Chapter 2
Literature Review

Every year 11.2 billion tonnes of solid waste are collected worldwide (UNEP 2011). In upcoming years the amount of accumulated waste will continue to increase together with growing population, an urbanization rate, overall economic and GDP/GNI per capita growth, an increase in production and consumption, and changes in a consumption pattern. Furthermore, the latest World Bank report predicts that annual global solid waste management costs will increase from USD 205.4 billion to about USD 375.5 billion by 2025 (Hoornweg and Bhada-Tata 2012). However, there is a positive aspect to this waste—its huge economic potential. Today the world waste market, from collection to recycling, is estimated at USD 410 billion a year, not including the sizable informal segment in developing countries (UNEP 2011).

According to the Eurostat data, the European Union alone generates about 3 billion tonnes of waste annually, and due to the OECD projections by 2020, this amount will increase by 45 % in comparison to 1995 (European Commission 2013b). Such a quantity of waste and its complexity not only have a significant adverse environmental impact, causing pollution, greenhouse gas emissions, and posing threats to human health, but also wastes a huge amount of material and energy resources (European Commission 2010; EEA 2013b).

Highly dependent on imported raw materials, Europe, in its long-term goals and strategies strives to reduce the amount of waste generated by improving its resource efficiency through recycling, avoiding waste and using unavoidable waste as a resource wherever it possible (European Commission 2010).

Waste prevention has been identified as one of the top priorities in the EU's Sixth Environment Action Programme (European Commission 2013b) as well as in the proposal of the European Commission for the 7th Environment Action Programme and the Roadmap to a resource efficient Europe (EEA 2013a).

The European Union's approach to waste management is based on the following principles:

- Waste prevention, which is closely linked with improving manufacturing methods and influencing consumers to demand greener products and less packaging.

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- Recycling and reuse as an alternative to waste prevention in cases when it is not possible.
- Improvement of final disposal and monitoring as the last option, where waste is safely incinerated or landfilled (European Commission 2013b).

2.1 Legislation

These principles are reflected in the European framework of waste legislation. The framework includes a variety of requirements and technical standards for waste management in general (for all waste streams), for specific waste streams (e.g. packaging waste) and for specific waste treatment modes such as landfill and waste incineration (Neubauer 2007; EAUC 2013). All of these standards are implemented through a large number of EU Directives and Regulations, the cornerstone of which is the EU Waste Framework Directive considered as the "basic law" of the EU Waste Policy. The Directive dates from 1975 and was re-edited in 2006 (Neubauer 2007) as a result of the 2005 Thematic Strategy on Waste Prevention and Recycling (European Commission 2010).

The Thematic Strategy on the Prevention and Recycling of Waste (COM (2005) 666) adopted in 2005 (Commission of the European Communities Communication COM (2005) 666 2005) became a main driver for reforming out-dated principles and requirements of the EU waste legislation and bringing a new approach which is dictated by the realities of the world today. The Strategy defines the long term goal of switching the EU to a recycling society that seeks to avoid waste and uses waste as a resource. It promotes prevention, recycling and re-use measures as well as an application of a life-cycle orientated approach to waste management. It sets minimum EU standards for recycling activities and a framework for specific national policies. Moreover, the document recommends an improvement of the knowledge base on the impact of resource use, waste generation and management (Commission of the European Communities Communication COM (2005) 666 2005).

According to the Strategy, the Revised Waste Framework Directive (2008/98/EC) (2008) sees waste as a valued resource by strengthening its economic value and sets out targets for EU Member States to recycle 50 % of their municipal waste by 2020 (European Commission 2010). The countries are also required to introduce legislation on waste collection, reuse, recycling and disposal (European Commission 2013b). In addition to the definition of key concepts related to waste management, the document clarifies the difference between waste and by-products, sets criteria and conditions for situations when waste ceases to be waste and focuses on reducing the environmental impacts of waste generation. The Directive extends producer responsibilities and requires that the Member States establish waste management plans as well as waste prevention programs (Directive 2008/98/EC 2008).

However, based on the review of the progress towards achieving the Strategy's objectives, experts have stated that despite an improvement of legislation, increased

recycling rates, a reduction of the amount of waste going to landfill and of the relative environmental impacts per ton of waste treated, after 5 years, the Strategy's main objectives still remain valid (European Commission Report COM (2011) 13 2011).

Another important directive that sets out the main requirements for waste disposal is the EU Landfill Directive (1999/31/EC) (Council Directive 1999/31/EC 1999). It is necessary to stress that by defining the term 'waste' the directive refers to the Council Directive on waste (75/442/EC) from 1975 (Council Directive 75/442/EEC 1975). The document includes a definition of waste types with no reference to the waste list adopted in Commission Decision 2000/532/EC (2000) (Commision Decision 2000/532/EC 2000), which could result in collisions, confusions, and a necessary revision of the Directive.

The Directive sets maximum capacities for landfill sites and defines targets for the reduction of biodegradable municipal waste (BMW) going to landfills. It also bans certain waste streams from being put into landfill sites. The document requires the member states to set up a national strategy for operations aimed at the reduction of BMW, such as recycling, composting, recovery and biogas production. It contains requirements for opening and maintaining a landfill during its operational and after-care phases (Council Directive 1999/31/EC 1999).

However, the results of the assessment of achievements in this area show that in 2010 despite significant successes in increasing material recycling the majority of the European countries still send more than half of their municipal waste to landfill (EEA 2013a).

