing casual effect on waste generation in the regression model.

Another important statement is that the Gini coefficient has effect on our dependent variable based on the regression model. If the Gini coefficient of a country is higher, the distribution of wealth is less balanced in the society. A country heading towards a more equal income distribution shall face growing amount of municipal waste generation. This may stem from the accumulation of goods of households once their income is increasing. Every household shall buy of the items usually needed to run a household, for example. This could be leveled out by increasing reuse and sharing.

The survey confirmed that there is high degree of uncertainty in knowledge on reuse and recycling, more than 40% did not know which one was basically higher on the waste pyramid.

Environmental factors identified in the literature were selective (Gentil, 2011), as those are closely linked to waste management operations which were out of scope. However, the most comprehensive form of measuring the environmental burden, life cycle assessment findings were included relative to waste prevention, which could serve well as impact analysis in the DPSIR

framework. Such good examples are the environmental emission (WMP) of waste prevention actions based on LCA (Cleary 2010) and the Global Warming Potential, the Water Depletion the Metal Depletion and Human Toxicity indicators of waste prevention actions that can be also calculated by LCA methods (Hutner et al. 2018). The consumption footprint per inhabitant also has a casual effect on municipal waste generation, which is quite obvious.

Among the economic factors the most important goal is decoupling, ie. achieving economic growth without increasing the use of natural resource, ie. generating waste. This could be achieved by the so-called dematerialisation of the economy . The only way to do so, is increasing resource productivity, but behind that again there is a dual motivation. Lilja (2009) states waste prevention equals resource efficiency, plus moderation of consumption and prevention of hazardousness. This dual approach was confirmed in the survey run as difference in motivation when waste reduction is a positive externality of an economic consumer decision, and when it requires effort, time, investment of extra spending. The openness to action was substantially higher in the case the action led to financial savings, not only waste prevention.

How does waste prevention appear in the EU and Member States policies? The National Waste Prevention Programmes (NWPP) are mandatory since 2013, and were ex ante conditions to EU financing. They developed in huge steps since the first programmes including very basic waste indicators or even no indicators, lacking quantitive targets, and focusing on recycling (Wilts et al., 2015). The 2020 review shows that some programmes are explicitly detailed, and all of them are much more focused on the pre-waste phases like reuse, repair, bulk shopping, banning packaging, etc. Regarding the indicators countries either include only those already subject to mandatory reporting – probably to lower political risk –, or in the other extreme very detailed indicators in case of which data availability shall be an issue (e.g. Greece: quantity of reusable utensils, cutlery and cups used at events; Spain: number and economic value of R&D and innovation projects, etc.). Still, there are countries that remain without any targets and/or indicators (e.g. no indicator: Luxembourg, Malta, Netherlands, Romania, no target: Slovenia), or only the binding EU recycling or plastic packaging reduction targets are set.

Returning to the theory of environmental policies, waste prevention is the classic case of the re-structuring (preventive) environmental policy (Kerekes et al., 1996) aiming to transform production and consumption patterns. Forecasting in this set is crucial, this should be born in mind when selecting indicators, demographics and consumption data could give approximations on how much waste shall be produced.

Based on the NWPP review the most applied policy instrument of this environmental policy for MSW prevention is information campaigns, almost all countries have applied them confirming the

finding of Barr (2007) on household consumption habits that the lack of information is a main barrier to waste prevention. Setting up or supporting the running of reuse and repair centres are also priority, followed by green procurement, the ban on single-use plastic packaging together with tap water campaigns. Labelling of products as part of information actions is also emphasized as well as the establishment or running of food banks, together with tax reductions for donations. Organic waste reduction is targeted by home composting, and unsolicitied mail reduction is also the case in some countries. The common use (rental, sharing) is rarely addressed in NWPPs, but this has a huge potential in waste reduction, this might be the next step of development for many countries. Collaborative consumption models are the best choice for shifting consumption (Ghisellini et al., 2014). This priority list is also reflected by the Zero Waste Workshop findings of Zsámbék, it was completed by waste free shopping (in bulk), and the preference of short supply chains. According to Karigl et al. (2022) "instruments should be legally binding, voluntary agreements should be disregarded, and tax incentives should be given (some countries already apply that), green procurement, and the formalisation of community engagements must take place among others". The principle of subsidiarity (Zaman, 2017) has to be applied to perform community and household level actions, and measure them. So far 74% of EU Member States have increasing municipal waste generation since the adoption of NWPPs, so further steps should definitely be taken, as instruments so far used proved to be ineffective.

Regarding the waste streams the quantity of measures show that food waste is a key waste stream having substantial potential in reduction (Cox et al., 2010), and the policy instruments and monitoring methodologies are relatively well-developed. The food waste voluntary agreements target businesses in the value chain of food products, which is obvious as food waste divergence may happen effectively in bulk on the production side. Food waste is accompanied by home composting. Reuse and repair activities are also important, because the EU recycling targets indeed are recycling and reused targets, so in case data could be collected in a formal, official way, they could be added to country performance. This is why EPR also focuses on reusability, repairability apart from recycling in some countries.

Which are the commonly used waste prevention indicators? Taking the DPSIR model (Smeets et al., 1999) as a widely used environmental indicator model as basis, major part of the indicators are descriptive pressure indicators featuring output of human activity. There is hardly any circular approach (in terms of the DPSIR models circularity), the few cases of drivers, i.e. demographic, material use and consumption data are above mentioned. For the state indicator Lithuania and Denmark presents the only cases with the GHG emission of the waste sector. Few response indicators occur on policies, incentives.

From another perspective three 'schools' were identified in this research regarding measurement. The first school's ('Theory-based School') priority is theory, and builds calculated, composite indicators based on how the waste prevention should be ideally measured (Waste Hierarchy Index, Pires et al., 2019, Annual Product Demand - APD, Tasaki et al., 2006, Mass Prevented Waste, Matsuda et al., 2018, Zero Waste Index, Zaman, 2013, Progress in waste reduction, Fernández-Brana et al., 2019, MIPS F Schmidt-Bleek, 1992, Food Loss Index, FAO, 2018, Food Waste Index, 2018, UNEP). In this case, the theoretical problem is well-addressed by monitoring, but data availability is often crucial problem. The second school is the 'Data-driven School', representatives of this group usually create indicator sets based on (partly or entirely) available indicators to better describe the phenomena of waste prevention (examples: Yano et al., 2016, Due et al., 2023, Zaman, 2014, Resource Efficiency Scoreboard 2020, Circular Economy Monitoring Framework, 2018). These are closer to become applied in practice, however their weakness is that they are often not addressing the measurement of key policy instruments, or the ideal level in terms of subsidiarity.

The review of NWPPs show that waste generation is the most commonly applied indicator. It is positive that this is usually placed into context by creating relative indicators, like waste generated per capita, per unit of GDP, per unit of GVA, etc. This ads to a better understanding of the phenomena, and also promotes comparability of country performances. The main issue with this, is that policymakers do not get a picture on why the waste is increasing of decreasing. It could change because of the economy's performance if no decoupling appears, and this is the case for municipal waste.

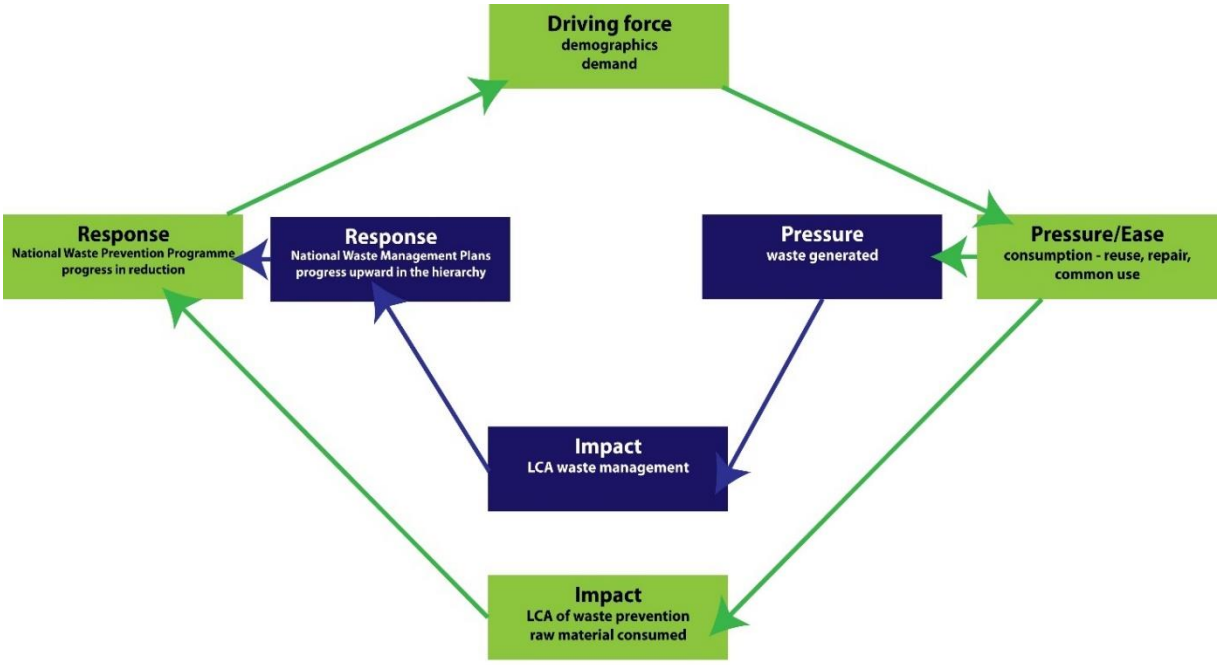
Applying waste indicators related to other stages of the waste hierarchy than prevention are also misleading. Typical cases were in the literature interpreting zero waste as zero waste to landfill, meaning that all achievements in waste management, instead of prevention are considered. NWPPs regularly include recycling although it has nothing to do with prevention (74% of EU Members). The latent convergence towards end-of-pipe indicators stems from path dependencies understood as 'self-reinforcing feedback loops' meaning that once a decision for a system design is made, this is favoured over all other, as well as future alternatives (Wilts, 2012). If we consider the evolution of waste management priorities, they historically follow the steps of the waste hierarchy. For this reason, the financing structure is stuck by the end-of-pipe technologies.

Are there other, more appropriate indicators for the measurement of waste prevention? An indicators set may be a convenient form, rather than a composite index to reduce risks from methodology, to avoid over-aggregation causing information loss, and to diversify among the various driver and impact areas. The basic framework chosen is the widely used DPSIR framework (Smeets et al., 1999) which also structures indicators in a casual framework, but in a modified form. The main

issue with this framework is that focusing on avoidance, phase P – pressure could be rather E – ease, leading to DESIR in the future. This could only happen, if standardised data collection on waste prevention activities could take place. Another problem faced with DPSIR was that in case of waste generation the 'State' of environment is hard to describe, and even if we can quantify the GHG emission or the soil or other damages caused by waste management operations those are just one, smaller portion of the waste's environmental effect. The main problem – especially in the context of waste prevention – goes back to the roots, it is the depletion of natural resources. The real 'Pressure' put on the environment is consumption. The state includes indicators causing change in the state of the environment, that is the e.g. quality of soil by landfills, quality of air at incinerators, but if we approach from the natural resource and consumption, it becomes clear, that the state could be best described by the raw material consumed, i.e. missing from the natural resources. The impact is the consequence of change in state such as the environmental, health, social and economic impacts. Waste management operations could cause illness, but also the loss of biodiversity, as well as exploiting the natural resources. Response includes political indicators referring to the waste prevention programmes, and this is where the local level should step in besides providing data on prevention action. It is fine to present national level data to the European Union, but for being able to follow-up on the National Waste Prevention Programmes it is crucial to measure at settlement level. The aggregation of settlement level data leads to robust, reliable national data with its diversified source.

The new model of DPSIR including waste prevention is demonstrated in Figure 52. Keeping the casual framework, the model becomes combined. The 'Driving force' is based on demographic indicators. These indicators define the demand that ultimately triggers consumption. The consumption in terms of waste prevention is the real pressure, and also 'easing' factors step in the model by including reuse, repair and common use perfomance. Home composting is arguable, the author accepts the concept that it belongs to prevention as it does not leave the doors of the homes. At the same time, there is an official estimation method regulated by the European Commission which permits to make the calculation of home composting, even though estimated, and add it the the recycling performance of the country. Obviously, double-count should be avoided.

Figure 54 – The new indicator system for waste and prevention based on DPSIR



Source: own compilation based on Smeets et al., 1999

The DPSIR framework is simplified by integrating 'State' into 'Impact'. The 'State' according to Smeets et al. includes indicators related to state of the environment caused by emission, in other words immission. Immission by definition is the aggregate level of pollutants in the environment, a general state of the environment following 'pressure'. Even though it is one of the most important indicators in environmental protection, it is difficult to distinguish the effects one-by-one that cause a general state of the environment at the indicator level. There are indicators describing the state of the environment, but in today's statistical datasets it is not realistic to establish the connection between the 'pressuriser'and the general state. At the same time, the impact is crucial to understand the effect of a specific human activity, and also from the impact one can indirectly conclude on the state of environment. The indicators proposed having casual effect on municipal waste are the following based on the literature review, the policy and legislative analysis, the regression model and the survey run.

Table 15 - Proposed indicators for prevention of municipal waste

Headline indicator	**General Indicator**	**Source/Methodology**	
	Municipal waste generation *(kg per capita)*	official statistics	
	Performance Indicators		
	Waste intensity of raw material consumption per capita (MSW/RMC)	official statistics	
	Waste intensity of total individual consumption per capita (MSW/COICOP Total)	official statistics	
Dimensions	**WasteDPSIR/DESIR Indicator**		**Basedon**
Driver	Median age of population	official statistics, negative relation	by regression

	Average household size	official statistics, negative relation	by regression
	Government spending on education - COFOG (classification of functions of government): Education *(% of GDP)*	official statistics positive relation	by regression
	Gini-coefficient	official statistics, negative relation	by regression
Pressure	Total individual consumption - COICOP (classification of individual consumption by purpose) total per capita *(chain-linked volume (2015), million EUR)*	official statistics, positive relation	by regression, by literature (Coggins, 2001)
	Mean consumption expenditure by degree of urbanisation *(purchasing power standard (PPS) per household)*	official statistics, positive relation	by regression
Ease	Reuse rate *(tonnes or if GVA-based: million EUR)*	data from reuse centres and/or online platforms NACE retail of second-hand goods	by regulation, by survey
	Repair rate *(million EUR)*	NACE repair sector, GVA and survey	by survey, by literature (Due et al., 2023)
	Common use *(million EUR)*	NACE rental sector, GVA and survey	by literature
	Home composting *(kg/household/year)*	settlement survey	by literature (Zorpas et al., 2013, Cox et al., 2010), survey
	Other individual and community waste prevention actions: • number of households reached • number of households taken action • changes in municipal waste generation (before-after) *(%)*	survey and collection round or local MSW data compared to the outcome of the survey	by literature (Zorpas et al., 2013, Cox et al., 2010)
(State)/ Impact	Raw material consumption *(tons per capita)*	official statistics	by literature (Due et al., 2023, Zaman, 2014) and correlation
	Consumption footprint per inhabitant	official statistics, positive relation	by regression
	LCA waste prevention: - environmental emission of waste prevention actions (WMP) - environmental impact of waste prevention actions: Global Warming potential, Water Depletion, Metal Depletion, Human Toxicity	calculations to be made for typical cases – estimation based on that	by literature (Cleary, 2010, Hutner et al., 2018)
Response	National waste prevention programme: - availability of quantitative targets Y/N - availability of relevant indicators (recycling excl.) Y/N - is there dedicated budget to the programme Y/N - rate of progress in MSW per capita reduction *(%)*	official programmes, country factsheets and statistics	by literature (Due et al., 2023, Karigl et al., 2022, Wilts et al., 2015)
	Rate of settlement level with implemented waste prevention programmes to total number of settlements	administrative data collection	survey

Source: own compilation

All indicators should meet requirements of statistical standards presented in the chapter on theory of indicators. The final performance can still be best measured by the municipal waste generation per

capita, however, the additional indicator set give insight into the details of policy effectiveness. The two performance indicators are extremely important in assessing the overall outcome of consumption and production related policy actions. These three headline indicators give a good view on how effectively the closing, and shrinking of the loop is happening. It provides a process-oriented approach from raw material use, to consumption linked to waste at the end of the process.

