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Mihai, Florin-Constantin

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# Electronic waste management in Romania: pathways for sustainable practices (Preprint version )

**Florin-Constantin MIHAI\***, Department of Research, Faculty of Geography and Geology, Alexandru Ion Cuza University of Iasi, Romania,

\*Corresponding author: email: [mihai.florinconstantin@gmail.com](mailto:mihai.florinconstantin@gmail.com)

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Abstract

This chapter aims to examine the current challenges in electronic waste (e-waste) management in a new EU Member State like Romania. The chapter analyses the route from unsound disposal practices (e.g. illegal dumping) towards sustainable practices of e-waste under EU targets and objectives. This e-waste stream is toxic for the environment and public health, thus, proper collection, treatment, and recycling facilities are required. The waste management infrastructure must be completed by a comprehensive e-waste statistic database, reliable monitoring, and law enforcement activities. The chapter reveals the current gaps in e-waste management activities in Romania while highlighting the best practices in this sector. The chapter identifies the specific pathways for sustainable practices associated with electronic waste management. The role of different actors involved in e-waste flows is examined such as public institutions, private sector, NGOs or local community. This emerging e-waste stream has a high recycling and recovery potential which could further support a circular economy in Romania.

Keywords: electronic waste, e-waste, waste management; recycling; recovery; circular economy;

## 1 Introduction

Electronic waste (e-waste) or waste electrical and electronic equipment (WEEE) is an emerging waste stream which poses serious challenges in sustainable waste management practices for both developed and developing countries while consumer of electronic goods is expected to increase in following years. At the global level, there are huge disparities in e-waste generation rates and e-waste management activities while specific e-waste legislation is still missing in several countries (Mihai et al., 2019).

The Countering WEEE Illegal Trade (CWIT) project found that in Europe, only 35% (3.3 million tons) of all the e-waste discarded in 2012 are covered by collection reporting systems while the other 65% (6.15 million tons) was either: exported (1.5 million tons), recycled under non-compliant conditions in Europe (3.15 million tons), scavenged for valuable parts (750,000 tons) or simply thrown in waste bins (750,000 tons) as shown by Huisman et al. (2015). These findings point out some serious gaps in e-waste management activities among EU countries. Former Soviet countries try to reduce such gaps by transposing EU legislation and to develop better treatment activities supported by improved e-waste collection schemes.

This chapter aims to examine such challenges in case of a new EU Member State like Romania, where some progress is made in the right direction. The chapter points out the route from unsound e-waste disposal activities (e.g. illegal dumping or landfill of e-waste) towards the sustainable collection, treatment, and recycling practices among various stakeholders (EEE producers, waste operators, recycling companies, public institutions, and local authorities, civil society). The best e-waste management practices are outlined in the chapter. To make an easier transition towards a circular economy in Romania such activities must be further supported.

## 2. E-waste disposal activities

### 2.1 Illegal dumping of the e-waste stream

Smaller urban areas and rural communities are still exposed to illegal dumping activities associated with the lack of proper waste management facilities. In the latter case, the rural population still lacks waste collection services, therefore, the e-waste stream generated by rural population is susceptible to illegal dumping practices. However, poorer socioeconomic conditions increase the lifespan of electronic products and there is a low purchasing power compared to larger urban areas which reduce the magnitude of this practice. Wild dumps and open burning activities were the main waste disposal options across rural communities prior to 2010. Frequently, each village from commune to town had an open dump to dispose of the household wastes (Orlescu and Costescu, 2013). E-waste stream contains toxic pollutants (e.g. heavy metals) contaminating the soil and water bodies. The closure of rural dumpsites was performed by local authorities and supervised by the National Environmental Guard. These actions comply with the obligations assumed by the EU Landfill Directive transposed by Government Decision no 345/2005 regarding the landfill of waste. These actions obliged rural municipalities to seek solutions for waste collection services and transport the wastes to urban landfill sites. The delays in the implementation of regional integrated waste management systems cause gaps in the current waste collection schemes favoring illegal waste disposal practices around urban and rural areas (Mihai, 2018). Despite the closure of wild dumps and expansions of waste operators coverage areas the collection efficiency is not 100, particularly in less developed areas, thus, there is an uncollected waste flow (including e-waste fraction) which is dispersed on the surroundings or burnt. Also, individuals focus to recover valuable items from electronic scraps and the rest of the items are prone to littering behavior.