The next significant document is the Directive (94/62/EC as amended by 2004/12/EC 2004) on packaging and packaging waste (European Parliament and Council Directive 94/62/EC 1994; Directive 2004/12/EC 2004), which takes precedence over the Waste Framework Directive where packaging and packaging waste are concerned (Arcadis et al. 2010). The document clarifies the definition of the term 'waste', by introducing a number of additional criteria and defines such operations as 'recovery', 'recycling', 'energy recovery', 'organic recycling' and 'disposal'. It also obliges the member states to set up return, collection and energy recovery systems, and to encourage the use of materials obtained from recycled packaging waste. A reduction of the overall volume of packaging is stated as the best means of preventing the creation of packaging waste. The document discusses a necessity of a harmonized reporting technique and clear guidelines for data provision. It also requires implementation of preventive measures with an emphasis on the minimization of environmental impact (Directive 2004/12/EC 2004).

2.2 Waste Management Hierarchy

Looking at food waste historically, The early 1970s could be considered as a turning point for waste management in Europe. The 1972 Report to the Club of Rome and the oil crisis in 1973 drew attention to an issue of the scarcity of raw materials. These events induced the change in societys' perception of the term

'waste', methods of waste handling and necessary transitions in waste management (Kemp and van Lente 2011). In 1979, a Dutch politician Ad Lansink developed a priority list for the various waste management methods, which became known as 'Lansink's Ladder' and became official policy in 1981 (Raven 2007). At the top of the Ladder is 'prevention of waste', followed by 're-use (of products)', 'recycling (of materials)', 'incineration (with energy-production)' and 'landfilling' as the last option (Kemp and van Lente 2011).

Today's waste prevention framework, which uses the 'Lansink's Ladder' as a prototype, is widely used in various waste related areas such as legislation and numerous projects, initiatives and strategies. The current framework is a five-step hierarchy of waste management and waste treatment options ordered according to what is best for the environment (UK Department of Energy and Climate Change and Defra 2011). It is a set of rules for waste management planning, qualified waste collection and treatment (Neubauer 2007). Such a framework is helpful for understanding how management approaches can be used to influence materials as they flow through the material life cycle (U.S. EPA 2009). However, in each particular case the hierarchy passes through "modifications". Having waste prevention as a final goal, different expert groups and institutions adjust the waste hierarchy by extending or narrowing the content of its stages.

In the US it is implemented by the U.S. Environmental Protection Agency (EPA). The EPA works under the Resource Conservation and Recovery Act, primary law, which governs the disposal of solid and hazardous waste in the country. Under this law the EPA encourages practices that reduce the amount of waste needing to be disposed of, such as waste prevention, recycling, and composting (U.S. EPA 2013b). The agency has ranked the most environmentally preferable options for waste management from 'source reduction' (including reuse) to 'treatment and disposal', with 'recycling', 'composting' and 'energy recovery' between (Fig. 2.1) (U.S. EPA 2012b).

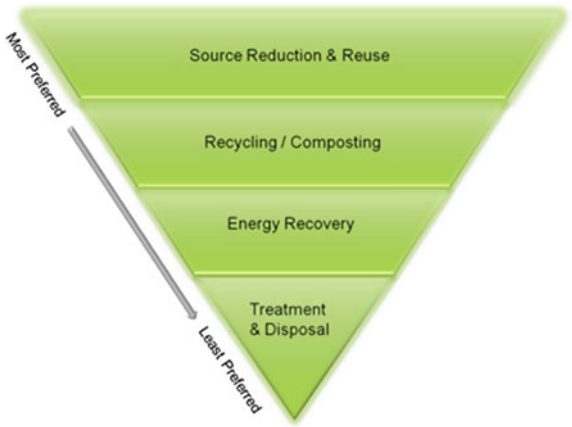

Fig. 2.1 Waste Management Hierarchy (U.S. EPA 2012b)

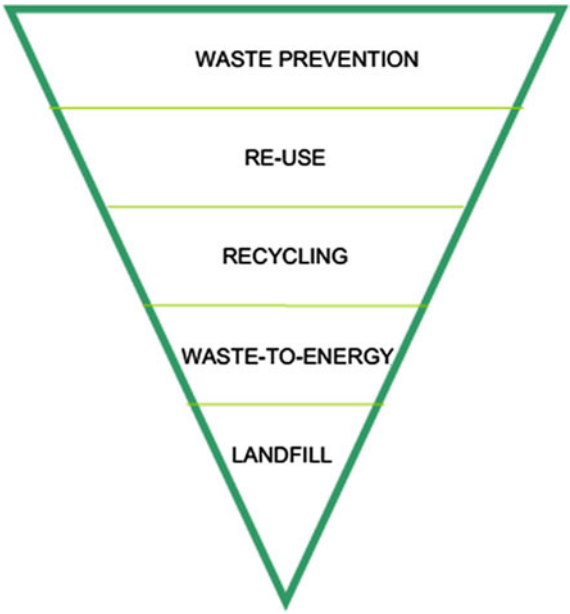

Fig. 2.2 Waste hierarchy (UNEP Division of Technology, Industry and Economics International Environmental Technology Centre 2010)

UNEP's various programmes and projects also endeavour to align with the waste management hierarchy (Fig. 2.2) used by the International Solid Waste Association (UNEP Division of Technology, Industry and Economics International Environmental Technology Centre 2010).