The level of disaggregation is important to be able to involve local governments. Demographic data is fairly available at settlement level, but for a better forecast on waste generation household at least consumption data would be also useful in every country. The indicators of the 'Ease' phase are substantial to get feedback on local community and household actions. The State/Impact phase could hardly be monitored directly at settlement level for cost-effectiveness reasons, but estimations could take place.

The Commission decision laying down the rules of reuse (EC, 2021) is currently inexecutable for countries where reuse centres do not exist. Getting mass data on reused product categories by household surveys is not a solution. The survey among citizens of Zsámbék intentionally included the estimation for textile, furniture and e-goods, but almost half of the respondents left the survey at these questions, because it is so hard to estimate the reuse of these in mass unit. The experiment showed that other data sources should be identified. The physical infrastructure should be first established for collecting items for reuse, repair and rental besides recycling then data collection can be built on that. The other option requires much deeper change: classifications of official business statistics should be adapted to such demands, and reused goods should be distinguished in PRODCOM[7] similarly to the secondary raw materials.

Home composting is now included in recycling data reporting to the EU based on an estimation formula. Home composting should be excluded from recycling, and should get an independent indicator as one of the most important household actions of waste prevention.

Other local actions (reducing packaging waste, nappies campaigns, single use cutlery avoidance at events, short supply chain based shopping, etc.) could be collected via surveys. Indicators for important waste streams may also be included (e.g. food waste, e-goods, furniture, etc.).

Further research could follow-up waste similar to household waste, addressing legal entities, public institutions. Green procurement could definitely be one indicator, however, waste prevention-related evaluation aspects should be clarified. In case of companies the new European Sustainability Reporting Standards (ESRS) could encompass prevention of waste similar to household waste. The

[7] PRODuction COMmunautaire' (Community Production). Prodcom data cover the economic activities of mining and quarrying, manufacturing, and materials recovery, which refer to the sections B, C, and E of the 'Statistical classification of economic activities in the EU' (NACE).

production-focused waste prevention policy also needs to be more elaborate, primarily by the right choices of measures. The data collection should also take place on waste reduction of production. Ideally, the material flow accounts development covering the so far unknown fields (hidden environmental burdens), the increased disaggregation in terms of sectors and material flows, and the establishment of connection with the waste accounts (to be developed) could be used as a part of the basis for waste prevention policies.

7 Conclusions

The limitations of natural resources has become palpable in our life during supply chain disturbances in the pandemics and the energy crisis. The economies of the Member States of the European Union heavily rely on material resources, and imports of goods outside the borders of the Union. Not only do they dependent on the rest of the world at the input side, but also on the output side, as significant waste shipments are also taking place outwards from the Union. As a new strategy the EU has recognised the need to create competitive advantage from becoming 'green', and also by reducing it's material dependency.

Waste generation shall not decrease in the upcoming years. The recovery of the economy following the crises has pulled municipal waste generation with itself, the desired decoupling did not take place. As long as waste prevention does not step into force with binding targets and indicators, with formalised and standardised reporting schemes not much shall happen. Waste prevention will not be a priority by its own behalf, unless somekind of serious material supply crisis does not occur, but it would be better to avoid that.

This dissertation created a panorama of currently existing policies, actions, targets and indicators in the Member States. It took Hungary as an example to make a comprehensive review on how the EU level legislative intentions manifested at the local governments' level, and what are the realities of implementing waste prevention actions at the community and household level.

First, there are a number of point where differences are experienced among the 'old' EU Members and the less developed Members in waste management, prevention, and material use. The highly developed countries perform much better in resource productivity, but generate higher amount of municipal waste due to higher levels of consumption. These countries run 'high-tech' waste management facilities with high levels of energy recovery and incinerator capacities, and lower levels of landfilling. They have sound separate collections schemes. Contrary to that, the countries of CEE and the countries with subsequent accession are weaker performers in resource productivity, produce less MSW, but their waste management heavily relies on landfilling, with low levels of energy recovery. They often face difficulties in meeting recycling targets.

Regarding the households in general, rationalisation of consumption should be supported by information actions: the attention of citizens and communities should be drawn on the fact, that reducing material use and waste could lead to financial savings parellel to being environmentally conscious. In the 'passive' form of waste prevention knowledge transfer and enabling methods, tools should be offered to households. In the 'active' form, when additional efforts are needed to reduce waste – reducing comfort level, assigning time, energy to alternative consumption forms, investing in waste free alternatives – information campaigns are not enough, financial incentives should be given (tax discount, payback schemes, vouchers, etc.). Municipalities should offer or support the infrastructure for reuse, repair, common use, waste free shopping, home composting, and were appropriate laying down rules, targets to achieve the shift in household behavior. To achieve the decoupling of consumption and waste in citizens' minds.

The findings of the research focus on monitoring, the least discussed topic within the scientific literature of waste prevention. Evidence-based policy should be provided with comprehensive foundations, i.e., resource efficiency should be observed from a holistic perspective: material efficiency (or rather savings) should be viewed together with energy-efficiency indicators, and raw material uses should be assessed together with impacts – emissions to water, air and soil. This is to avoid the shift from one non-efficient action to another substitute which may perform well in one aspect but turns out to have worse impact in another aspect (e.g. incineration may lead to a more energy efficient solution than landfilling but has counter effects in terms of air emissions). Monitoring is the very basis of evidence-based policy, and also gives feedback to the policymakers and the public. To some extent, it has a binding effect, as the public control, the watchdog activity relies on these data. Monitoring support waste prevention by its existence per se. Individual, community and society level models and incentives should be defined to achieve a green economy, and the present concept of economic growth should be challenged. Waste prevention is shaking the foundations of today's social and economic settings. An improved and accountable waste prevention policy could push towards this shift in paradigm in consumption and production.

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Annex I – Relevant literature for waste prevention or zero waste and monitoring or measurement or indicator

		Keywords													
n=31		data collection	indicator	indicator set	behaviour	action	policy	statistics	city	state	material use	waste prevention	lca / environmental impact	waste management / zero waste / circular economy	sustainable development
	Percentage	13	19	10	35	39	29	26	45	6	10	19	16	19	6
	Absolute	4	6	3	11	12	9	8	14	2	3	6	5	6	2
Zorpas, AA; Lasaridi, K	Measuring waste prevention	x			x	x						x			
Yano, J; Sakai, S	Waste prevention indicators and their implications from a life cycle perspective: a review			x			x	x		x		x			
Zaman, AU	Identification of key assessment indicators of the zero waste management systems			x				x						x	
Silva, A; Stocker, L; Mercieca, P; Rosano, M	The role of policy labels, keywords and framing in transitioning waste policy						x				x				
Zaman, AU; Lehmann, S	The zero waste index: a performance measurement tool for waste management systems in a 'zero waste city'		x						x					x	
Wilts, H	National waste prevention programs: indicators on progress and barriers			x			x	x		x					
Sahimaa, O; Mattinen, MK; Koskela, S; Salo, M; Sorvari, J; Myllymaa, T; Huuhtanen, J; Seppälä, J	Towards zero climate emissions, zero waste, and one planet living - Testing the applicability of three indicators in Finnish cities		x						x						x
Matsuda, T; Hirai, Y; Asari, M; Yano, J; Miura, T; Ii, R; Sakai, S	Monitoring environmental burden reduction from household waste prevention							x	x				x	x	
Sharp, V; Giorgi, S; Wilson, DC	Methods to monitor and evaluate household waste prevention	x			x	x			x			x		x	

Read, M; Gregory, MK; Phillips, PS	An evaluation of four key methods for monitoring household waste prevention campaigns in the UK	x			x	x						x			
Magrini, C; Degli Esposti, A; De Marco, E; Bonoli, A	A framework for sustainability assessment and prioritisation of urban waste prevention measures					x			x				x		
Zacho, KO; Mosgaard, MA	Understanding the role of waste prevention in local waste management: A literature review		x						x			x			
Fernandez-Brana, A; Sousa, V; Dias-Ferreira, C	Are municipal waste utilities becoming sustainable? A framework to assess and communicate progress		x					x	x					x	x
Zaman, AU	Measuring waste management performance using the 'Zero Waste Index': the case of Adelaide, Australia							x	x					x	
Ribeiro-Rodrigues, E; Bortoleto, AP; Fracalanza, BC	Exploring the influence of contextual and sociodemographic factors on waste prevention behaviour-the case of Campinas, Brazil				x	x			x						
Lilja, R	From waste prevention to promotion of material efficiency: change of discourse in the waste policy of Finland						x				x				
Hutner, P; Helbig, C; Stindt, D; Thorenz, A; Tuma, A	Transdisciplinary Development of a Life Cycle-Based Approach to Measure and Communicate Waste Prevention Effects in Local Authorities				x				x				x		
Coskun, S	Zero Waste Management Behavior: Conceptualization, Scale Development and Validation-A Case Study in Turkey				x	x									
Cox, J; Giorgi, S; Sharp, V; Strange, K; Wilson, DC; Blakey, N	Household waste prevention - a review of evidence	x			x	x						x			
Zorpas, AA; Lasaridi, K; Voukkali, I; Abeliotis, K; Loizia, P; Fitiri, L; Trisokka, V; Chroni, C; Fanou, K; Pyrilli, D; Goumenou, P; Georgiou, A	DEVELOPMENT OF WASTE PREVENTION CAMPAIGN IN THE WASTE FRAMEWORK DIRECTIVE FROM PARALIMNI MUNICIPALITY WHICH BASED IN THE EASTERN REGION OF CYPRUS						x								
Puig-Ventosa, I; Jofra-Sora, M; Freire-González, J	Prevention of waste from unsolicited mail in households: measuring the effect of anti-advertising stickers in Barcelona				x	x									
Mazzanti, M	Is waste generation de-linking from economic growth? Empirical evidence for Europe						x								
Sevigné-Itoiz, E; Gasol, CM; Farreny, R; Rieradevall, J; Gabarrell, X	CO2ZW: Carbon footprint tool for municipal solid waste management for policy options in Europe. Inventory of Mediterranean countries												x		
Marti, L; Puertas, R	Influence of environmental policies on waste treatment		x				x	x							

Tasaki, T; Hashimoto, S; Moriguchi, Y	A quantitative method to evaluate the level of material use in lease/reuse systems of electrical and electronic equipment										x				
Pucherova, Z; Jakab, I; Barekova, A; Kralova, J	Streamlining the Municipal Waste Management System in the City of Nitra (Slovak Republic) Based on a Public Survey				x	x			x						
Pineiro-Villaverde, G; García-Alvarez, MT	Sustainable Consumption and Production: Exploring the Links with Resources Productivity in the EU-28		x					x							
Zorpas, AA; Voukkali, I; Loizia, P	A PREVENTION STRATEGY PLAN CONCERNING THE WASTE FRAMEWORK DIRECTIVE IN CYPRUS				x	x			x						
Lagman-Bautista, J	CRAFTING A THEORETICAL FRAMEWORK ON WASTE MANAGEMENT: A CASE FOR SUSTAINABLE CITIES				x	x			x						
Milios, L; Dalhammar, C	ASCENDING THE WASTE HIERARCHY: RE-USE POTENTIAL IN SWEDISH RECYCLING CENTRES					x	x						x		
Zotos, G; Karagiannidis, A; Zampetoglou, S; Malamakis, A; Antonopoulos, IS; Kontogianni, S; Tchobanoglous, G	Developing a holistic strategy for integrated waste management within municipal planning: Challenges, policies, solutions and perspectives for Hellenic municipalities in the zero-waste, low-cost direction						x		x						

Annex II – Proposed Waste Prevention indicators by Yano et al.