In 2015, every Romanian (urban area) has in average 72 kg of EEE of which 7,35 kg became e-waste which is further managed as follows: 30 % is collected by formal e-waste activities, 21 % reused by friends/family and 49 % are improperly managed via informal sector, municipal bins or illegal dumping practices (Ecotic, 2015). These findings confirm that illegal dumping is a possible route for e-waste flow uncollected by the formal sector. This situation could be worse in rural areas where waste management facilities are scarcely seen. Best practices should be promoted and supported by awareness campaigns.

These are necessary steps to combat illegal dumping practices or bad situations where individuals keep the e-waste in their households in unsafe conditions and are not motivated to take such wastes to collection centers (Recycling4Regions, 2014).

## 2.2. Open burning of the e-waste stream

Open burning of e-waste release harmful pollutants in the air threatening the public health, particularly in transition and developing countries with a less developed waste management infrastructure (Mihai and Gnoni, 2016). In Romania, this bad practice sporadically occurs in rural areas without access to proper waste collection schemes. The rural population is still unaware of public health risks associated with open burning activities of this e-waste stream. The burning process of household waste is performed in open piles which could contain electronic items beside agricultural waste fraction. There are some recommendations of the Inspectorate for Emergency Situation regarding the burning of agricultural and organic fraction of MSW stream in special conditions as seasonal cleaning activities (mainly in spring and autumn). Burning of hazardous items (such as e-waste, batteries, spray) is forbidden and a special permit from the local council is required for each individual in the case of open-fire activities. Better law enforcement is needed to eradicate such bad practices among inhabitants.

## 2.3 Landfill of the e-waste stream

Prior to EU accession e-waste stream was regarded mainly as part of the municipal solid waste flow (including bulky items) managed by public or private waste operators as residual waste.

The mixed municipal waste collection prevailed through collection points or “door to door” schemes, including e-waste fraction of private households or commerce sector. The presence of e-waste stream in urban landfills increases the in-situ and/or nearby pollution risks through the leachate contaminants or direct contact with soil.

In Europe, around 750,000 tons of mainly small appliances end up in the waste bin, with varying amounts per country of between 1 and 2 kg per inhabitant per year, while waste management systems are still landfill-based (Huisman et al., 2015).

In the last two decades, most of the urban landfills were non-compliant with EU regulations and such sites should be closed until 2017.

However, the delays in building and operating activities of the new regional sanitary landfill sites (supported by EU funds) lead to temporary dumpsites where mixed municipal waste is disposed of, including e-waste streams which are not source-separated by population or economic agents, thus, these are discharged either on dumps or in mixed residual waste bins or containers. The e-waste represents around 5-6 % of the total amount of waste in a community and Romania household has EEE products older than 5 years (Region4recycling, 2014). Landfill of e-waste is often used in Romania while recycling work is done in small plants based on manual dismantling (Ciocoiu et al., 2016). The correct source-separated of dry recyclables and special waste streams (such as e-waste, oils, batteries, construction and demolition waste, tires, etc.) are key challenges to avoid contamination of residual wastes with hazardous items which are further sent to landfill sites. Low amounts of e-waste were found in WEEE in household waste composition in Cluj-Napoca city as a result of separate collection scheme and e-waste collection campaigns since 2011 (Pop et al., 2015). Environmental awareness of citizens is crucial in this regard and further campaigns must be implemented in both urban and rural areas.

### 3. E-waste collection practices

#### 3.1 EU collection targets

Source separate collection and special treatment activities are required in the EU, which updated new legislation dedicated to this waste fraction such as *Directive 2012/19/EU* which entered into force on 13 August 2012 and it had to be transposed into national law of Member States by 14 February 2014. The old Directive 2002/96/CE imposed the EU Member States a per capita collection target of 4 kg per capita year valid for 2012-2015. This flat collection rate was difficult to be achieved in a country like Romania with limited e-waste management infrastructure, particularly in towns and rural areas combined with lower purchasing power at EU level and greater lifespan of electronic goods in less developed regions.