The association describes the hierarchy as 'a valuable conceptual and political prioritisation tool which can assist in developing waste management strategies aimed at limiting resource consumption and protecting the environment' (ISWA 2009).

A waste management hierarchy is also a framework used in the approach of Integrated Solid Waste Management (ISWM) (Fig. 2.3). This strategic concept is used for managing all sources of waste: prioritising waste avoidance and minimisation; practicing segregation; promoting the 3Rs (Reduce, Re-use, Recycle); implementing safe waste transportation; and treatment and disposal in an integrated manner with an emphasis on maximising resource-use efficiency (UNEP 2011).

Encouraged by the Thematic Strategy on the Prevention and Recycling of Waste (Commission of the European Communities Communication COM (2005) 666 2005), the EU waste policy has put an increasing focus on waste prevention (WRAP 2012). The waste management hierarchy and its stages (Fig. 2.4) are defined in the WFD.

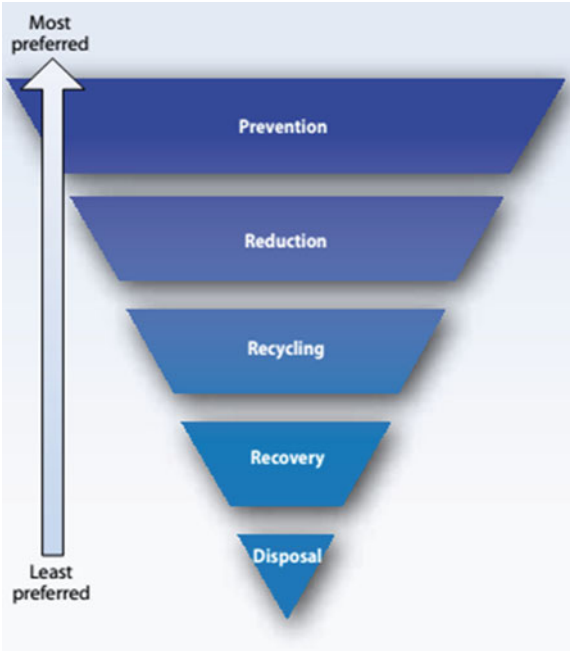

Fig. 2.3 The waste management hierarchy (UNEP 2011)

Fig. 2.4 The EU waste hierarchy (WRAP 2012)

2.2.1 Differences and Similarities in the Waste Management Hierarchies

All 'users' of the hierarchies agree upon the most and least preferable options for waste management. The top option 'waste prevention/avoidance/reduction' is stated as a crucial aspect of waste management (U.S. EPA 2012b; ISWA 2009; UNEP 2011; WRAP 2012; Directive 2008/98/EC 2008). However, institutions define this

stage differently. The WFD defines 'prevention' as "measures taken before a substance, material or product has become waste that reduces:

- The quantity of waste, including through the re-use of products or the extension of the life span of products;
- The adverse impacts of the generated waste on the environment and human health; or
- The content of harmful substances in materials and products".

(Directive 2008/98/EC 2008).

In its definition, the EPA also stresses such waste prevention techniques as donating items, buying in bulk and reducing packaging (U.S. EPA 2012b). At the same time the ISWM approach distinguishes between 'prevention' and 'reduction' stages (Fig. 2.3) (UNEP 2011).

The results achieved during this stage of the hierarchy are very important because it leads to resource conservation (WRAP 2012) and eliminates the need to dispose something that is not produced. Yet this is a very challenging concept because it is difficult to measure something which, by definition, never existed (European Commission 2010).

The next step, further down the WFD's hierarchy, is 'preparing for re-use' (Fig. 2.4). The directive differentiates between 'preparing for re-use', which means checking, cleaning or repairing, recovery operations, by which products or components of products that have become waste are prepared so that they can be re-used without any other pre-processing, and 're-use', which means any operation by which products or components that are not waste are used again for the same purpose for which they were conceived (Directive 2008/98/EC 2008). This is one of the main differences between the WFD's waste management hierarchy and the frameworks used by other institutions. At the same time the EPA merges the 'source reduction' and 're-use' stages (Fig. 2.1), whereas the waste management hierarchy, used in the ISWM approach, does not include the 're-use' option as a separate/stand-alone stage in general (Fig. 2.3) (UNEP 2011).

'Recycling' means a series of activities that includes collecting recyclable materials that would otherwise be considered waste, sorting and reprocessing into products, materials or substances whether for the original or other purposes (Directive 2008/98/EC 2008).

In the EPA's version of the hierarchy 'recycling' and 'composting' stages are merged (Fig. 2.1). Moreover, the Agency considers composting of food scraps, yard trimmings, and other organic materials as a part of the 'recycling' options. The definition again points out the importance of consumers who provide the last link in recycling by purchasing products made from recycled content (U.S. EPA 2012b).

The next step in every version of the hierarchy is 'energy recovery' from waste. The EPA defines it as "the conversion of non-recyclable waste materials into useable heat, electricity, or fuel through a variety of processes, including combustion, gasification, anaerobic digestion, and landfill gas recovery" (U.S. EPA 2012b).