(Yano et al., 2016, p 41-43)

OECD

Direct pressure indicators

Generation of waste type I

I: municipal waste (MSW), C&D waste, non-hazardous industrial waste	tons/year
MSW generation/population	tons/cap./year
MSW generation/private final consumption for MSW and its components	tons/value/year
Generation of waste type I/gross domestic products	tons/GDP/year

I: C&D waste, non-hazardous industrial waste

Direct response indicators

For short-to-medium-term purposes;	
Number of companies with a certified environmental management system (EMS)	company/cap., company/GDP
Consumption of virgin material and recycling of the material for selected materials (e.g., glass, paper, and metals)	tons/year
''No thanks'' -stickers hand out (percentage of total households)	%
For long-term purposes;	
Existence of a national waste prevention plan or strategy	yes or no
Number of products and/or product groups targeted by extended producer responsibility products nationally or regionally	
Number of households with variable-rate pricing households	%

Material flow accounting-based indirect pressure and response indicators

Hidden flow index (domestic hidden flows/total material input)	tons
Waste disposal index (waste disposed of/net additions to stock)	tons
Manure utilization index (dissipative use of manure/total generation of manure)	tons

EU

Decoupling of waste generation from private consumption expenditure	
Pure quantitative waste generation statistics	tons

Output assessment:

Output assessment is a standardized checklist with yes/no questions on the policy mix of public waste prevention measures leading to a single overall score, expressed as a percentage	%
Resource productivity: GDP/DMC	GDP/ton
Resource loss on bio-products: The ratio between biological waste generated and biological resources used, expressed in a percentage of the amount of resources that ends up as a waste	%

Hazardous substance indicator:

How many out of 300 random samples of specific waste fractions contain quantities of RoHS substances above thresholds	%

Packaging waste minimization:

Total amount of packaging waste in an economy compared to the total amount of packaged product	%

Nordic Council

Food waste

Share of edible FW in household, retailers and catering	%
Amount of FW generated per household	kg/household/year
Resource loss on bio-products (ratio between biological w aste generated and biological resources used by weight)	%
Amount of FW generated against the consumption of food by weight	%
Consumption of food	kg/cap./year
Total FW generation	kg/cap./year
FW generation per enterprise (specific sector: retail sale, hospitality, food processing)	kg/enterprise/year
Total avoidable FW generation	kg/cap./year
Avoidable FW generated per household	kg/household/year
Avoidable FW generation per enterprise (specific sectors: retail sale, hospitality, food processing)	kg/enterprise/year
FW generated along the production chain per unit production of foodstuffs	%
Amount of FW generated by end users per unit of food consumption	%
FW generated in households per unit of household expenditure output	kg/value
GHG emissions (upstream) associated with avoidable FW	tons
Share of animal-derived FW in total FW generation	%
Economic value of avoidable household FW	value/cap./year

C&D

C&D waste generation	kg/cap. or kg/GDP
C&D waste generation per unit gross value added in the construction sector	kg/value
Material consumption in the construction of buildings per floor area of new buildings	tons/m2
Domestic extraction of construction materials per floor area of new buildings	tons/m2
Number of new buildings and sales of building materials certified by labeling schemes that limit quantities of hazardous or harmful substances numbers	
Hazardous C&D waste generation as a % of total C&D waste generation	%
Environmental impacts versus consumption of construction materials Unit	pressure/kg
Average design life expectancy of buildings and roads	Years
Economic renovation versus the total output of the sector	%

WEEE

Collection efficiency of WEEE	%
Total amount (value) of EEE bought for the purpose of reuse per capita	value/cap./year
The amount of reused EEE sold	value/year
Hazardous substances found in EEE (weight/total weight of EEE)	%
WEEE generation per capita	kg/cap./year
WEEE generation versus GDP per capita	kg/value/year
WEEE generation versus EEE put on the market (value) per capita	kg/value/year
Amount of EEE put on the market (kg) per capita	kg/cap./year
WEEE collection per capita	kg/cap./year
Number of second-hand shops handling EEE numbers	
Number of repair services for EEE numbers	
Number of manufacturers and importers of EEE that include end-of-life consideration in their design strategies numbers	

Textile waste

Textile waste generation	kg/cap./year
New textile products put on the market by weight	kg/cap./year
Purchase of second-hand textile products by weight	kg/cap./year
Household expenditure on textile products	value/cap./year
Share of second-hand products in total textile products put on the market (weight or value basis)	%
Ratio (by weight) of exported second-hand products to total textile products put on the domestic market	%
Household expenditure on textile products per ton of textile products put on the market	value/ton
Quantities of specific chemicals present in imported textile products	mg/kg

Number of textile products models certified by eco-labeling schemes relative to the Nordic countries (Nordic Swan, Swedish Good Environmental Choice, EU Flower) numbers	
Number of textile product models certified by Oeko-Tex Standard 100 and Bluesign numbers Repaired textile products	number/cap./year

Japan

Material flow indicators with targets

Resource productivity:	GDP/DMI Yen/ton
Cyclical use rate: amount of cyclical use (reuse + recycled use) per amount of cyclical use and DMI	%
Final disposal amount	ton

Material flow indicators without targets, but monitored

Resource productivity of fossil resources: GDP/DMI (fossil resources input)	Yen/ton

Effort indicators with targets

Reduction of MSW (Reference: FY2000) %	
Citizens' awareness about reduction of waste generation, cyclical use, and green purchase	%

Effort indicators without targets, but monitored

Average use time of consumer durable goods	Year
Percentage of citizens engaging in actual efforts: (e.g., refraining from using plastic shopping bags or asking for less packaging)	%

Hashimoto et al.
Material use efficiency
Material use time year

Zaman et al
Zero waste index

Annex III – Scope of municipal waste (LoW codes)

LoW codes regarded as being part of municipal waste (Eurostat, 2016):

Chapter 20: Municipal wastes (Household waste and similar commercial, industrial and institutional wastes) including

separately collected fractions

20 01 separately collected fractions (except 15 01)

20 01 01 paper and cardboard

20 01 02 glass

20 01 08 biodegradable kitchen and canteen waste

20 01 10 clothes

20 01 11 textiles

20 01 13* solvents

20 01 14* acids

20 01 15* alkalines

20 01 17* photochemicals

20 01 19* pesticides

20 01 21* fluorescent tubes and other mercury-containing waste

20 01 23* discarded equipment containing chlorofluorocarbons

20 01 25 edible oil and fat

20 01 26* oil and fat other than those mentioned in 20 01 25

20 01 27* paint, inks, adhesives and resins containing dangerous substances

20 01 28 paint, inks, adhesives and resins other than those mentioned in 20 01 27

20 01 29* detergents containing dangerous substances

20 01 30 detergents other than those mentioned in 20 01 29

20 01 31* cytotoxic and cytostatic medicines

20 01 32 medicines other than those mentioned in 20 01 31

20 01 33* batteries and accumulators included in 16 06 01, 16 06 02 or 16 06 03 and unsorted batteries and accumulators

containing these batteries

20 01 34 batteries and accumulators other than those mentioned in 20 01 33

20 01 35* discarded electrical and electronic equipment other than those mentioned in 20 01 21 and

20 01 23 containing hazardous components

20 01 36 discarded electrical and electronic equipment other than those mentioned in 20 01 21, 20 01 23 and 20 01 35

20 01 37* wood containing dangerous substances

20 01 38 wood other than that mentioned in 20 01 37

20 01 39 plastics

20 01 40 metals

20 01 41 wastes from chimney sweeping

20 01 99 other fractions not otherwise specified

20 02 garden and park waste (including cemetery waste)

20 02 01 biodegradable waste

20 02 03 other non-biodegradable wastes

20 03 other municipal wastes

20 03 01 mixed municipal waste

20 03 02 waste from markets

20 03 03 street-cleaning residues

20 03 07 bulky waste

20 03 99 municipal wastes not otherwise specified

Chapter 15 Waste packaging; absorbents, wiping cloths, filter materials and protective clothing not otherwise specified

15 01 packaging (including separately collected municipal packaging waste)

15 01 01 paper and cardboard packaging

15 01 02 plastic packaging

15 01 03 wooden packaging

15 01 04 metallic packaging

15 01 05 composite packaging

15 01 06 mixed packaging

15 01 07 glass packaging

15 01 09 textile packaging

15 01 10* packaging containing residues of or contaminated by dangerous substances

15 01 11* metallic packaging containing a dangerous solid porous matrix (for example asbestos), including empty pressure

containers

Any waste marked with an asterisk (*) is considered as a hazardous waste.

Annex IV – Waste Prevention in the Waste Framework Directive (Article 9 and Annex IV/Article 29)

Article 9 - Prevention of waste

1. Member States shall take measures to prevent waste generation. Those measures shall, at least:

(a) promote and support sustainable production and consumption models;

w(b) encourage the design, manufacturing and use of products that are resource-efficient, durable (including in terms of life span and absence of planned obsolescence), reparable, re-usable and upgradable;

(c) target products containing critical raw materials to prevent that those materials become waste;

(d) encourage the re-use of products and the setting up of systems promoting repair and re-use activities, including in particular for electrical and electronic equipment, textiles and furniture, as well as packaging and construction materials and products;

(e) encourage, as appropriate and without prejudice to intellectual property rights, the availability of spare parts, instruction manuals, technical information, or other instruments, equipment or software enabling the repair and re-use of products without compromising their quality and safety;

(f) reduce waste generation in processes related to industrial production, extraction of minerals, manufacturing, construction and demolition, taking into account best available techniques;

(g) reduce the generation of food waste in primary production, in processing and manufacturing, in retail and other distribution of food, in restaurants and food services as well as in households as a contribution to the United Nations Sustainable Development Goal to reduce by 50 % the per capita global food waste at the retail and consumer levels and to reduce food losses along production and supply chains by 2030;

(h) encourage food donation and other redistribution for human consumption, prioritising human use over animal feed and the reprocessing into non-food products;

(i) promote the reduction of the content of hazardous substances in materials and products, without prejudice to harmonised legal requirements concerning those materials and products laid down at Union level, and ensure that any supplier of an article as defined in point 33 of Article 3 of Regulation (EC) No 1907/2006 of the European Parliament and of the Council (6) provides the information pursuant to Article 33(1) of that Regulation to the European Chemicals Agency as from 5 January 2021;

(j) reduce the generation of waste, in particular waste that is not suitable for preparing for re-use or recycling;

(k) identify products that are the main sources of littering, notably in natural and marine environments, and take appropriate measures to prevent and reduce litter from such products; where Member States decide to implement this obligation through market restrictions, they shall ensure that such restrictions are proportionate and non-discriminatory;

(l) aim to halt the generation of marine litter as a contribution towards the United Nations Sustainable Development Goal to prevent and significantly reduce marine pollution of all kinds; and

(m) develop and support information campaigns to raise awareness about waste prevention and littering.

Waste Framework Directive, Examples of Waste Prevention Measures Referred to in Article 29

Measures that can affect the framework conditions related to the generation of waste

1. The use of planning measures, or other economic instruments promoting the efficient use of resources.
2. The promotion of research and development into the area of achieving cleaner and less wasteful products and technologies and the dissemination and use of the results of such research and development.
3. The development of effective and meaningful indicators of the environmental pressures associated with the generation of waste aimed at contributing to the prevention of waste generation at all levels, from product comparisons at Community level through action by local authorities to national measures.

Measures that can affect the design and production and distribution phase

4. The promotion of eco-design (the systematic integration of environmental aspects into product design with the aim to improve the environmental performance of the product throughout its whole life cycle).
5. The provision of information on waste prevention techniques with a view to facilitating the implementation of best available techniques by industry.
6. Organise training of competent authorities as regards the insertion of waste prevention requirements in permits under this Directive and Directive 96/61/EC.
7. The inclusion of measures to prevent waste production at installations not falling under Directive 96/61/EC. Where appropriate, such measures could include waste prevention assessments or plans.
8. The use of awareness campaigns or the provision of financial, decision making or other support to businesses. Such measures are likely to be particularly effective where they are

aimed at, and adapted to, small and medium sized enterprises and work through established business networks.

9. The use of voluntary agreements, consumer/producer panels or sectoral negotiations in order that the relevant businesses or industrial sectors set their own waste prevention plans or objectives or correct wasteful products or packaging.
10. The promotion of creditable environmental management systems, including EMAS and ISO 14001.

Measures that can affect the consumption and use phase

11. Economic instruments such as incentives for clean purchases or the institution of an obligatory payment by consumers for a given article or element of packaging that would otherwise be provided free of charge.
12. The use of awareness campaigns and information provision directed at the general public or a specific set of consumers.
13. The promotion of creditable eco-labels.
14. Agreements with industry, such as the use of product panels such as those being carried out within the framework of Integrated Product Policies or with retailers on the availability of waste prevention information and products with a lower environmental impact.
15. In the context of public and corporate procurement, the integration of environmental and waste prevention criteria into calls for tenders and contracts, in line with the Handbook on environmental public procurement published by the Commission on 29 October 2004.
16. The promotion of the reuse and/or repair of appropriate discarded products or of their components, notably through the use of educational, economic, logistic or other measures such as support to or establishment of accredited repair and reuse-centres and networks especially in densely populated regions.

Annex V – Indicators selected from the Eurostat database as related to waste prevention

Nr	Domain	Source table (EUROSTAT)	Frequency	Time series	Indicator	Variable name (SPSS)	Type (Calculated/Original)	Unit of measure	Note
1	WASTE	Municipal waste by waste management operations [env_wasmun__custom_12211109]	Annual	2005-2020	Waste generated	MSW_GEN	Original	Thousand tonnes	
2	WASTE	Municipal waste by waste management operations [env_wasmun__custom_12211109]	Annual	2005-2020	Waste generated per capita	MSW_GEN_PC	Original	Kg per capita	
3	WASTE	Municipal waste by waste management operations [env_wasmun__custom_12211109]	Annual	2005-2020	Disposal - incineration (D10) and recovery - energy recovery (R1)	MSW_INC_ERECO	Original	Thousand tonnes	
4	WASTE	Municipal waste by waste management operations [env_wasmun__custom_12211109]	Annual	2005-2020	Disposal - landfill and other (D1-D7, D12)	MSW_LAND	Original	Thousand tonnes	
5	WASTE	Municipal waste by waste management operations [env_wasmun__custom_12211109]	Annual	2005-2020	Recycling	MSW_RECYC	Original	Thousand tonnes	
6	WASTE	Municipal waste by waste management operations [env_wasmun__custom_12211109]	Annual	2005-2020	Disposal - incineration (D10) and recovery - energy recovery (R1) per capita	MSW_INC_ERECO_PC	Original	Kg per capita	
7	WASTE	Municipal waste by waste management operations [env_wasmun__custom_12211109]	Annual	2005-2020	Disposal - landfill and other (D1-D7, D12) per capita	MSW_LAND_PC	Original	Kg per capita	
8	WASTE	Municipal waste by waste management operations [env_wasmun__custom_12211109]	Annual	2005-2020	Recycling per capita	MSW_RECYC_PC	Original	Kg per capita	
9	WASTE	Circular material use rate [env_ac_cur__custom_12208925]	Annual	2010-2020	Circular material use rate	CIRCULARUSERATE	Original	Percentage	
10	POPULATION	Population on 1 January by broad age group and sex [demo_pjanbroad__custom_12202055]	Annual	2005-2020	Population total	POP_TOT	Original	Number	
11	POPULATION	Population on 1 January by broad age group and sex [demo_pjanbroad__custom_12202055]	Annual	2005-2020	Population:Less than 15 years	POP_AGE_UNDER15Y	Original	Number	
12	POPULATION	Population on 1 January by broad age group and sex [demo_pjanbroad__custom_12202055]	Annual	2005-2022	Population:From 15 to 64 years	POP_AGE_15_64Y	Original	Number	