Thus, Romania reported a value of around 1.5 kg of e-waste per capita per year (taking into consideration private households and other sectors) which is the lowest among EU countries (UNU-IAS, 2015). In fact, the total amount of e-waste collected in Romania during 2006-2010 is 4.3 kg.per.capita of which 2.7 recycled or recovered (Popescu, 2015). Cyprus, Croatia, Estonia, Italy, Latvia, Malta, Poland, Romania, and Slovakia did not achieve this collection target in 2014 (Kling et al., 2017). The new Directive changes this approach based on a flat per-capita basis towards economic market conditions associated with EEE products. This new requirement is to collect 45 % of the total amount of EEE put on the market (as an average of the last 3 years) starting from 2016 and increasing to 65% in 2019 or to collect 85% of the total e-waste generated. There are countries which already fulfilled the new targets for 2016 in 2014 such as Austria, Bulgaria, Denmark, Hungary, Ireland, Lithuania, the Netherlands, Portugal, and Sweden (Kling et al., 2017). Romania, as other new EU countries, has the possibility to apply for a derogation for these new collection targets.

In 2014, e-waste collection rate is only 24% of EEE put on the Romanian market supported mainly by retailers while municipalities do not provide adequate collection schemes (Kling et al., 2017). There is a proposal to collect the equivalent amount of 40 % EEE introduced on the market during 2016-2010 then this rate will increase to 65% in 2021 or collect 85% of the total e-waste generated (as an average of the last 3 years) according to UNU-IAS (2015). The main contributors are industry sectors (EEE producers) and consumers (private households, offices, public institutions, shops, hotels, etc ) which feeds this e-waste flow. The table 1 shows the amounts of EEE put on market and e-waste collected breakdown per each major category as follows: 1-Large household appliances; 2-Small household appliances; 3-IT&C equipment; 4-Consumer equipment; 5-Lighting equipment; 6-Electrical and electronic tools; 7-Toys, leisure and sport equipment; 8-Medical devices; 9-Monitoring and control instruments 10 -Automatic dispensers

Table1.Amounts of EEE put on the market (t) compared to WEEE collected (t) per each category

Category	EEE_ 2008	WEEE_ 2008	EEE_ 2011	WEEE_ 2011	EEE_ 2014	WEEE_ 2014
1	161964.55	8923.68	69456.21	9987.33	84995.17	20465.24
2	18080.61	735.82	14422.82	673.18	10466.12	1021.16
3	19715.01	6252.69	14349.97	5446.3	13400.46	4803.3
4	22659.92	5175.38	13348.15	3199.49	14832.53	3513.27
5	3926.90	206.20	5747.56	291.95	5350.9	1140.05
6	9918.45	321.83	6728.90	743.07	7727.25	815.37
7	466.23	32.80	744.09	94.57	999.47	65.6
8	5605.49	16.49	472.57	20.51	394.51	34.07
9	934.14	39.66	2981.97	464.17	938.16	236.42
10	457.48	13.85	261.21	87.69	482.54	64.51
<b>Total</b>	<b>243728.78</b>	<b>21718.40</b>	<b>128513.45</b>	<b>21008.26</b>	<b>139587.1</b>	<b>32158.99</b>

Data source: National Environmental Protection Agency (NEPA, 2017)

In 2008, the largest amount of EEE was put on the market (before the economic crisis) compared with 2011 with a slight increase in 2014. On the opposite side, the amount of e-waste collected is largest in 2014 (after the economic crisis) due to improvements made in e-waste collection schemes. However, there are huge differences between amounts of EEE put on the market and WEEE collected and registered in official statistics.

The collection targets assumed by Romania could not be achieved because of several factors: the greater lifespan of EEE products, low purchasing power (particularly in rural areas), insufficient e-waste collection points, large informal sector, landfill of e-waste, poor awareness of citizens related to e-waste management issues and improper monitoring activities.