The WFD sees 'energy recovery' as one of many recovery options. It defines recovery as "any operation the principal result of which is waste serving a useful purpose by replacing other materials which would otherwise have been used to fulfil a particular function, or waste being prepared to fulfil that function, in the plant or in the wider economy." It provides a list of recovery operations, which among others includes such operations as recycling/reclamation of metals and metal compounds, regeneration of acids or bases, oil re-refining or other reuses of oil, land treatment resulting in benefit to agriculture or ecological improvement and etc. (Directive 2008/98/EC 2008).

The last and least preferable option, which all actors agree upon, is 'disposal'. This stage includes landfilling and incineration without energy recovery. The WFD defines 'disposal' as "any operation which is not recovery even where the operation has as a secondary consequence the reclamation of substances or energy" (Directive 2008/98/EC 2008). In addition to these options the EPA adds collection and usage of methane as fuel to generate electricity and includes future possibilities of usage of capped landfills as recreation sites such as parks, golf courses, and ski slopes (U. S. EPA 2012b).

In addition, it is worth remarking that in a certain case if some options are not stressed as separate stages, it does not mean that these have not been considered by experts. Such a situation might be perceived as a way to leave more space and flexibility for their activities in the frame of this concept.

One of the main purposes of the EU waste legislation is to move up the waste management hierarchy (European Commission 2010). However, according to the Eurostat data the main methods of waste treatment in EU-28 in 2010 were 'recovery other than energy recovery', 'disposal' and 'deposit onto or into land' (Fig. 2.5). Even despite the fact that sending waste to landfill is considered as the worst waste management option it is still one of the most used municipal solid waste (MSW) disposal methods in the EU (Commission of the European Communities Green Paper COM (2008) 811 2008; European Commission 2010, 2012).

Tagore 2011 has been changed to Tagore 2010 so that this citation matches the list.

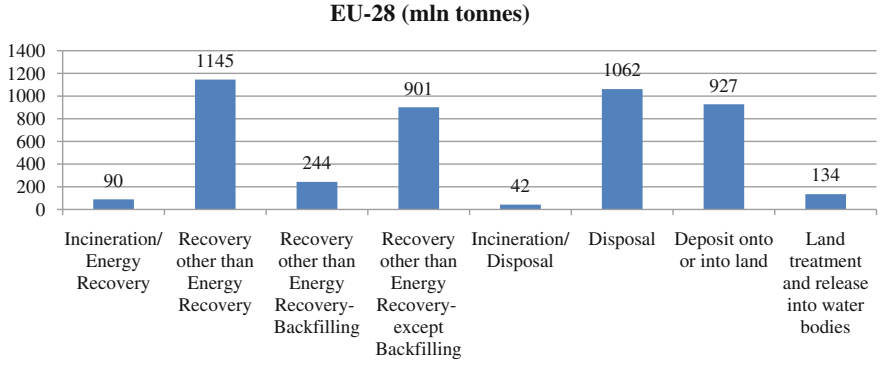

Fig. 2.5 Treatment of waste in EU-28 in 2010, in million tonnes (Eurostat 2013a, b)

On a national level, the WFD obliges countries to develop national waste management plans which include a baseline analysis of the current waste management situation in that country. Furthermore, the MS are required to establish National Waste Prevention Programmes by the end of 2013, which clearly identify the waste prevention measures and objectives (Directive 2008/98/EC 2008). In order to support the MS during the development of these programmes, the European Commission [DG Environment] has prepared a guidance document (European Commission Directorate-General Environment 2012). The guide provides detailed information about the stages of the waste hierarchy, and relevant EU waste prevention strategies and initiatives. It defines key waste streams, key stakeholders and types of waste that they produce. In addition, the document offers a procedure for planning and implementing a national waste prevention programme, and lists principle approaches which identify the most efficient measures for it (European Commission Directorate-General Environment 2012).

2.3 Bio-Waste

One of these waste types, which draw particular attention in the waste management policies, is bio-waste > This is mainly because of the environmental threats associated with its decomposition in landfills. The amount of bio-waste accounts for about one third of the waste generated by households in the EU. Each year Europe produces between 118 and 138 million tonnes of bio-waste, of which about 88 million tonnes is municipal waste (European Commission Communication COM (2010) 235 2010), on average, 40 % of this type of waste goes to landfill (European Commission 2010). Annually, the decay of the organic proportion of solid waste is contributing to about 5 % of global Greenhouse Gas (GHG) emissions (UNEP 2011). Experts talk about a need for greater focus on bio-waste recycling in line with the waste hierarchy (EEA 2013a). Arcadis et al. 2010, based on a multi-criteria-assessment, prioritized the bio-waste flow as one of the top four priority material and waste flows which have to become target areas for waste prevention measures (Arcadis et al. 2010). In addition the experts predict an increase in the share of bio-waste in the total generation of MSW at the EU-27 level, which will reach about 35.6 % by year 2020 (Fig. 2.6).

The WFD defines ‘bio-waste’ as “biodegradable garden and park waste, food and kitchen waste from households, restaurants, caterers and retail premises and comparable waste from food processing plants” (Directive 2008/98/EC 2008). It does not cover forestry or agricultural residue and it should not be confused with the wider term “biodegradable waste” (European Commission Communication COM (2010) 235 2010). The Landfill Directive defines ‘biodegradable waste’ as “any waste that is capable of undergoing anaerobic or aerobic decomposition, such as food and garden waste, and paper and paperboard” (Council Directive 1999/31/EC 1999). Thus bio-waste excludes paper and paperboard waste.