13	POPULATION	Population on 1 January by broad age group and sex [demo_pjanbroad__custom_12202055]	Annual	2005-2023	Population:65 years or over	POP_AGE_OVER65Y	Original	Number	
14	POPULATION	Average household size - EU-SILC survey [ilc_lvph01__custom_12208301]	Annual	2005-2020	Average household size	AVG_HH_SIZE	Original	Number	
15	POPULATION	Population structure indicators at national level [demo_pjanind__custom_12196059]	Annual	2005-2020	Median age of population	POP_STRUCT_MEDIAN_AGE	Original	Number	
16	POPULATION	Population structure indicators at national level [demo_pjanind__custom_12196059]	Annual	2005-2020	Old-age dependency ratio	POP_STRUCT_OLD_DEPEND	Original	Number	3rd variant (population 65 years or over to population 20 to 64 years)
17	POPULATION	Population structure indicators at national level [demo_pjanind__custom_12196059]	Annual	2005-2020	Women per 100 men	POP_STRUCT_WPERM	Original	Number	
18	POPULATION	Population structure indicators at national level [demo_pjanind__custom_12196059]	Annual	2005-2020	Young-age dependency ratio	POP_STRUCT_YOUNG_DEPEND	Original	Number	3rd variant (population 0 to 19 years to population 20 to 64 years)
19	POPULATION	Distribution of population by degree of urbanisation, dwelling type and income group - EU-SILC survey [ilc_lvho01__custom_12208367]	Annual	2005-2020	Distribution of population,Cities	POP_DEGURBA_CITY	Original	Percentage	
20	POPULATION	Distribution of population by degree of urbanisation, dwelling type and income group - EU-SILC survey [ilc_lvho01__custom_12208367]	Annual	2005-2020	Distribution of population,Towns and suburbs	POP_DEGURBA_TOWN	Original	Percentage	
21	POPULATION	Distribution of population by degree of urbanisation, dwelling type and income group - EU-SILC survey [ilc_lvho01__custom_12208367]	Annual	2005-2020	Distribution of population,Rural areas	POP_DEGURBA_RURAL	Original	Percentage	
22	POPULATION	Distribution of population by degree of urbanisation, dwelling type and income group - EU-SILC survey [ilc_lvho01__custom_12208367]	Annual	2005-2020	House Total	POP_DWELL_HOUSE	Calculated	Percentage	House Total = House (Cities+Towns and suburbs+Rural areas)
23	POPULATION	Distribution of population by degree of urbanisation, dwelling type and income group - EU-SILC survey	Annual	2005-2020	Flat Total	POP_DWELL_FLAT	Calculated	Percentage	House Total = House (Cities+Towns and

		[ilc_lvho01__custom_12208367]							suburbs+Rural areas)
24	POPULATION	Distribution of population by degree of urbanisation, dwelling type and income group - EU-SILC survey [ilc_lvho01__custom_12208367]	Annual	2005-2020	Other dwelling Total	POP_DWELL_OTHER	Calculated	Percentage	House Total = House (Cities+Towns and suburbs+Rural areas)
25	MATERIAL	Material footprints - main indicators [env_ac_rme__custom_12211656]	Annual	2008-2020	Material Footprint, Domestic extraction	MF_DE	Original	Thousand tonnes	
26	MATERIAL	Material footprints - main indicators [env_ac_rme__custom_12211656]	Annual	2008-2020	Material Footprint, Exports in raw material equivalents	MF_EXP	Original	Thousand tonnes	
27	MATERIAL	Material footprints - main indicators [env_ac_rme__custom_12211656]	Annual	2008-2020	Material Footprint, Imports in raw material equivalents	MF_IMP	Original	Thousand tonnes	
28	MATERIAL	Material footprints - main indicators [env_ac_rme__custom_12211656]	Annual	2008-2020	Material Footprint, Raw material consumption	MF_RMC	Original	Thousand tonnes	
29	MATERIAL	Material footprints - main indicators [env_ac_rme__custom_12211656]	Annual	2008-2020	Material Footprint, Raw material input	MF_RMI	Original	Thousand tonnes	
30	MATERIAL	Resource productivity [cei_pc030__custom_12190914]	Annual	2005-2020	Resource productivity	RP	Original	Euro per kilogram, chain linked volumes (2015)	GDP/DMC
31	FINANCES	Gini coefficient of equivalised disposable income by age [ilc_di12__custom_12208243]	Annual	2014-2020	Gini coefficient	GINI	Original	Gini coefficient (scale from 0 to 100)	
32	FINANCES	Average full time adjusted salary per employee [nama_10_fte__custom_12199662]	Annual	2005-2020	Average full time adjusted salary per employee	AVG_SALARY	Original	Euro	
33	FINANCES	The real gross disposable income of households per capita (index = 2008) [tepsr_wc310__custom_12343508]	Annual	2005-2020	Real gross disposable income of households per capita	DIPOS_INCOME_HH	Original	Per capita, Current prices, million units of national currency (index = 2008)	

34	FINANCES	Key indicators - annual data [nasa_10_ki__custom_12201546]	Annual	2005-2020	Gross household saving rate	HH_SAVINGRATE	Original	Percentage	
35	FINANCES	Key indicators - annual data [nasa_10_ki__custom_12201546]	Annual	2005-2020	Gross investment rate of households	HH_INVESTMENT	Original	Percentage	
36	FINANCES	Key indicators - annual data [nasa_10_ki__custom_12201546]	Annual	2005-2020	Gross debt-to-income ratio of households	HH_DEBT_TO_INCOME	Original	Percentage	
37	ENVIRONMENT	National expenditure on environmental protection by institutional sector (2006-2021) [env_ac_epneis__custom_12210781]	Annual	2014-2019	Environmental protection expenditure - Households	ENVIRO_EXPEND_HH	Original	Million euro	
38	ENVIRONMENT	Environmental protection investments of total economy (2006-2020) [env_ac_epite__custom_12210818]	Annual	2014-2019	Environmental protection investments of total economy	ENVIRO_INVEST	Original	Million euro	
39	ENVIRONMENT	Production of environmental protection services of general government by economic characteristics (2006-2021) [env_ac_pepsgg__custom_12210850]	Annual	2014-2019	Production of environmental protection services of general government:Total	ENVIRO_SERV_GOVT_TOT	Original	Million euro	
40	ENVIRONMENT	Production of environmental protection services of general government by economic characteristics (2006-2021) [env_ac_pepsgg__custom_12210850]	Annual	2014-2019	Production of environmental protection services of general government:Waste management output	ENVIRO_SERV_GOVT_WASTE	Original	Million euro	
41	ENVIRONMENT	Environmental tax revenues [env_ac_tax__custom_12209004]	Annual	2005-2020	Total environmental taxes	ENVIRO_TAX_TOT	Original	Percentage of gross domestic product (GDP)	
42	ENVIRONMENT	Environmental tax revenues [env_ac_tax__custom_12209004]	Annual	2005-2020	Taxes on Pollution/Resources	ENVIRO_TAX_POLL_RES	Original	Percentage of gross domestic product (GDP)	
43	ENVIRONMENT	Environmental protection transfers by environmental protection activity and institutional sector [env_ac_eptrf1__custom_12209770]	Annual	2014-2020	Current and capital transfers for environmental protection, received by households	ENV_TRANS_HH	Original	Million euro	

44	ENVIRONMENT	Production, value added and exports in the environmental goods and services sector [env_ac_egss2__custom_12211048]	Annual	2014-2020	GVA_Waste management sector	GVA_WASTEMAN	Original	Million euro	
45	EDUCATION	Population by educational attainment level, sex and age (%) - main indicators [edat_lfse_03__custom_12203206]	Annual	2005-2020	Less than primary, primary and lower secondary education (levels 0-2)	EDU_1	Original	Percentage	From 15 to 64 years
46	EDUCATION	Population by educational attainment level, sex and age (%) - main indicators [edat_lfse_03__custom_12203206]	Annual	2005-2020	Upper secondary and post-secondary non-tertiary education (levels 3 and 4)	EDU_2	Original	Percentage	From 15 to 64 years
47	EDUCATION	Population by educational attainment level, sex and age (%) - main indicators [edat_lfse_03__custom_12203206]	Annual	2005-2020	Tertiary education (levels 5-8)	EDU_3	Original	Percentage	From 15 to 64 years
48	EDUCATION	Graduates by education level, programme orientation, sex and field of education [educ_uoe_grad02__custom_12203759]	Annual	2013-2020	Art and humanities	EDU_ARTHUM	Original	Number	
49	EDUCATION	Graduates by education level, programme orientation, sex and field of education [educ_uoe_grad02__custom_12203759]	Annual	2013-2020	Social sciences, journalism and information	EDU_SOCIAL	Original	Number	
50	EDUCATION	Graduates by education level, programme orientation, sex and field of education [educ_uoe_grad02__custom_12203759]	Annual	2013-2020	Business, administration and law	EDU_BUSINESS	Original	Number	
51	EDUCATION	Graduates by education level, programme orientation, sex and field of education [educ_uoe_grad02__custom_12203759]	Annual	2013-2020	Natural sciences, mathematics and statistics	EDU_NATURAL	Original	Number	
52	EDUCATION	Graduates by education level, programme orientation, sex and field of education [educ_uoe_grad02__custom_12203759]	Annual	2013-2020	Information and Communication Technologies	EDU_ICT	Original	Number	
53	EDUCATION	Graduates by education level, programme orientation, sex and field of education [educ_uoe_grad02__custom_12203759]	Annual	2013-2020	Engineering, manufacturing and construction	EDU_ENGINEER	Original	Number	

54	EDUCATION	Graduates by education level, programme orientation, sex and field of education [educ_uoe_grad02__custom_12203759]	Annual	2013-2020	Agriculture, forestry, fisheries and veterinary	EDU_AGRI	Original	Number	
55	EDUCATION	Graduates by education level, programme orientation, sex and field of education [educ_uoe_grad02__custom_12203759]	Annual	2013-2020	Health and welfare	EDU_HEALTH	Original	Number	
56	EDUCATION	Graduates by education level, programme orientation, sex and field of education [educ_uoe_grad02__custom_12203759]	Annual	2013-2020	Services	EDU_SERVICE	Original	Number	
57	EDUCATION	Out-of-school rate by sex and age - as % of the population of the corresponding age [educ_uoe_enra27__custom_12203164]	Annual	2015-2020	Out-of-school rate by sex and age - as % of the population of the corresponding age	OUTOFSCHOOL	Original	Percentage	14 years
58	ECONOMY	GDP and main components (output, expenditure and income) [nama_10_gdp__custom_12199112]	Annual	2005-2020	Gross domestic product at market prices	GDP	Original	Chain linked volumes (2015), million euro	
59	ECONOMY	GDP and main components (output, expenditure and income) [nama_10_gdp__custom_12199112]	Annual	2005-2020	Final consumption expenditure	GDP_FIN_CONSUMP_EXP	Original	Chain linked volumes (2015), million euro	
60	ECONOMY	GDP and main components (output, expenditure and income) [nama_10_gdp__custom_12199112]	Annual	2005-2020	Exports of goods	GDP_EXP	Original	Chain linked volumes (2015), million euro	
61	ECONOMY	GDP and main components (output, expenditure and income) [nama_10_gdp__custom_12199112]	Annual	2005-2020	Imports of goods	GDP_IMP	Original	Chain linked volumes (2015), million euro	
62	ECONOMY	Labour productivity and unit labour costs [nama_10_lp_ulc__custom_12201163]	Annual	2005-2020	Real labour productivity per hour worked	REAL_LAB_PROD	Original	Index, 2015=100	
63	ECONOMY	Population and employment [nama_10_pe__custom_12199533]	Annual	2005-2020	Employment rate	EMPLOY_RATE	Calculated		Total employment national concept

									(thousand persons)/Total population national concept (thousand persons)
64	CONSUMPTION	General government expenditure by function (COFOG) [gov_10a_exp__custom_12198428]	Annual	2005-2020	COFOG:Total	COFOG_TOT	Original	Percentage of gross domestic product (GDP)	
65	CONSUMPTION	General government expenditure by function (COFOG) [gov_10a_exp__custom_12198428]	Annual	2005-2020	COFOG:General public services	COFOG_PUBLICSERV	Original	Percentage of gross domestic product (GDP)	
66	CONSUMPTION	General government expenditure by function (COFOG) [gov_10a_exp__custom_12198428]	Annual	2005-2020	COFOG:Defence	COFOG_DEFENCE	Original	Percentage of gross domestic product (GDP)	
67	CONSUMPTION	General government expenditure by function (COFOG) [gov_10a_exp__custom_12198428]	Annual	2005-2020	COFOG:Public order and safety	COFOG_SAFETY	Original	Percentage of gross domestic product (GDP)	
68	CONSUMPTION	General government expenditure by function (COFOG) [gov_10a_exp__custom_12198428]	Annual	2005-2020	COFOG:Economic affairs	COFOG_ECON	Original	Percentage of gross domestic product (GDP)	
69	CONSUMPTION	General government expenditure by function (COFOG) [gov_10a_exp__custom_12198428]	Annual	2005-2020	COFOG:Environmental protection	COFOG_ENVIRO	Original	Percentage of gross domestic product (GDP)	
70	CONSUMPTION	General government expenditure by function (COFOG) [gov_10a_exp__custom_12198428]	Annual	2005-2020	COFOG:Waste management	COFOG_WASTEMAN	Original	Percentage of gross domestic product (GDP)	
71	CONSUMPTION	General government expenditure by function (COFOG) [gov_10a_exp__custom_12198428]	Annual	2005-2020	COFOG:Housing and community amenities	COFOG_HOUSING	Original	Percentage of gross domestic product (GDP)	
72	CONSUMPTION	General government expenditure by function (COFOG) [gov_10a_exp__custom_12198428]	Annual	2005-2020	COFOG:Health	COFOG_HEALTH	Original	Percentage of gross domestic product (GDP)	

73	CONSUMPTION	General government expenditure by function (COFOG) [gov_10a_exp__custom_12198428]	Annual	2005-2020	COFOG:Recreation, culture and religion	COFOG_RECREATION	Original	Percentage of gross domestic product (GDP)	
74	CONSUMPTION	General government expenditure by function (COFOG) [gov_10a_exp__custom_12198428]	Annual	2005-2020	COFOG:Education	COFOG_EDUCATION	Original	Percentage of gross domestic product (GDP)	
75	CONSUMPTION	General government expenditure by function (COFOG) [gov_10a_exp__custom_12198428]	Annual	2005-2020	COFOG:Social protection	COFOG_SOCIALPROT	Original	Percentage of gross domestic product (GDP)	
76	CONSUMPTION	Final consumption expenditure of households by consumption purpose (COICOP 3 digit) [nama_10_co3_p3__custom_12200052]	Annual	2005-2020	COICOP:Total	COICOP_TOT	Original	Chain linked volumes (2015), million euro	
77	CONSUMPTION	Final consumption expenditure of households by consumption purpose (COICOP 3 digit) [nama_10_co3_p3__custom_12200052]	Annual	2005-2020	COICOP:Food and non-alcoholic beverages	COICOP_FOOD	Original	Chain linked volumes (2015), million euro	
78	CONSUMPTION	Final consumption expenditure of households by consumption purpose (COICOP 3 digit) [nama_10_co3_p3__custom_12200052]	Annual	2005-2020	COICOP:Alcoholic beverages, tobacco and narcotics	COICOP_ALCOHOLIC	Original	Chain linked volumes (2015), million euro	
79	CONSUMPTION	Final consumption expenditure of households by consumption purpose (COICOP 3 digit) [nama_10_co3_p3__custom_12200052]	Annual	2005-2020	COICOP:Clothing and footwear	COICOP_CLOTHING	Original	Chain linked volumes (2015), million euro	
80	CONSUMPTION	Final consumption expenditure of households by consumption purpose (COICOP 3 digit) [nama_10_co3_p3__custom_12200052]	Annual	2005-2020	COICOP:Housing, water, electricity, gas and other fuels	COICOP_HOUSING	Original	Chain linked volumes (2015), million euro	
81	CONSUMPTION	Final consumption expenditure of households by consumption purpose (COICOP 3 digit) [nama_10_co3_p3__custom_12200052]	Annual	2005-2020	COICOP:Furnishings, household equipment and routine household maintenance	COICOP_FURNISHINGS	Original	Chain linked volumes (2015), million euro	
82	CONSUMPTION	Final consumption expenditure of households by consumption purpose (COICOP 3 digit)	Annual	2005-2020	COICOP:Health	COICOP_HEALTH	Original	Chain linked volumes (2015),	