The category 1 or large household appliances (e.g. refrigerators, washing machines) are the largest flow both EEE and WEEE during 2008 and 2014. Other key categories are small household appliances (category 2) and IT&C equipment (category 3). The total amount of e-waste collected is almost the same for 2008 and 2011 (around 21 000 t) but much lower in comparison with 2014 (32158 t).

In fact, there are some e-waste categories with a strong increase compared to previous years such as large household appliances (category 1) and lighting equipment (category 5) as shown in table 1. A decreased level in 2014 compared to 2011 is specific to categories 3, 7, 9 and 10. In such cases, more efforts need to be made to increase collection rates to fulfill the overall EU targets. The chapter further examines the e-waste collection challenges in urban and rural areas.

### 3.2 E-waste collection in urban areas

Collection centers are required in each large urban area for each 50 000 inhabitants and local authorities need to organize in each year e-waste collection events. Unfortunately, such collection points cover only 10% of the urban population and these are almost not existing in rural areas (Kling et al., 2017). Retailer's e-waste collection points play an additional key role in formal e-waste management sector in urban areas.

"Buy-back" practices represent around 30 % of the total e-waste sales in Romania, but some retailers have the tendency to use such initiative for marketing purpose offering good rates only for the electronic goods which are not well sold (Regions4Recycling, 2014). There are over 2,000 collection points in commercial networks in Romania, with adequate infrastructure for weekly or monthly collection (Pacesila et al., 2016). However, the necessary of municipal e-waste collection points are less than the number of authorized collectors in most of the Romanian counties (Ciocoiu et al., 2016).

Figure 2 depicts the discarded patterns of e-waste flow in Romania considering a total e-waste generation of 7.35 kg per person where retailers and municipal collection points catch only 20 % of e-waste flows (Magalini, 2017). This figure points out the role of life extension and bad habits (e.g. mixed with household waste ) as key factors for a limited performance of separate e-waste collection schemes.

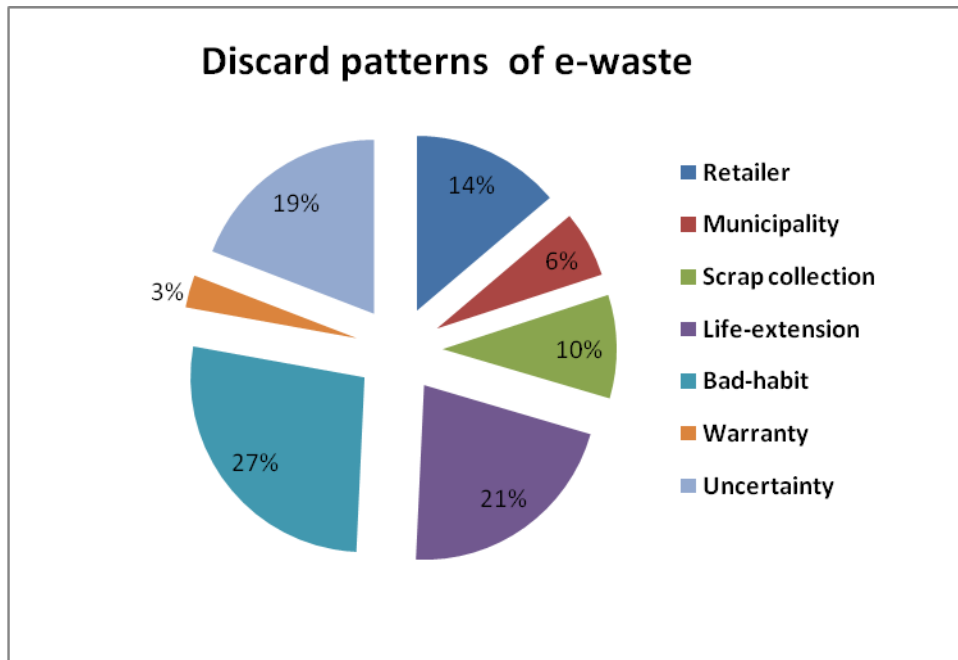


Figure 1 Discard patterns of e-waste in Romania (data source: F. Magalini, 2017 )