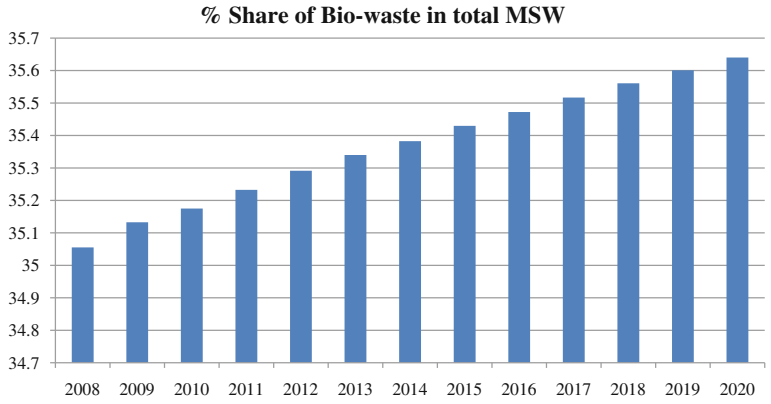

Fig. 2.6 The projection of % share of Bio-waste in total MSW generation at the EU-27 level (Arcadis 2010)

Today, the set of available techniques for the bio-waste treatment includes prevention at source, separate collection, biological treatment such as anaerobic digestion and composting, incineration, and landfill (Commission of the European Communities Green Paper COM (2008) 811 2008). Landfill and incineration methods are prevailing (Fig. 2.7) because they are considered by these countries as one of the easiest and cheapest options for bio-waste treatment (European Commission 2012). Aiming to change the current situation and move up the waste hierarchy the European Commission has taken a number of steps reflected in the EU waste policy and legislation.

In order to reduce the amount of bio-waste sent to landfill, the Landfill Directive sets binding targets regarding the allowed amount of municipal biodegradable waste to be landfilled. It should be reduced to 35 % of 1995 levels by 2016, which

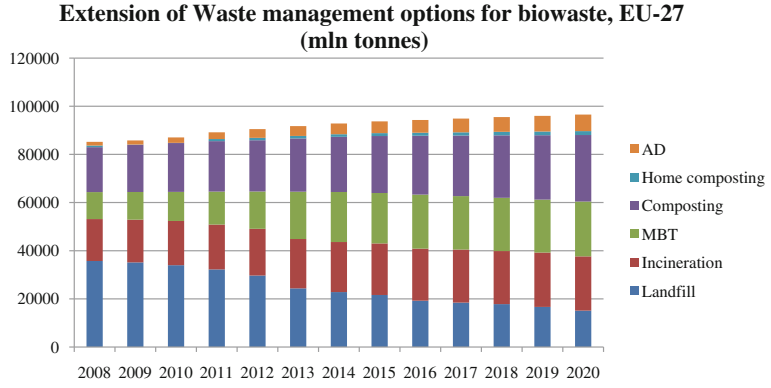

Fig. 2.7 The projection of extension of Bio-waste management options at the EU-27 level (Arcadis 2010)

leads to significant reduction of the problem of methane production (European Commission 2010). The 'dead-line' for such countries as Estonia, Latvia, Lithuania etc. is extended to 2020 (European Commission Directorate-General Environment 2012).

To discourage the incineration of bio-waste with low calorific value, the WFD defines energy efficiency levels below which the incineration of municipal solid waste may not be regarded as recovery (European Commission Communication COM (2010) 235 2010). The incineration of bio-waste is regulated by the Waste Incineration Directive (Directive 2000/76/EC 2000), which sets emission limit values and monitoring requirements for pollutants to air (Arcadis 2010; Commission of the European Communities Green Paper COM (2008) 811 2008). The WFD also requires the MS to encourage the use of materials produced from bio-waste, and to consider future options of bio-waste composting and digestion through separate collection (Directive 2008/98/EC 2008). The benefits of separate collection include easy diversion of biodegradable waste from landfills, enhancement of the calorific value of the remaining MSW, and generation of a cleaner bio-waste fraction that allows to produce high quality compost and facilitates biogas production (Commission of the European Communities Green Paper COM (2008) 811 2008; European Commission 2010, 2012). Results of the EC study on the 'evolution of (bio-) waste generation/prevention and (bio-) waste prevention indicators' (Reisinger et al. 2011) showed that some MS (or regions of the MS) have already implemented programmes for separate collection, diversion from landfill of bio-waste, and prevention of bio-waste via the use of economic instruments or targets. However, no national prevention targets specific to bio-waste were identified (Reisinger et al. 2011). At the same time a Green Paper, which explored options for the further development of the bio-waste management in the EU (BIO Intelligence Service 2010), published by the Commission in 2008, stated that there are no easy administrative solutions for bio-waste prevention and possible actions should be generally linked to changing consumer behaviour and retail policies (Commission of the European Communities Green Paper COM (2008) 811 2008).