		[nama_10_co3_p3__custom_12200052]						million euro	
83	CONSUMPTION	Final consumption expenditure of households by consumption purpose (COICOP 3 digit) [nama_10_co3_p3__custom_12200052]	Annual	2005-2020	COICOP:Transport	COICOP_TRANSPORT	Original	Chain linked volumes (2015), million euro	
84	CONSUMPTION	Final consumption expenditure of households by consumption purpose (COICOP 3 digit) [nama_10_co3_p3__custom_12200052]	Annual	2005-2020	COICOP:Communications	COICOP_COMMUNICATIONS	Original	Chain linked volumes (2015), million euro	
85	CONSUMPTION	Final consumption expenditure of households by consumption purpose (COICOP 3 digit) [nama_10_co3_p3__custom_12200052]	Annual	2005-2020	COICOP:Recreation and culture	COICOP_RECREATION	Original	Chain linked volumes (2015), million euro	
86	CONSUMPTION	Final consumption expenditure of households by consumption purpose (COICOP 3 digit) [nama_10_co3_p3__custom_12200052]	Annual	2005-2020	COICOP:Education	COICOP_EDUCATION	Original	Chain linked volumes (2015), million euro	
87	CONSUMPTION	Final consumption expenditure of households by consumption purpose (COICOP 3 digit) [nama_10_co3_p3__custom_12200052]	Annual	2005-2020	COICOP:Restaurants and hotels	COICOP_RESTAURANTS	Original	Chain linked volumes (2015), million euro	
88	CONSUMPTION	Final consumption expenditure of households by consumption purpose (COICOP 3 digit) [nama_10_co3_p3__custom_12200052]	Annual	2005-2020	COICOP:Miscellaneous goods and services	COICOP_MISCELLANEOUS	Original	Chain linked volumes (2015), million euro	
89	CONSUMPTION	Final consumption expenditure on environmental protection services by institutional sector (2006-2020) [env_ac_cepsgh__custom_12210883]	Annual	2014-2020	Total environmental protection activities:Final consumption expenditure of households	FIN_CONSUMP_HH_ENVIRO_TOT	Original	Million euro	
90	CONSUMPTION	Final consumption expenditure on environmental protection services by institutional sector (2006-2020) [env_ac_cepsgh__custom_12210883]	Annual	2014-2020	Waste management:Final consumption expenditure of households	FIN_CONSUMP_HH_WASTEMAN	Original	Million euro	

91	CONSUMPTION	Consumption footprint – single weighted score [sdg_12_31__custom_12211715]	Annual	2010-2020	Consumption footprint single weighted score	CONSUMP_FP	Original	Per inhabitant	
92	CONSUMPTION	Final consumption aggregates by durability [nama_10_fcs__custom_12199407]	Annual	2005-2020	Final consumption expenditure of households, durable goods	FINCONS_HH_DURABLE	Original	Chain linked volumes (2015), million euro	
93	CONSUMPTION	Final consumption aggregates by durability [nama_10_fcs__custom_12199407]	Annual	2005-2020	Final consumption expenditure of households, semi-durable goods	FINCONS_HH_SEMIDUR	Original	Chain linked volumes (2015), million euro	
94	CONSUMPTION	Final consumption aggregates by durability [nama_10_fcs__custom_12199407]	Annual	2005-2020	Final consumption expenditure of households, non-durable goods	FINCONS_HH_NONDUR	Original	Chain linked volumes (2015), million euro	
95	CONSUMPTION	Final consumption aggregates by durability [nama_10_fcs__custom_12199407]	Annual	2005-2020	Final consumption expenditure of households, services	FINCONS_HH_SERVICE	Original	Chain linked volumes (2015), million euro	
96	CONSUMPTION	Mean consumption expenditure by degree of urbanisation [hbs_exp_t136__custom_12207593]	5 years	2005-2020	Mean consumption expenditure by degree of urbanisation, Cities	MEANCONSUMP_CITY	Original	Purchasing power standard (PPS) per household	
97	CONSUMPTION	Mean consumption expenditure by degree of urbanisation [hbs_exp_t136__custom_12207593]	5 years	2005-2020	Mean consumption expenditure by degree of urbanisation, Towns and suburbs	MEANCONSUMP_TOWN	Original	Purchasing power standard (PPS) per household	
98	CONSUMPTION	Mean consumption expenditure by degree of urbanisation [hbs_exp_t136__custom_12207593]	5 years	2005-2020	Mean consumption expenditure by degree of urbanisation, Rural areas	MEANCONSUMP_RURAL	Original	Purchasing power standard (PPS) per household	
99	CONSUMPTION	Mean consumption expenditure by type of household [hbs_exp_t134__custom_12207565]	Annual	2005-2020	Mean consumption expenditure by type of household, Total	MCONSUMP_HHTYPE_TOT	Original	Purchasing power standard (PPS) per household	
100	CONSUMPTION	Mean consumption expenditure by type of household [hbs_exp_t134__custom_12207565]	Annual	2005-2020	Mean consumption expenditure by type of household, Single Person	MCONSUMP_HHTYPE_SINGLEP	Original	Purchasing power standard (PPS) per household	

101	CONSUMPTION	Mean consumption expenditure by type of household [hbs_exp_t134__custom_12207565]	Annual	2005-2020	Mean consumption expenditure by type of household, Single person with dependent children	MCONSUMP_HHTYPE_SINGLEPCH	Original	Purchasing power standard (PPS) per household	
102	CONSUMPTION	Mean consumption expenditure by type of household [hbs_exp_t134__custom_12207565]	Annual	2005-2020	Mean consumption expenditure by type of household, Two adults	MCONSUMP_HHTYPE_2ADULT	Original	Purchasing power standard (PPS) per household	
103	CONSUMPTION	Mean consumption expenditure by type of household [hbs_exp_t134__custom_12207565]	Annual	2005-2020	Mean consumption expenditure by type of household, Two adults with dependent children	MCONSUMP_HHTYPE_2ADULTCH	Original	Purchasing power standard (PPS) per household	
104	CONSUMPTION	Mean consumption expenditure by type of household [hbs_exp_t134__custom_12207565]	Annual	2005-2020	Mean consumption expenditure by type of household, Three or more adults	MCONSUMP_HHTYPE_3PLUSADULT	Original	Purchasing power standard (PPS) per household	
105	CONSUMPTION	Mean consumption expenditure by type of household [hbs_exp_t134__custom_12207565]	Annual	2005-2020	Mean consumption expenditure by type of household, Three or more adults with dependent children	MCONSUMP_HHTYPE_3PLUSADULTCH	Original	Purchasing power standard (PPS) per household	
106	CONSUMPTION	Mean consumption expenditure by income quintile [hbs_exp_t133__custom_12207533]	Annual	2005-2020	Mean consumption expenditure by income quintile, First quintile	MCONSUMP_Q1	Original	Purchasing power standard (PPS) per household	
107	CONSUMPTION	Mean consumption expenditure by income quintile [hbs_exp_t133__custom_12207533]	Annual	2005-2020	Mean consumption expenditure by income quintile, Second quintile	MCONSUMP_Q2	Original	Purchasing power standard (PPS) per household	
108	CONSUMPTION	Mean consumption expenditure by income quintile [hbs_exp_t133__custom_12207533]	Annual	2005-2020	Mean consumption expenditure by income quintile, Third quintile	MCONSUMP_Q3	Original	Purchasing power standard (PPS) per household	
109	CONSUMPTION	Mean consumption expenditure by income quintile [hbs_exp_t133__custom_12207533]	Annual	2005-2020	Mean consumption expenditure by income quintile, Fourth quintile	MCONSUMP_Q4	Original	Purchasing power standard (PPS) per household	
110	CONSUMPTION	Mean consumption expenditure by income quintile [hbs_exp_t133__custom_12207533]	Annual	2005-2020	Mean consumption expenditure by income quintile, Fifth quintile	MCONSUMP_Q5	Original	Purchasing power standard (PPS) per household	

111	CONSUMPTION	Nights spent at tourist accommodation establishments [tour_occ_ninat__custom_12208762]	Annual	2005-2020	Total: Hotels; holiday and other short-stay accommodation; camping grounds, recreational vehicle parks and trailer parks	NIGHTS	Original	Per thousand inhabitants	

Annex VI – Pearson correlation test for dependent and potential independent variables for year 2015 and 2020

		Waste generated	Disposal - incineration (D10) and recovery - energy recovery (R1)	Disposal - landfill and other (D1-D7, D12)	Recycling	Waste generated per capita	Disposal - incineration (D10) and recovery - energy recovery (R1) per capita	Disposal - landfill and other (D1-D7, D12) per capita	Recycling per capita	Circular material use rate	Population total	Population: Less than 15 years	Population:From 15 to 64 years	Population: 65 years or over	Average household size
Waste generated 2015	Pearson Correlation	1	,950**	,508**	,961**	0,202	0,173	-0,253	,456*	,441*	,973**	,946**	,970**	,985**	-0,302
	Sig. (2-tailed)		0,000	0,008	0,000	0,322	0,407	0,213	0,019	0,024	0,000	0,000	0,000	0,000	0,134
	N	26	25	26	26	26	25	26	26	26	26	26	26	26	26
Waste generated 2020	Pearson Correlation	1	,943**	,488**	,966**	0,044	0,074	-0,243	0,328	0,380	,976**	,960**	,974**	,980**	-0,247
	Sig. (2-tailed)		0,000	0,010	0,000	0,827	0,714	0,223	0,095	0,051	0,000	0,000	0,000	0,000	0,214
	N	27	27	27	27	27	27	27	27	27	27	27	27	27	27

		Median age of population	Old-age dependency ratio	Women per 100 men	Young-age dependency ratio	Distribution of population,Cities	Distribution of population,Towns and suburbs	Distribution of population,Rural areas	House Total	Flat Total	Other dwelling Total	Material Footprint, Domestic extraction	Material Footprint, Exports in raw material equivalents	Material Footprint, Imports in raw material equivalents	Material Footprint, Raw material consumption
Waste generated 2015	Pearson Correlation	,458*	0,382	-0,106	0,005	0,044	0,298	-0,319	-0,197	0,188	0,103	,864**	,945**	,890**	,949**
	Sig. (2-tailed)	0,019	0,054	0,607	0,980	0,833	0,140	0,113	0,336	0,357	0,617	0,000	0,000	0,000	0,000
	N	26	26	26	26	26	26	26	26	26	26	26	15	15	26
Waste generated 2020	Pearson Correlation	0,356	0,319	-0,052	-0,015	-0,043	0,281	-0,211	-0,209	0,187	0,326	,839**	,904**	,778**	,924**
	Sig. (2-tailed)	0,069	0,104	0,798	0,941	0,831	0,156	0,292	0,296	0,350	0,097	0,000	0,000	0,003	0,000
	N	27	27	27	27	27	27	27	27	27	27	27	12	12	27

		Material Footprint, Raw material input	Resource productivity	Gini coefficient	Average full time adjusted salary per employee	Real gross disposable income of households per capita	Gross household saving rate	Gross investment rate of households	Gross debt-to-income ratio of households	Environmental protection expenditure - Households	Environmental protection investments of total economy	Production of environmental protection services of general government:Total	Production of environmental protection services of general government:Waste management output	Total environmental taxes	Taxes on Pollution/Resources
Waste generated 2015	Pearson Correlation	,962**	,441*	0,042	0,235	-0,037	0,385	0,168	-0,063	,980**	,944**	,905**	,748**	-0,250	-0,164
	Sig. (2-tailed)	0,000	0,024	0,839	0,259	0,858	0,070	0,445	0,774	0,000	0,000	0,000	0,000	0,218	0,422
	N	15	26	26	25	26	23	23	23	26	25	26	26	26	26
Waste generated 2020	Pearson Correlation	,937**	,408*	0,080	0,181	-0,209	0,305	0,059	-0,032	.c	.c	.c	.c	-0,185	-0,148
	Sig. (2-tailed)	0,000	0,034	0,690	0,376	0,305	0,147	0,786	0,883					0,356	0,461
	N	12	27	27	26	26	24	24	24	0	0	0	0	27	27

		Current and capital transfers for environmental protection, received	GVA_Waste management sector	Less than primary, primary and lower secondary education (levels 0-2)	Upper secondary and post-secondary non-tertiary education (levels 3 and 4)	Tertiary education (levels 5-8)	Art and humanities	Social sciences, journalism and information	Business, administration and law	Natural sciences, mathematics and statistics	Information and Communication Technologies	Engineering, manufacturing and construction	Agriculture, forestry, fisheries and veterinary	Health and welfare	Services
Waste generated 2015	Pearson Correlation	-0,073	,978**	0,143	-0,061	-0,132	,900**	,671**	,913**	,959**	,813**	,924**	,810**	,903**	,733**
	Sig. (2-tailed)	0,780	0,000	0,486	0,766	0,520	0,000	0,001	0,000	0,000	0,000	0,000	0,000	0,000	0,000
	N	17	22	26	26	26	22	21	21	21	21	21	21	21	21
Waste generated 2020	Pearson Correlation	,636**	,969**	0,207	-0,061	-0,160	,836**	,817**	,900**	,917**	,869**	,944**	,819**	,916**	,820**
	Sig. (2-tailed)	0,000	0,000	0,299	0,763	0,425	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
	N	27	27	27	27	27	23	22	22	22	22	22	22	22	22

		Out-of-school rate by sex and age - as % of the population of the corresponding age	Gross domestic product at market prices	Final consumption expenditure	Exports of goods	Imports of goods	Real labour productivity per hour worked	Employment rate	COFOG: Total	COFOG: General public services	COFOG: Defence	COFOG: Public order and safety	COFOG: Economic affairs	COFOG: Environmental protection	COFOG: Waste management
Waste generated 2015	Pearson Correlation	-0,130	,990**	,990**	,928**	,948**	.c	0,054	0,219	0,053	0,122	-0,132	-0,321	-0,018	0,056
	Sig. (2-tailed)	0,535	0,000	0,000	0,000	0,000		0,792	0,283	0,796	0,552	0,520	0,109	0,932	0,784
	N	25	26	26	26	26	26	26	26	26	26	26	26	26	26
Waste generated 2020	Pearson Correlation	-0,073	,988**	,991**	,906**	,943**	-0,206	-0,047	0,356	0,166	-0,035	-0,047	-0,246	0,130	0,134
	Sig. (2-tailed)	0,718	0,000	0,000	0,000	0,000	0,303	0,816	0,068	0,408	0,863	0,815	0,215	0,519	0,505
	N	27	27	27	27	27	27	27	27	27	27	27	27	27	27