### 3.3 E-waste collection in rural areas

Prior to EU accession, the household e-waste stream was associated with municipal waste which (in most cases) had been mixed collected by a waste operator and sent to an urban landfill site without any pre-treatment activities. The e-waste diversion from wild dumps or open burning activities is related to the development stage of municipal waste collection schemes across rural communities. There are some collection campaigns dedicated to e-waste or obsolete electronic products in rural areas, but with poorer results in terms of per-capita collection rates. Romania is facing a prolonged life of large appliances 13–17 years (even 50-year-old appliances in some rural households) compared to Europe (8–10 years) which makes more difficult to achieve collection targets (Torretta et al., 2013). However, the benefits of such initiatives were noticed in Buzau county where 20 tons e-waste were collected across Patarlage and Pogoanele towns and Berca, Maracineni, Sapoca, Vadu Pasii, Valea Ramnicului, Cochirleanca and Zarnesti communes in 2009 (Ecotic, 2009). Some informal collectors could operate in peri-urban areas in searching for scrap electronics. In 2010, Ecotic organization expanded awareness campaigns for e-waste collection in rural communities from Salaj, Vrancea, Bacau, Iasi, Ialomita, Valcea, Dambovita, and Cluj which cover over 500 communes (Ecotic, 2010). This campaign proposes an exchange a sack of wood briquettes for 10 kg e-waste resulting 60 t of total e-waste collected during this event. Rural areas are the most exposed to open dumping or even open burning activities until the new integrated regional waste management systems (at each county level) will be fully operational.



### 3.4 Informal sector and illegal e-waste trade

Scrap metals are the most valued items among informal urban street collectors in Romania. Large e-waste appliances and electric tools rich in metals are susceptible to be managed by individuals who sell such scrap items to recycling companies. Frequently, the e-wastes are mixed with scrap metals which are further improperly treated and few e-waste items are sent from scrap recycling sites to proper e-waste treatment facilities (UNU-IAS, 2015). In this context, a certain fraction of e-waste treated is out of official statistics and included in the scrap metal stream (NWMP, 2017). The role of the informal sector in the collection process of scrap metals (including e-waste fraction) could be significant in the context of improper local municipal waste management systems and the lack of reliable e-waste collection schemes. Frequently, people go from house to house and collect WEEE and other recyclables before these waste fractions enter into the formal waste management system (Tartiu, 2011). In fact, industry stakeholders claim a high informal collection sector and competitive disadvantages for certified treatment facilities due to substandard informal e-waste treatment (Kling et al., 2017). Few EU Member States have implemented conclusive reporting and monitoring of de-pollution and up-to-standard treatment conditions and knowledge gap in e-waste flows is one of the largest in Romania around 60 % (Huisman et al., 2015).

However, there are no data about illegal e-waste trade in Romania, but such knowledge gap could be explained by the poor reporting systems and the unknown impact level of the informal sector on e-waste flows at local, regional and national levels.

## 4. E-waste recycling and recovery practices

In Romania, the amount of WEEE available for proper collection and treatment activities is around 20 % (70 kt) compared to total e-waste resulted from households in 2015 (UNU-IAS, 2015). The same study reveals that around 22 % of e-waste is reused by extending the lifespan of electronic goods from holders to relatives, friends or other individuals. This fact could explain the low collection rate of e-waste fraction across Romanian regions. However, the new National Waste Management Plan (NWMP) stipulates that total treatment capacity in Romania is around 120 000 t/yr which should be sufficient in the following years. Despite this fact, e-waste collected is assumed to be properly treated only by some facilities (Kling et al., 2017). The main issue is to feed such treatment facilities by improved e-waste collection schemes. The average rate for recycling/preparation for re-use of e-waste was relatively high in all the Member States, ranging from 76% to 96% and Romania is on top 10 countries besides Croatia, Finland, Hungary, Italy, Latvia, Luxembourg, Poland, Slovakia (Kling et al., 2017). This situation is also supported by table 1 where national targets are fulfilled during 2008-2014 breakdown by the main 10 e-waste categories. The only exception is the year 2008 in the case of category 5 where the valorization rate is under 80 % threshold, 63 % respectively.