Experts have also identified additional obstacles associated with the implementation of alternative methods to landfill to treat bio-waste. Firstly, bio-waste management options depend on a variety of factors such as inter alia collection systems, waste composition and quality, climatic conditions, population density, and the potential of use of various waste-derived products such as electricity, heat, methane-rich gas or compost (Commission of the European Communities Green Paper COM (2008) 811 2008; European Commission 2012), which define their environmental and economic benefits. Therefore, the EU legislation does not limit Member States' choices of bio-waste treatment options. The choice of treatment options needs to be explained and justified in national or regional Waste Management Plans and Prevention Programmes (Commission of the European Communities Green Paper COM (2008) 811 2008). Secondly, the results of the EC assessment of feasibility of setting bio-waste recycling targets in the EU outlined the following barriers of the implementation of separate collection and recycling of bio-waste:

- A general lack of experience and knowledge of the benefits of recycling/separate collection, the methods to set up a successful collection scheme, the cost structures, the ways to ensure compost/digestate quality, the uses of compost/digestate, the market functioning of waste-derived products such as compost, etc.;
- The costs linked to separate collection and recycling;
- Political barriers, logistical and social issues, mainly in rural areas and city centres.

(Vito et al. 2011).

To overcome these obstacles and to assist decision-makers in making the best use of biodegradable waste in line with the waste hierarchy, the Commission recommends to use the Life Cycle Assessment tool and Life Cycle Thinking approach to plan the management of bio-waste (European Commission 2012). Such an approach can be used alongside the waste hierarchy in order to make sure that the best overall environmental option is identified (European Commission et al. 2011). The Green Paper recommends the Commission to provide additional measures to support incineration with high energy recovery, anaerobic digestion with biogas production and recycling of bio-waste (Commission of the European Communities Green Paper COM (2008) 811 2008). Moreover, the production of good quality compost and bio-gas contributes to enhanced soil quality and resource efficiency, as well as a higher level of energy self-sufficiency (European Commission 2012).

Despite aforementioned constraints and barriers, efforts undertaken by the Commission such as legal restrictions and the support of a variety of programmes, projects and initiatives are having a positive effect. Experts, in their projection of the extension of bio-waste management options to 2020, predict an increase in the extension of MBT together with other treatment methods which will lead to a significant decrease in usage of the option of landfill (Fig. 2.7) (IEEP et al. 2010; Arcadis 2010).

Aligning the management of bio-waste with the waste hierarchy and other provisions of the WFD could have both financial and environmental benefits. Due to the communication from the Commission to the Council and the European Parliament on future steps in bio-waste management in the EU, the financial benefits could range between EUR 1.5–EUR 7 billion depending on the extent of recycling, and as a result environmental benefits could include an approximately 34 million tonnes CO_2 equivalent saving, 80–90 % of which would be due to prevention (European Commission Communication COM (2010) 235 2010).

2.4 Food Waste

However, the type of bio-waste that raises the biggest concern is food waste, which is the main focus of the current study. The problem of food waste takes a very particular place, by touching not only such issues as depletion of natural resources,

environmental pollution and climate change, but also ethical and social aspects of throwing away food, where due to the FAO estimations about 870 million people globally were suffering from chronic undernourishment in 2010–2012 (FAO 2013a). According to the FAO, about a third (around 1.3 billion tonnes) of the food for human consumption is wasted globally (FAO 2013b) and about 90 million tonnes of food is wasted annually in Europe (European Commission 2013a), where 16 million citizens receive food aid from charitable institutions (European Parliament Resolution (2011/2175 (INI)) 2012).

Food waste is responsible for various negative environmental effects with the high relevant costs (Bakas and Herczeg 2010). Food loss and waste impact on global climate change, resulting in unnecessary greenhouse gas emissions and inefficiently used water and land. This in turn leads to diminished natural ecosystems and the services they provide (Hall et al. 2009; Foresight 2011; Lipinski et al. 2013).

Economically, food loss and waste amounts to roughly USD 680 billion in industrialized countries and USD 310 billion in developing countries (FAO 2013b). In addition, it represents wasted investments that can reduce producers' incomes and increase consumers' expenses (Lipinski et al. 2013). In addition, ethically, it results in missed opportunities to feed the growing world population (FAO 2012). One quarter of the food currently lost or wasted globally could be saved, and this would be enough to feed the 870 million people globally who are in need of food (FAO 2013b).

Food waste has been identified by the European Commission as the most important household waste stream that must be prevented, therefore, the reduction of food waste required to be the core of any biodegradable waste (or bio-waste) prevention activity (European Commission Directorate-General Environment 2012), and the support of such activities on the EU level, would have the biggest impact (Reisinger et al. 2011).

Oddly enough, the definition of the term 'food waste' arises in many discussions as the problem of its generation. The interpretation of the term depends on each particular research group and the boundaries of group's work.

In 1981 the FAO defined 'food' as weight of whole some edible material that would normally be consumed by humans in the book "Food loss prevention in perishable crops". Inedible portions such as skins, stalks, leaves, and seeds, potential foods (e.g., leaf protein), feed (intended for consumption by animals) were not defined as food. 'Loss' was defined as any change in the availability, edibility, wholesomeness or quality of the food that prevents it from being consumed by people (FAO 1983).

Based on the aforementioned definition Escaler and Teng 2011 define 'food loss or waste' as "edible material intended for human consumption, arising at any point in the food supply chain that is instead discarded, lost, degraded or consumed by pests between harvest and reaching the consumer" (Escaler and Teng 2011).

The FAO in its report "Global losses and Food waste" uses the following definition (Parfitt et al. 2010): "food losses occurring at the end of the food chain (retail and final consumption), which relates to retailers' and consumers' behaviour"

(Gustavsson et al. 2011). The experts do not make a clear differentiation between food losses and food waste by defining it as "the masses of food lost or wasted in the part of food chains leading to "edible products going to human consumption" (Gustavsson et al. 2011).