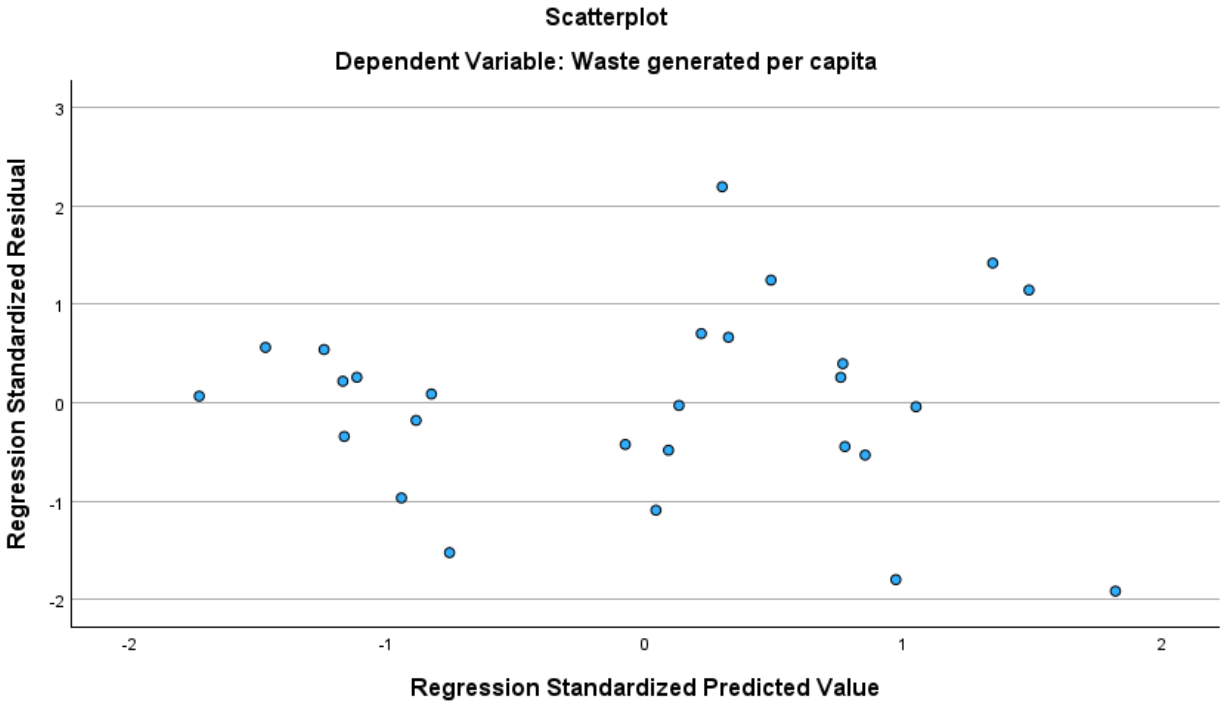
		COFOG: Housing and community amenities	COFOG: Health	COFOG: Recreation, culture and religion	COFOG: Education	COFOG: Social protection	COICOP: Total	COICOP: Food and non-alcoholic beverages	COICOP: Alcoholic beverages, tobacco and narcotics	COICOP: Clothing and footwear	COICOP: Housing, water, electricity, gas and other fuels	COICOP: Furnishings, household equipment and routine household maintenance	COICOP: Health	COICOP: Transport	COICOP: Communications
Waste generated 2015	Pearson Correlation	-0,132	0,328	-0,255	-0,269	,397*	,993**	,974**	,981**	,971**	,989**	,987**	,990**	,995**	,988**
	Sig. (2-tailed)	0,520	0,102	0,208	0,185	0,045	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
	N	26	26	26	26	26	26	26	26	26	26	26	26	26	26
Waste generated 2020	Pearson Correlation	-0,047	,390*	-0,150	-0,189	,536**	,994**	,976**	,983**	,964**	,987**	,983**	,989**	,994**	,983**
	Sig. (2-tailed)	0,815	0,044	0,454	0,344	0,004	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
	N	27	27	27	27	27	27	27	27	27	27	27	27	27	27

		COICOP: Recreation and culture	COICOP: Education	COICOP: Restaurants and hotels	COICOP: Miscellaneous goods and services	Total environmental protection activities: Final consumption expenditure of households	Waste management: Final consumption expenditure of households	Consumption footprint per inhabitant	Final consumption expenditure of households, durable goods	Final consumption expenditure of households, semi-durable goods	Final consumption expenditure of households, non-durable goods	Final consumption expenditure of households, services	Nights spent	Mean consumption expenditure by degree of urbanisation, Cities	Mean consumption expenditure by degree of urbanisation, Towns and suburbs
Waste generated 2015	Pearson Correlation	,981**	,923**	,886**	,988**	,979**	,938**	0,162	,982**	,990**	,990**	,988**	-0,081	0,196	0,200
	Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000	0,000	0,431	0,000	0,000	0,000	0,000	0,695	0,338	0,327
	N	26	26	26	26	26	26	26	26	26	26	26	26	26	26
Waste generated 2020	Pearson Correlation	,974**	,905**	,912**	,991**	.c	.c	0,100	,973**	,988**	,991**	,987**	-0,024	0,189	0,255
	Sig. (2-tailed)	0,000	0,000	0,000	0,000			0,619	0,000	0,000	0,000	0,000	0,904	0,375	0,230
	N	27	27	27	27	0	0	27	27	27	27	27	27	24	24

		Mean consumption expenditure by degree of urbanisation, Rural areas	Mean consumption expenditure by type of household, Total	Mean consumption expenditure by type of household, Single Person	Mean consumption expenditure by type of household, Single person with dependent children	Mean consumption expenditure by type of household, Two adults	Mean consumption expenditure by type of household, Two adults with dependent children	Mean consumption expenditure by type of household, Three or more adults	Mean consumption expenditure by type of household, Three or more adults with dependent children	Mean consumption expenditure by income quintile, First quintile	Mean consumption expenditure by income quintile, Second quintile	Mean consumption expenditure by income quintile, Third quintile	Mean consumption expenditure by income quintile, Fourth quintile	Mean consumption expenditure by income quintile, Fifth quintile
Waste generated 2015	Pearson Correlation	0,239	0,201	0,244	0,161	0,271	0,225	0,266	0,233	0,151	0,164	0,161	0,165	0,209
	Sig. (2-tailed)	0,250	0,325	0,231	0,432	0,180	0,268	0,189	0,253	0,472	0,432	0,442	0,430	0,316
	N	25	26	26	26	26	26	26	26	25	25	25	25	25
Waste generated 2020	Pearson Correlation	0,201	0,205	0,221	0,077	0,290	0,201	0,281	0,171	0,167	0,150	0,157	0,206	0,228
	Sig. (2-tailed)	0,357	0,337	0,300	0,721	0,169	0,345	0,183	0,425	0,458	0,504	0,484	0,357	0,307
	N	23	24	24	24	24	24	24	24	22	22	22	22	22

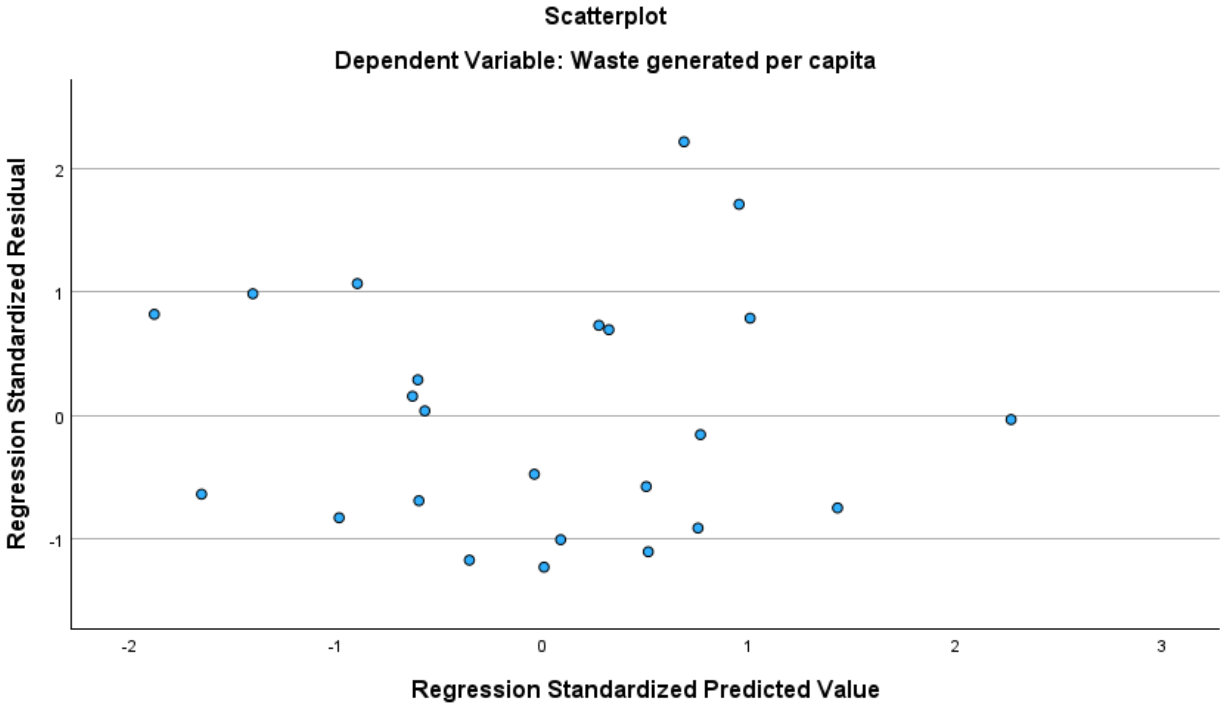
Annex VII – Scatterplots for models of statistical analysis