Table 2 E-waste valorization rate in Romania

E-waste category	Recycling and reuse target	2008	2009	2010	2011	2012	2013	2014
1	80	84	93	93	91	89	93	93
2	70	76	84	84	89	88	89	88
3	75	77	84	86	86	86	85	87
4	75	88	86	89	87	87	88	88
5	80	63	84	88	85	84	92	93
6	70	75	85	87	90	89	88	91
7	70	68	71	73	84	83	84	84
8	NA	NA	NA	NA	NA	NA	NA	NA
9	70	77	85	85	86	86	86	88
10	80	89	90	91	91	90	92	92

Data source: National Environmental Protection Agency NA= not available

1-Large household appliances; 2- Small household appliances; 3-IT&C equipment; 4-Consumer equipment; 5-Lighting equipment; 6- Electrical and electronic tools; 7-Toys, leisure, and sports equipment; 8-Medical devices; 9- Monitoring and control instruments 10 - Automatic dispensers

These data are based on reports submitted by e-waste collection and treatment facilities. Their reliability is questionable compared to e-waste flows in Romania since the e-waste collection schemes are insufficiently developed across Romanian counties and the informal sector is considered to be widespread. Informal recycling is the result of interactions between economic incentives legislative gaps, industrial interdependence, and socio-economic conditions (Ciocoiu et al., 2011). Overall, waste statistics data rely on the one hand, to waste operators honesty and on the other hand, depend on volumetric estimations due to the improper weighing systems.

## 5. Pathways for sustainable practices related to e-waste management activities in Romania

Figure 2 highlights the main steps for a reliable transition towards a sustainable e-waste management system in Romania under the circular economy approach promoted by the EU. The left side points out the need to reduce the unsound e-waste disposal practices as previously discussed in subchapter 2 and to provide better statistics and improved monitoring activities under environmental authorities supervision. E-waste management infrastructure needs to be further developed involving all key actors such as EEE producers, municipalities, and environmental NGOs with particular focus to e-waste collection schemes including smaller urban areas and rural communities.