At the beginning of 2012 the European Parliament released a resolution on "how to avoid food wastage: strategies for a more efficient food chain in the EU", where 'food waste' was defined as "all the foodstuffs discarded from the food supply chain for economic or aesthetic reasons or owing to the nearness of the 'use by' date, but which are still perfectly edible and fit for human consumption and, in the absence of any alternative use, are ultimately eliminated and disposed of, generating negative externalities from an environmental point of view, economic costs and a loss of revenue for businesses" (European Parliament Resolution (2011/2175 (INI)) 2012).

Lipinski et al. 2013 defines 'food waste' as "food that is of good quality and fit for human consumption but that does not get consumed because it is discarded—either before or after it spoils" (Lipinski et al. 2013).

Such variety of different views requires inclusion of additional criteria to characterize food waste. The first one is food waste classification.

WRAP classified food waste into three types due to an availability rating:

- **avoidable food waste**—the food has been thrown away because it is no longer wanted or has been allowed to go past its best (e.g. an apple, half a pack of cheese, milk, or an fruit juice);
- **possibly avoidable food waste**—this is food that some people will eat and others will not, or that can be eaten when prepared in one way but not in another (e.g. bread crusts);
- **unavoidable food waste**—this waste arises from food preparation and includes foods such as meat bones and hard vegetable or fruit peelings (e.g. melon rind) (WRAP 2008), which have not been considered as food by FAO in 1981 in the first place.

Avoidable food waste gives rise to the biggest concern because it is food that could have been eaten if it had been better managed or stored. The food may not have been fit for consumption at the time of disposal because it had gone mouldy or had been spoilt (WRAP 2008; NSW Office of Environment and Heritage Australia 2011). The resolution on "how to avoid food wastage: strategies for a more efficient food chain in the EU" addresses main aspects regarding the problem of food waste and lists causes of food waste such as overproduction, faulty product targeting (unadapted size or shape), deterioration of the product or its packaging, marketing rules (problems of appearance or defective packaging), and inadequate stock management or marketing strategies (European Parliament Resolution (2011/2175 (INI)) 2012).

Another question to discuss is about the stage in a food supply chain where food becomes food waste/loss. Food losses and waste occur along a food supply chain in both developed and developing countries (World Economic Forum 2009). In developing countries over 40 % (European Commission 2013a) of food loss/waste arise at production, harvest, processing, storage and transportation stages, whereas

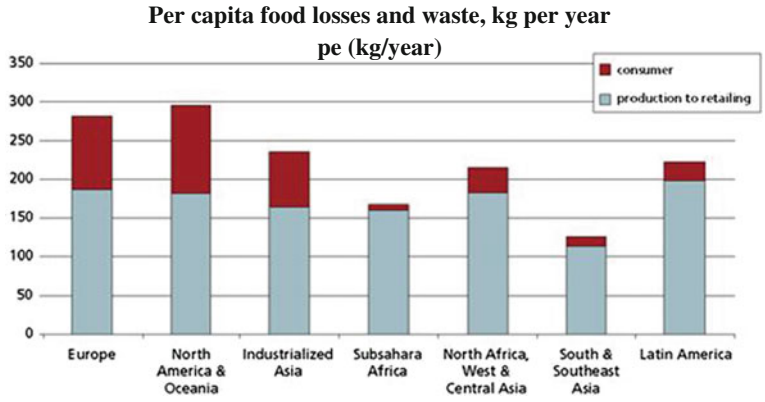

Fig. 2.8 Per capita food losses and waste, at consumption and pre-consumptions stages, in different regions (FAO 2013b)

in developed countries the majority of food waste is generated at the retail and consumption stages (Foresight 2011). In Europe and North America waste per capita by consumers is between 95–115 kg a year, while in sub-Saharan Africa, south and south-eastern Asia this amount does not exceed 6–11 kg a year (Fig. 2.8) (FAO 2013b).

Until today, a few frameworks have been suggested for food waste treatment. Through an analogy with the waste management hierarchy, the EPA developed 'Food waste recovery hierarchy' (Fig. 2.9) (U.S. EPA 2013a).

At the top of the hierarchy 'Source Reduction', followed by 'Feed Hungry People' which includes donation of extra food to food banks, recovery programs, soup kitchens, and shelters, 'Food Animals'—diversion of food scraps to animal

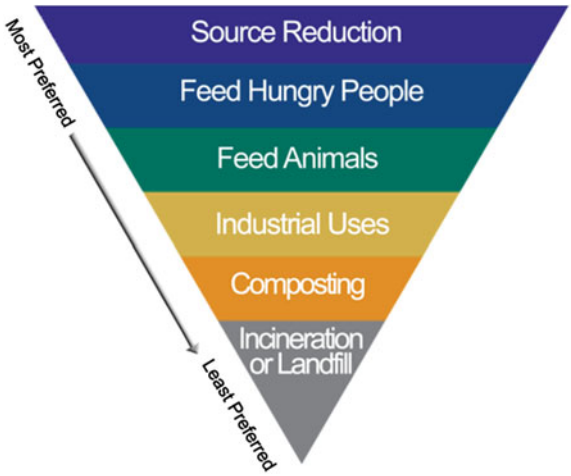

Fig. 2.9 U.S. EPA Food waste recovery hierarchy (U.S. EPA 2013a)

feed, 'Industrial Uses'—provision of waste oils for rendering and fuel conversion, and food scraps for digestion to recover energy, 'Composting'—creation of a nutrient-rich soil amendment, and the least preferable option is 'Landfill/Incineration' (U.S. EPA 2012a).