Scatterplot for Model1



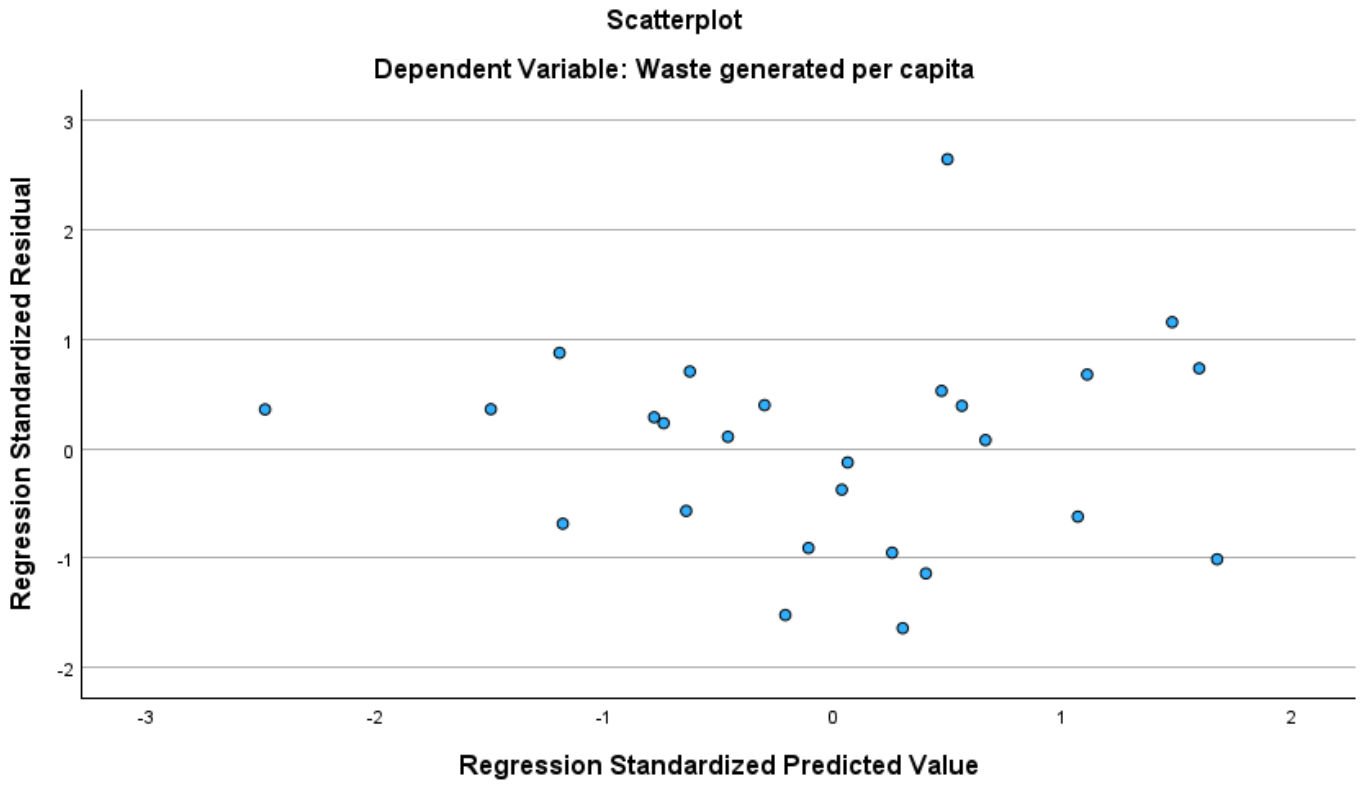
Source: own compilation

Scatterplot for Model2



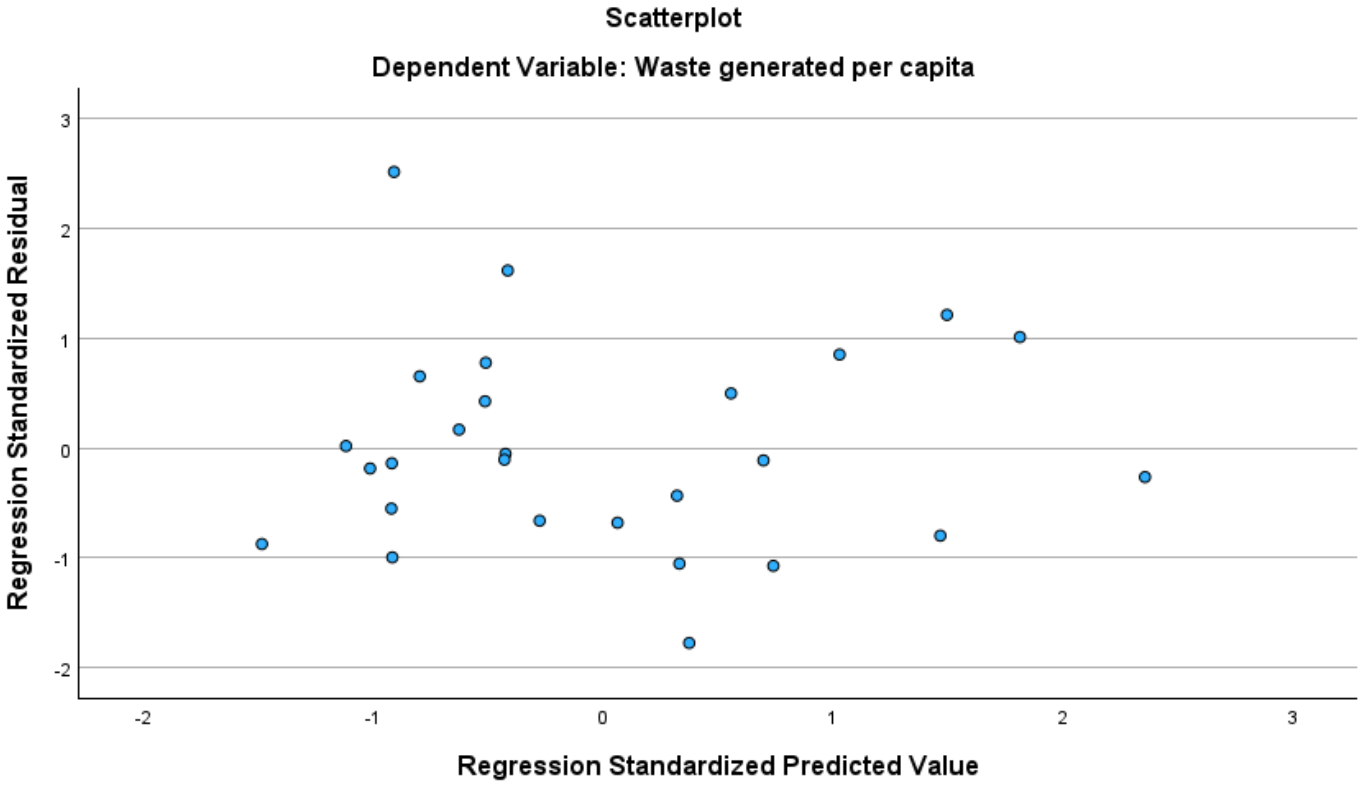
Source: own compilation

Scatterplot for Model3



Source: own compilation

Scatterplot for Model4



Source: own compilation

Annex VIII – Invitation towards stakeholders to the workshop and photos

Zero Waste Workshop, Zsámbék, April 2023

Source: own source

Annex IX – The questionnaire addressing citizens of Zsámbék

Zsámbék Nulla Hulladék(Qualtrics)

Start of Block: INTRO

INTRO „Nulla hulladék" tervezés Zsámbékon

A kutatásról

A felmérés Graczka Sylvia doktori kutatásának része, amely a települési szintű hulladékcsökkentési lehetőségek azonosítása mellett olyan mutatókat keres, amelyekkel jól mérheti a település és az ország vezetése a hulladékmegelőzés érdekében tett lépéseket. A kutatás részeként elkészül Zsámbék Nulla Hulladék Terve, amely ezen a felmérésen fog alapulni, így kérjük, hogy ha foglalkoztatja hogy mennyire környezetbarát a település, amelyen él, akkor töltse ki a kérdőívet, jelezze igényeit!

A kutatómunkában jelentős segítség Horváth László Zsámbék polgármestere és Böhm András képviselő, a Környezetvédelmi Bizottság vezetőjének támogatása, továbbá a Zsámbéki Ökoműhely részéről Varga Ágnes közreműködése.

Az adatfelvétel ANONIM, amennyiben érdekli a kutatás eredménye, úgy megadhatja a kérdőív végén az elérhetőségét, de ez nem kötelező. 18 év feletti kitöltőket várunk. A felmérés kb. 15 percet vesz igénybe!

Miért jó a hulladékmegelőzés a településnek és a lakosságnak?

A hulladék csökkentés célját számos számos nemzetközi és hazai jogszabály előírja. Túl azon, hogy a hulladékmegelőzéssel a település meg tud felelni ezeknek, a kapcsolódó programok révén a lakosság egy környezettudatos városban élhet, ahol közösségi kezdeményezések az egyéni elköteleződést is támogatni tudják elérhető új szolgáltatásokkal. Ilyen például a házi és közösségi komposztálás népszerűsítése, az újrahasználati központ működtetése, különböző kölcsönzési szolgáltatások révén a közös használat, a helyi vállalkozások motiválása, az oktatási intézmények bevonása stb. Az aktív lakossági közreműködés a hulladékcsökkentésben végső soron a társadalmi költséget csökkenti, és a természetet közvetlenül óvja a jelen és következő generációk számára.

Mit jelent a nulla hulladék?

A nulla hulladék (zero waste) egy jövőkép. Olyan életmód, társadalmi berendezkedés kialakítását célozza, amely a természetben tapasztalható anyagkörforgást biztosítja. Ilyen módon távoli – ideális, közelítendő – célként nem keletkezik hulladék.

Mi a hulladékmegelőzés?

A hazai hulladéktörvény egyik alapelve a hulladék keletkezésének mérséklésére vonatkozik a természeti erőforrások hatékony felhasználása, innovatív üzleti és fogyasztási modellek, az újrahasználat, a megosztás (közös használat) révén. Az alapelv kimondja, hogy a fogyasztók körében figyelemfelkeltésre van szükség, és „lehetőségeket kell biztosítani a fogyasztók részére a

hulladékképződés megelőzését és a hulladékelhagyást övező kérdésekkel kapcsolatos tudatosság növelésére". A megelőzés az anyag vagy termék hulladékká válását megelőzően hozott olyan intézkedés, amely csökkenti

a) a hulladék mennyiségét, többek között a termékek újrahasználata vagy a termékek élettartamának meghosszabbítása révén,

b) a képződött hulladék környezetre és emberi egészségre gyakorolt káros hatásait, vagy

c) az anyagok és a termékek veszélyesanyag-tartalmát.

End of Block: INTRO

Start of Block: ALAP

A00 ALAPADATOK

A01 NEM Neme:

- ○ Nő (1)
- ○ Férfi (2)
- ○ Nem kívánok válaszolni. (3)

A02 KOR Kora:

_____

A03 VEGZETTSEG Legmagasabb iskolai végzettsége:

- ○ alapfokú iskolai végzettség (általános iskola 8 évfolyamának sikeres befejezése) (1)
- ○ középfokú iskolai végzettség (érettségi bizonyítvány, középfokú szakképesítés) (2)
- ○ felsőoktatási (felsőfokú) szakképzésben szerzett oklevél (3)
- ○ főiskolai vagy felsőfokú alapképzésben (BA/BsC oklevél, vagy azzal egyenértékű) (4)
- ○ egyetemi vagy felsőfokú mesterképzésben (MA/MsC, vagy azzal egyenértékű) (5)
- ○ tudományos fokozatot igazoló oklevél (PhD, DLA) (6)

A04 HAZTARTASMERET A háztartásában élő személyek száma:

- ○ 18 év feletti: (1) _____
- ○ 18 év alatti: (2) _____

A05 JOVEDELEM Háztartása havi nettó jövedelme:

- ○ 101– 300 ezer Ft (1)
- ○ 301– 500 ezer Ft (2)
- ○ 501– 700 ezer Ft (3)
- ○ 701– 900 ezer Ft (4)
- ○ 901 ezer – 1,1 millió Ft (5)
- ○ 1,101 – 1,3 millió Ft (6)
- ○ 1,301 – 1,5 millió Ft (7)
- ○ 1,5 millió Ft felett (8)
- ○ Nem tudom / Nem kívánok válaszolni. (9)

A05M *A havi nettó jövedelem összegének megadásánál kérjük az alábbi főbb tételeket vegyék figyelembe: munkaviszonyból származó jövedelmek (a munkabér, munkadíj, illetmény, továbbá a rendszeresen kapott túlórák, helyettesítési díjak, jutalékok, pótlékok, bónuszok, pályázat útján elnyert ösztöndíjak összege) az önálló vállalkozói tevékenységből származó jövedelem, egyéb jövedelmek (befektetésekből, tőkéből (ingatlanok, eszközök) származó jövedelmek), a szociális ellátásokból származó jövedelmek (családi és gyermektámogatások, munkanélküli segély, betegséggel és rokkantsággal összefüggő ellátások, a nyugdíjellátások, oktatáshoz kapcsolódó ellátások összege).*

A06 INGATLAN Kérjük, adja meg az ingatlan jellegét, amelyben él:

- ○ családi, vagy ikerház (1)
- ○ társasház (2)
- ○ közösségi lakóépület (3)

A07 KERT Van kertje?

- ○ igen, 100-500 m2 (1)
- ○ igen, 501-1000 m2 (2)
- ○ igen, 1001 m2 fölötti (3)

○ nincs (4)

End of Block: ALAP

Start of Block: VASARLAS

V00 VÁSÁRLÁSI ÉS FOGYASZTÁSI SZOKÁSOK

V01 FOGYASZTAS Az elmúlt 12 hónapban hogyan változott *mennyiségben* a háztartás fogyasztása az azt megelőző 12 hónaphoz képest?

○ 0 (0)

○ 1 (1)

○ 2 (2)

○ 3 (3)

○ 4 (4)

○ 5 (5)

○ 6 (6)

○ 7 (7)

○ 8 (8)

○ 9 (9)

○ 10 (10)

V01M *A fogyasztásnál elsősorban a heti rendszeres bevásárlásaira gondoljon, a gyorsan forgó termékekre (élelmiszer, tisztítószerek, kozmetikumok stb.), nem a ritkábban vásárolt tartós cikkekre!*

V02 HULLADEKTERM Az elmúlt 12 hónapban hogyan változott a háztartás által termelt hulladék mennyisége az azt megelőző 12 hónaphoz képest?

○ 0 (0)

○ 1 (1)

○ 2 (2)

○ 3 (3)

○ 4 (4)

○ 5 (5)

○ 6 (6)

○ 7 (7)

○ 8 (8)

○ 9 (9)

○ 10 (10)

V02M *A hulladék vonatkozásában a vegyes, illetve szelektíven gyűjtött hulladékra gondoljon!*

V03 Hol szokta a rendszeres (pl. heti) bevásárlásait végezni? (Több választ is megjelölhet!)

☐ magam termelek (1)

☐ termelőtől vásárolok (ideértve a bevásárlóközösséget is) (2)

☐ a zsámbéki piacon (3)

☐ a zsámbéki CBA-ban vagy Coopban (4)

☐ távolabbi szuper- és hipermarketekben (5)

☐ online rendelek (6)

V04 Vásárlásai során kiemelt szempont a környezetvédelem?

	nem fontos (1)	ha megtakaríthatok vele, akkor a környezetbarát terméket választom (2)	akkor is a környezetbarát terméket választom, ha drágább (3)
tartós fogyasztási cikkek (háztartási	○	○	○

gépek, bútorok, elektronikai cikkek, kerti szerszámok stb.) (1)			
gyorsan forgó fogyasztási cikkek (élelmiszer, ruházat, kozmetikumok, tisztítószerek stb.) (2)	○	○	○

V04M *Környezetbarát termék: a környezetre gyakorolt terhelése kisebb, mint a versenytársaié, leggyakrabban természetes összetevőket tartalmaz, vegyszermentes. Ide tartoznak a bio minősítésű termékek is. A kérdőívben elsősorban az anyagtakarékosságot vizsgáljuk, nem az energiahatékonyságot - pl. nagyobb mennyiségben történő vásárlás, kevesebb csomagolási hulladékkal jár, vagy a több funkciós készülékekkel is megspórolható, több különálló készülék stb.*

V05 Használ-e rendszeresen saját, újrahasználható csomagolószert? (Több választ is megjelölhet!)

- ☐ bevásárlótáskát, kosarat, ládát stb. (ami az áru elvitelét teszi lehetővé) (1)
- ☐ zacskót ömlesztett élelmiszerek elsődleges csomagolására (pékáru, zöldség, gyümölcs stb.) (2)
- ☐ egyéb csomagolóanyagot (pl. ételhordót, tojástartót, befőttes üveget stb.) (3)
- ☐ visszaváltható, betétdíjas csomagolást (pl. ital-, szikvíz csomagolás, vizes ballon, zöldséges ládák stb.) (4)
- ☐ nem használok (5)

V06 KOLCSONZES Kérjük, jelölje meg azokat a kölcsönző szolgáltatásokat, vagy magán jellegű kölcsönzéseket (pl. szomszédtól, ismerőstől), amelyeket igénybe vett az elmúlt 12 hónapban!

- ☐ könyvtár (1)
- ☐ kisgépkölcsönzés (kertészeti eszközök, barkácsszerszámok stb.) (2)
- ☐ közlekedési, szállítóeszköz (autó, utánfutó, kerékpár, roller stb.) (3)

☐ sporteszköz, túrafelszerelés kölcsönzés (4)

☐ ruha, jelmezkölcsönzés (5)

☐ egyéb: (6) _____

☐ nem szoktam kölcsönözni (7)

End of Block: VASARLAS

Start of Block: HULLADEK

H00 HULLADÉKKAL KAPCSOLATOS ISMERETEK ÉS SZOKÁSOK

H01 UJRA_TUDAS Kérjük, jelölje be, hogy Ön szerint az alábbiak közül melyik terheli nagyobb mértékben a környezetet?

○ Újrahasználat (1)

○ Újrahasznosítás (2)

○ Mindkettő azonos mértékben. (3)

○ Nem tudom a választ. (4)

H01M *Az újrahasználat és újrahasznosítás fogalmakat gyakran szinonimaként használják a köznyelvben, valójában nem ugyanazt a folyamatot jelölik. Amennyiben ismeri a két fogalom pontos jelentését és környezeti hatását, úgy válasszon a lehetőségek közül!*

H02 Az alábbi hulladékait jellemzően elkülönítve gyűjti, és adja le?

	Igen (1)	Nem (2)
Papír (1)	○	○
Fém (2)	○	○
Műanyag (3)	○	○
Üveg (4)	○	○
Használt olaj, sütőzsiradék (5)	○	○

Textil (6)	○	○
Elektronikai hulladék (7)	○	○
Gyógyszerhulladék (8)	○	○
Veszélyes hulladék (9)	○	○
Zöldhulladék (10)	○	○
Lom (11)	○	○

H03 ELELM_H_KELETK Hetente átlagosan hány liter *élelmiszer* hulladék keletkezik a háztartásban? (Csak számot írjon!)

_____

H03M *A becsléshez segítség, hogy egy átlagos konyhai műanyagdoboz 1l, egy átlagos felmosó vödör kb. 12 liter. Amennyiben szemeteszsákban gyűjtik, akkor annak az űrtartalma iránymutató. Élelmiszerhulladék: fogyasztásra alkalmatlan (lejárt és/vagy csomagolás nélküli, szennyezett), vagy fogyasztásra még alkalmas (pl. csomagolássérült) kidobásra szánt élelmiszer, az élelmiszerek tisztításából visszamaradó hulladék (pl. héj).*

H05 ELELM_HULLADEK Mit tesznek *leggyakrabban* az élelmiszerhulladékkal?

- ○ Kidobják a szemetesbe. (1)
- ○ Komposztálják. (2)
- ○ Odaadják az állatoknak. (3)

H05M *Élelmiszerhulladék: fogyasztásra alkalmatlan (lejárt és/vagy csomagolás nélküli, szennyezett), vagy fogyasztásra még alkalmas (pl. csomagolássérült) kidobásra szánt élelmiszer, az élelmiszerek tisztításából visszamaradó hulladék (pl. héj).*

H06 ELELM_FELESLEG Mit tesznek *leggyakrabban* az élelmiszerfeleslegel?

- ○ Kidobják a szemetesbe. (1)
- ○ Komposztálják. (2)
- ○ Odaadják az állatoknak. (3)

○ Átadják a maradékot ismerősnek, rászorulóknak. (4)

H07_KOMPOSZTAL Komposztálnak valamilyen módon?

○ Házi kerti komposztálás (1)

○ Társasházi komposztálás (2)

○ Közterületen, közösségi komposztálás (3)

○ Beltéri komposztálás (4)

○ Nem komposztálunk (5)

H07M *A komposztálás olyan biológiai folyamat, amely során a szerves hulladékok tápanyagban gazdag, humuszszerű anyaggá változnak.*

Display This Question:

If Komposztálnak valamilyen módon? = Házi kerti komposztálás

Or Komposztálnak valamilyen módon? = Társasházi komposztálás

Or Komposztálnak valamilyen módon? = Közterületen, közösségi komposztálás

Or Komposztálnak valamilyen módon? = Beltéri komposztálás

H08 Ha komposztál, átlagosan hány liter szerves hulladékot tesz az Önök háztartása komposztra hetente? (Csak számot írjon!)

_____

H08M A becsléshez segítség, hogy egy átlagos konyhai műanyagdoboz 1l, egy átlagos felmosó vödör kb. 12 liter. Amennyiben szemeteszsákban gyűjtik, akkor annak az űrtartalma iránymutató. A heti ürítésszámot is vegye figyelembe! Szerves hulladék: háztartások esetében jellemzően a kerti- és/vagy a konyhai élelmiszerhulladék. Kérjük, vegye figyelembe, ha mindkettőt komposztálja!

H09 Igénybe venne egy önkormányzati, kedvezményes díjú ágaprító szolgáltatást tavasszal és ősszel?

○ Igen (1)

○ Nem (2)

H09M *Az ágaprítás a komposztálás esetében kulcsfontosságú, a keletkezett mulcs pedig a talajnedvesség megtartására, gyomok távoltartására, ill. síkosságmentesítőként használható. A szolgáltatás azáltal válik kedvezményessé, hogy az önkormányzati koordinációjában, egyszerre sok háztartásban valósulhat meg az aprítás, így a fajlagos költség jelentősen csökkenthető.*

End of Block: HULLADEK

Start of Block: UJRAHASZNALAT

R00 ÚJRAHASZNÁLAT

R01 HASZNALT_VASAR Szoktak használt terméket vásárolni?

- ○ 0 (0)
- ○ 1 (1)
- ○ 2 (2)
- ○ 3 (3)
- ○ 4 (4)
- ○ 5 (5)
- ○ 6 (6)
- ○ 7 (7)
- ○ 8 (8)
- ○ 9 (9)
- ○ 10 (10)

Display This Question:

If Szoktak használt terméket vásárolni? = 1

Or Szoktak használt terméket vásárolni? = 2

Or Szoktak használt terméket vásárolni? = 3

Or Szoktak használt terméket vásárolni? = 4

Or Szoktak használt terméket vásárolni? = 5

Or Szoktak használt terméket vásárolni? = 6

Or Szoktak használt terméket vásárolni? = 7

Or Szoktak használt terméket vásárolni? = 8

Or Szoktak használt terméket vásárolni? = 9

Or Szoktak használt terméket vásárolni? = 10

R02 HASZNALT_OKA Mi a *legfőbb* oka annak, amiért használt termékeket vásárolnak?

- ○ Olcsóbbak, mint az új (1)
- ○ Egyediek (2)
- ○ Környezettudatosság miatt (3)
- ○ Egyéb okból: (4) _____

R03040506M *A következő négy kérdés esetében kérjük, becsülje a számokat! Főleg a nagyobb súlyú termékekre összpontosítson (pl. felsőruházat, nagyobb bútorok és nagy háztartási gépek)! Tisztában vagyunk azzal, hogy különösen a ruhákkal kapcsolatos kérdésre nehéz válaszolni, nagy ságrendi becslésre van szükség. Induljon ki egy hónapból, vagy egy szezonból és szorozza fel azt a könnyebb becslés érdekében. A ruháknál darabban VAGY "kukás" zsákban számolva is megadhatja a mennyiséget.*

Display This Question:

If Szoktak használt terméket vásárolni? = 1

Or Szoktak használt terméket vásárolni? = 2

Or Szoktak használt terméket vásárolni? = 3

Or Szoktak használt terméket vásárolni? = 4

Or Szoktak használt terméket vásárolni? = 5

Or Szoktak használt terméket vásárolni? = 6

Or Szoktak használt terméket vásárolni? = 7

Or Szoktak használt terméket vásárolni? = 8

Or Szoktak használt terméket vásárolni? = 9

Or Szoktak használt terméket vásárolni? = 10

R03 VASARLAS Az elmúlt 12 hónapban mennyi terméket *vásároltak* a háztartásban élők az alábbi termékkategóriákban? Ha nem vásároltak, írjon nullát!

- ○ Ruha és más textiliák (darabban) VAGY (1)

_____

- ○ Ruha és más textíliák (kb. 110 literes "kukás" zsákban számolva) (2)

_____

- ○ Bútor (db) (3) _____

○ Elektronikai és elektromos készülékek (db) (4)

_____

R04 ELADAS Az elmúlt 12 hónapban mennyi használt terméket *adtak el* az alábbi termékkategóriákban? Ha nem adtak el, írjon nullát!

○ Ruha és más textiliák (darabban) VAGY (1)

_____

○ Ruha és más textíliák (kb. 110 literes "kukás" zsákban számolva) (2)

_____

○ Bútor (db) (3) _____

○ Elektronikai és elektromos készülékek (db) (4)

_____

R05 ADOMANYOZAS Az elmúlt 12 hónapban mennyi használt terméket *adtak át ingyenesen* az alábbi termékkategóriákban? Ha nem volt ilyen, írjon nullát!

○ Ruha és más textiliák (darabban) VAGY (1)

_____

○ Ruha és más textíliák (kb. 110 literes "kukás" zsákban számolva) (2)

_____

○ Bútor (db) (3) _____

○ Elektronikai és elektromos készülékek (db) (4)

_____

R05M *Ingyenes átadás például az adomány, ajándék, csere-bere (pénzforgalom nélkül).*

R06 ADOMANYFOGADAS Az elmúlt 12 hónapban mennyi használt terméket *kaptak ingyenesen* az alábbi termékkategóriákban? Ha nem volt ilyen, írjon nullát!

○ Ruha és más textiliák (darabban) VAGY (1)

_____

○ Ruha és más textíliák (kb. 110 literes "kukás" zsákban számolva) (2)

_____

○ Bútor (db) (3) _____

○ Elektronikai és elektromos készülékek (db) (4)

_____

R06M *Ingyenes átadás például az adomány, ajándék, csere-bere (pénzforgalom nélkül).*

R07 HOL_ELAD_VASAROL Hol szoktak használt termékeket eladni és vásárolni? (Több választ is megjelölhet!)

	eladni (1)	vásárolni (2)
Online piactereken (1)	☐	☐
Személyes kapcsolatokon keresztül (ismerősök) (2)	☐	☐
Garázsvásárokon (3)	☐	☐
Használt cikk kereskedésekben (4)	☐	☐
Börzéken, zsibvásáron (5)	☐	☐
Adományboltokban (6)	☐	☐
Más helyen keresztül: (7)	☐	☐
Nem adunk el/nem vásárolunk használt terméket. (8)	☐	☐

R08_FOGAD_ADOMANYOZ Hol szoktak ingyen termékeket, adományt, ajándékot fogadni és felajánlani? (Több választ is megjelölhet!)

	fogadni (1)	felajánlani (2)
Ingyenesen felajánló közösségi médiacsoportokban (pl. Jó szívvel ingyen csoport) (1)	☐	☐
Személyes kapcsolatokon keresztül (család, barátok stb.) (2)	☐	☐

Adományboltokban (3)	☐	☐
Nonprofit szervezeteken keresztül (4)	☐	☐
Más helyen keresztül: (5)	☐	☐
Nem szoktunk ingyenes használt termékeket fogadni/felajánlani. (6)	☐	☐

R09 JAVITAS **Kérjük, jelölje meg az összes olyan terméktípust, amelyet saját maguk javítottak, vagy mással javíttattak meg az elmúlt évben! (Már akkor is jelölje, ha csak egy ilyen javítás is történt!)**

☐ Ruházat és textiltermékek (1)

☐ Bútor (2)

☐ Elektronikai és elektromos készülékek (3)

☐ Egyéb termékek: (4) _____

End of Block: UJRAHASZNALAT

Start of Block: PREFERENCIAK

P00 PREFERENCIÁK

P01 - TAMOGATAS Kérjük jelezze az álláspontját az alábbi kérdésekben!

	Igen (1)	Inkább igen (2)	Inkább nem (3)	Nem (4)
Támogatná a szemétdíj tényleges súly alapján történő meghatározását? (1)	○	○	○	○
A háztartásuk csatlakozna	○	○	○	○

használóként egy közösségi komposztáló projekthez? (2)				
Ön ügyfele lenne egy zsámbéki újrahasználati központnak? (3)	○	○	○	○
Ön ügyfele lenne egy zsámbéki kölcsönző központnak? (4)	○	○	○	○
Ön ügyfele lenne egy zsámbéki hulladékudvarnak? (5)	○	○	○	○
Ön ügyfele lenne egy zsámbéki élelmiszermentő pontnak (akár adományozóként, akár fogyasztóként)? (6)	○	○	○	○
Igénybe venné, ha a piacon szervezetten elérhető lenne újrahasználható csomagolás? (7)	○	○	○	○

P01M *Jelenleg a kuka mérete és az ürítésszám határozza meg a szemétdíj mértékét, amit változatlanul meg kell fizetni, ha valaki kevesebbet tesz a kukába. A súly alapján történő számlázással a hulladékot termelő érdekelt lenne a csökkentésben.*

Közösségi komposztáló a környéken élők számára nyújt lehetőséget a zöld hulladék elhelyezésére, a működtetés a használók feladata. "Ügyfélként leadhatna és vásárolhatna is ép használt termékeket.

Újrahasználati központ: egy olyan intézmény, ahol a lakosság leadhatja a használt termékeket, és ott ezeket megjavítva, áron alul értékesítenék. Ez új munkahelyeket teremt, és hozzájárul a hulladék csökkentéséhez.

Kölcsönző központ a megszokottnál szélesebb palettával kölcsönző vállalkozás (pl. kerti szerszámok, sportszerek, parti kellékek, utazáshoz kellékek, textilpelenka babáknak stb.)

Hulladékudvar: különböző fajtájú – többnyire hasznosításra alkalmas vagy veszélyes – hulladék átvételére és átmeneti tárolására szolgáló telephely, ahová a lakosság rendszerint ingyenesen leadhatja hulladékát. Nem azonos a hulladéklerakó, szeméttelep kifejezésekkel!

Élelmiszermentő pontra a lakosság leadhatja még fogyasztható élelmiszerfeleslegét, illetve mások - különösen a rászorulók - innen igényelhetnek ételt.

Piaci újrahasználható csomagolás: például a termelők saját, zárt betétdíjas rendszerű csomagolása, vagy elérhető lenne szabadon tojástartó, kartondoboz, befőttes üveg, amit a piacra járók visszahoznának használat után.

P02_JAVITAS_IGENY Milyen termékjavító műhelyre lenne Ön szerint igény Zsámbékon?

- ☐ ruházat és cipő javítás (1)
- ☐ bútorjavító (2)
- ☐ elektromos és elektronikai cikkek javítása (3)
- ☐ szerszámjavító (4)
- ☐ egyéb: (5) _____
- ☐ nem kell semmilyen javító vállalkozás (6)

P03_CSOMAGOLASMENTES Ön lenne-e rendszeres vásárlója egy helyi csomagolásmentes boltnak?

- ○ nem, maradok az eddig beszerzési helyeimnél (1)
- ○ ha olcsóbb lenne, mint az eddigi helyek, ahonnan vásárolok, akkor váltanék (2)
- ○ rendszeres vásárló lennék (3)

P03M *A csomagolásmentes bolt ömlesztve árulja termékeit, mely saját csomagolásban vihető el. Ezek a boltok jellemzően környezetbarát és/vagy bio és/vagy kézműves termékeket árulnak. Célközönségük elsősorban a környezettudatos fogyasztók.*

P04_RENDEZVENY Ön szívesen venne részt olyan helyi tömegrendezvényeken, amelyeknél kötelező a saját étkészlet, vagy betétdíjas poharak, étkészlet elérhető csak?

- ○ Igen (1)
- ○ Nem (2)
- ○ Nem járok helyi tömegrendezvényekre. (3)

P05_EU_TERMEKEK Amennyiben a háztartásban bárki használ nedvszívó egészségügyi termékeket (intim betét, pelenka), úgy ezek között van mosható, újrahasználható, azaz környezetbarát változat?

- ○ Van ilyen használatban, és van közte mosható betét/pelenka. (1)
- ○ Van ilyen használatban, de nincs közte mosható betét/pelenka. (2)
- ○ Nem használ senki ilyen termékeket. (3)

P06_SZERELVENYBOLT Szokott vásárolni a szerelvény bolt "zöld" sarkában?

- ○ Igen (1)
- ○ Nem (2)
- ○ Nem tudtam, hogy ott van "zöld" sarok. (3)

End of Block: PREFERENCIAK

Start of Block: ZARAS

Q70 Kedves Válaszadó! A kérdőív végére ért, köszönjük aktív részvételét a települése hulladékcsökkentési törekvéseiben.

Q71 Amennyiben érdekli a kutatás eredménye, úgy megadhatja elérhetőségét: Név (1) _____

- ○ E-mail (2) _____

Q72 Bármilyen további javaslatot, megjegyzést örömmel fogadunk:

_____

_____

_____

_____

End of Block: ZARAS