In the Netherlands, the Dutch Ministry of Economic Affairs, Agriculture and Innovation (EL&J), in parallel with Lansink's Ladder, uses the name 'Moerman Ladder'. Moerman's Ladder shows the 'optimum utilisation' of residual flows based on an ethical norm, prompted by worldwide food security problems (Waarts et al. 2011). The Ladder begins with the 'prevention' stage (avoiding food waste), where optimum use is food. The rest of the stages are

- 'use for human food' (for example food banks, Salvation Army);
- 'conversion to human food' (processing and reprocessing);
- 'use in animal feed';
- 'raw materials for industry' (biobased economy);
- 'processing to make fertiliser for cofermentation' (and energy generation);
- 'processing to make fertiliser through composting';
- 'use for sustainable energy' (objective is energy generation);
- 'burning as waste' (objective is destruction, with associated possibility of energy generation);
- 'dumping'

(Waarts et al. 2011).

The EC study on the "evolution of (bio-) waste generation/prevention and (bio-) waste prevention indicators" (Reisinger et al. 2011) compiled a list of recommended measures for the EU-action plan for food waste prevention, which includes but is not limited to:

- The setting of EU food waste reporting requirements (food waste generation, food waste in household waste);
- The setting of information/labelling requirements on resource efficiency and hazardous substance concentration of food (taking into account the potential of mobile and internet technology based information dissemination);
- The dissemination of best practice on more efficient food production and use of food, including logistical improvements (e.g. stock management improvements for retailers, reservation requirements for cafeterias, ordering flexibility in hospitals);
- The responsibility of waste prevention concepts and train planners to produce waste prevention concepts;
- Help organising networks on the redistribution of food;
- The clarification of standards (e.g. for setting "use by" and "best before" dates) by taking into consideration food safety;
- Awareness/information/motivation campaigns on food waste prevention;
- The tools and training for more efficient consumption (residual food cook books, shopping list and etc.)

(Reisinger et al. 2011).

At the European level, a list of necessary measures is stated in the resolution of the European Parliament. The document, amongst other things, calls as a matter of urgency the problem of food waste along the entire supply and consumption chain to be addressed, and to devise guidelines for and support ways of improving the efficiency of the food supply chain sector by sector, as well as to analyse the causes and effects of the disposal, wastage and landfilling, and associated economic, environmental, nutritional and social impacts. It asks to take practical measures towards halving food waste by 2025 and create specific food waste prevention targets for the Member States, as a part of the waste prevention targets to be reached by Member States by 2014 (European Parliament Resolution (2011/2175 (INI)) 2012). However in 2011 in the communication to the European Parliament "Roadmap to a Resource Efficient Europe" the Commission has set out the same target of a 50 % reduction of the disposal of food waste by the year 2020 (European Commission 2011). The communication has also pointed out that the wide-spreading of incentives to healthier and more sustainable food production and consumption would lead to a 20 % reduction in the food chain's resource inputs (European Commission 2011).

In order to support policymakers in developing National Waste Prevention Programmes (as well as waste management organisations, businesses, institutions, local authorities and environmental protection agencies and other actors dealing with food waste) the European Commission has prepared specific guidelines to address food waste. The "guidelines on the preparation of food waste prevention programmes," provides a general approach to food waste prevention, guidelines for developing a food waste prevention programme and addresses such key sectors as local authorities, households, the hospitality industry, the retail supply chain, businesses and institutions (such as schools and hospitals) (BIO Intelligence Service, Umweltbundesamt and Arcadis 2011).

In addition, the problem of food waste partly or entirely is covered in the following legal document: the Thematic Strategy on the Prevention and Recycling of Waste, the Landfill and Revised Waste Framework Directives, the Integrated Pollution Prevention and Control Directive, Incineration Directive, Nitrate Directive and EU Policy for Renewable Energy, Regulation on Animal By-Products, which constitutes the cornerstone of European legislation on food safety (Bakas and Herczeg 2010; Arcadis 2010).

It is important at this point to highlight that in the EU food waste is perceived as bio-waste and therefore all measures are applied from this perspective.

The most recent document "A Communication on Sustainable Food," is planned to be adopted by the EU in 2013 (EU-FUSIONS 2012).

Nevertheless, despite steps that have been taken, there is still a gap in data and information regarding the state of the problem of food waste in the MS. Moreover, a number of systematic investigations across the Europe regarding causes of food waste and ways of its reduction are very small. The most significant studies have been undertaken on behalf of the UK body, the Waste and Resources Action

Programme (WRAP) (Arcadis 2010) and by BIO Intelligence Service the 'Preparatory study on food waste across EU 27' (BIO Intelligence Service 2010).

Thereby, summing up the aforementioned points the following conclusions can be drawn:

- There is no single definition of the term 'food waste' as well as no clear classification and differentiation between what can be or cannot be considered as food waste.
- On a European level, there is some recognition of the problem of food waste and an acknowledged necessity to take measures to address it.
- One of the first steps is to reduce an existing gap in data and information about the state of the problem of food waste in the European countries.
- Currently, the number of conducted studies regarding volumes of food thrown away, its types, causes and applied methods of food waste reduction is very limited.

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