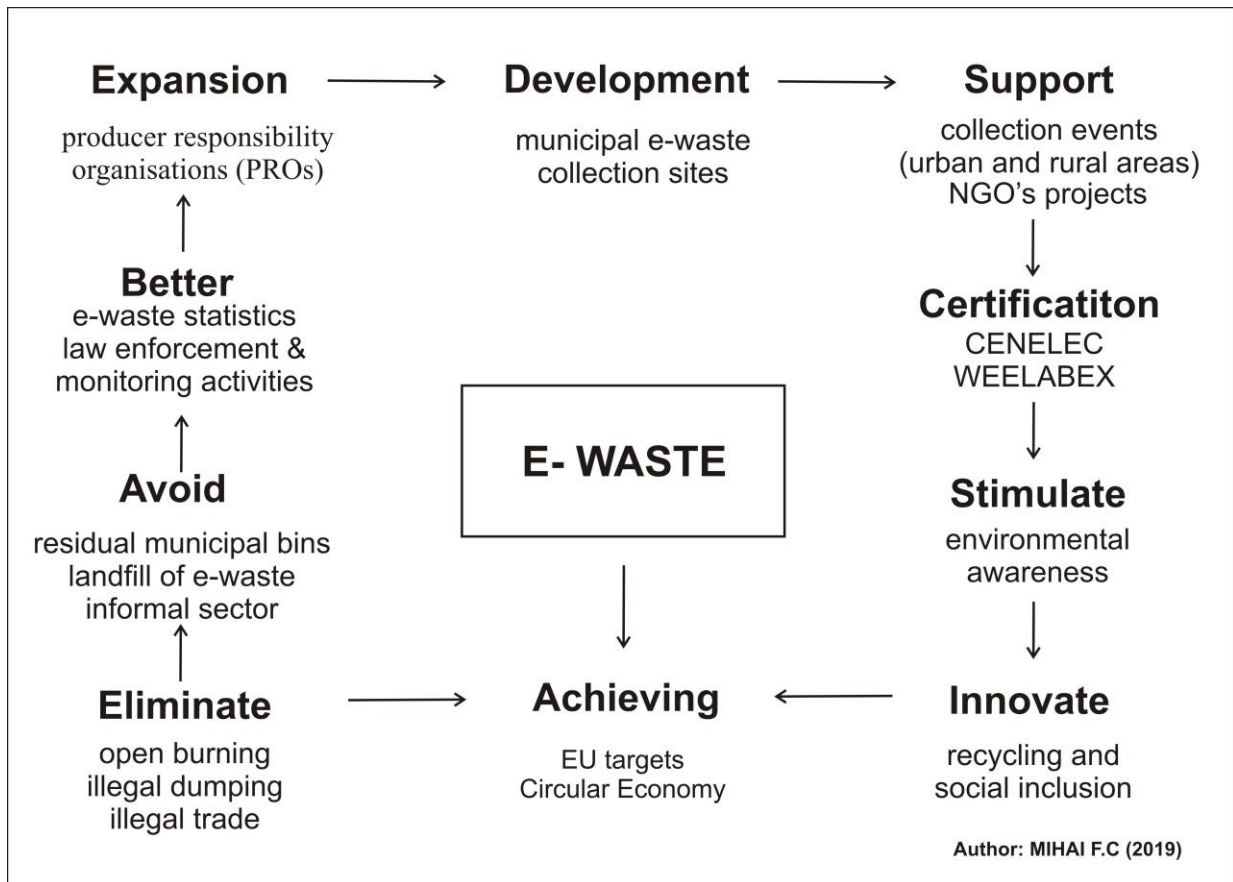


Figure 2. Pathways for sustainable e-waste management practices in Romania

The right side supports the current best e-waste management practices in Romania which are further examined in this section. Best European standards should be applied in treatment activities related to e-waste fraction by recycling companies. E-collection events and information campaigns about e-waste management challenges need to be further expanded (schools, mass media, social networks, local authorities) to stimulate environmental awareness of citizens. Furthermore, good cooperation between stakeholders can lead to innovative projects which promote both social inclusion and suitable e-waste recycling activities. Achieving EU targets related to e-waste management sector is possible by combining these both sides as pathways for sustainable practices in Romania.

### 5.1. Monitoring the EEE flows placed on the national market and improved e-waste statistical data

Any company that manufactures/imports electrical or electronic equipment is required to register with the National Environmental Protection Agency and to participate, through a collective or individual system, in the financing of WEEE management as stipulated by national regulation (GEO 5/2015). Romania is obliged to report on the achievement of the targets for e-waste collection, re-use, recycling and/or recovery on the basis of Commission Decision 2005/369/EC.

A common methodology for the calculation of the quantity of e-waste generated in each Member State and the weight of EEE placed on the national market is provided by EU (on the basis of the Commission Implementing Regulation 2017/699) are found at [http://ec.europa.eu/environment/waste/weee/data\\_en.htm](http://ec.europa.eu/environment/waste/weee/data_en.htm). The key issue is providing reliable data at national and regional (county) levels combined with e-waste statistics data for urban areas and rural communities if possible. Diverse geographical coverage of statistical data will enable a pertinent analysis of e-waste flows in Romania.

## 5.2 Better inspection and monitoring of e-waste management activities

In Belgium, Estonia, and Romania the inspection plan does not cover the entire territory or does not include both collection and treatment and in five Member States (Cyprus, Greece, Italy, Romania, Slovenia) no information was available about the existence of effective, proportionate and dissuasive penalties (Kling et al., 2017). In Romania, the National Environmental Guard supervises the implementation of waste related legislation by business sector and monitor the illegal practices throughout the County Commissariats. At the local level, illegal activities associated with unsound e-waste disposal activities (illegal dumping, open burning) could be supervised by local police. The responsibilities and obligations derived from environmental legislation are generally not known and individuals interests in improving e-waste management practices must be further stimulated (Regions4Recycling, 2014). Also, significant amounts of e-waste are lost in scrap collection or treatment activities due to the poor enforcement of legislation (Kling et al., 2017). Therefore, better inspection and control of collection and treatment activities are required to improve the current situation.

## 5.3 Expansion of ‘producer responsibility organizations’ (PROs)

The WEEE Forum ([www.weee-forum.org](http://www.weee-forum.org)) is a European not-for-profit association representing 32 electrical and electronic equipment waste (WEEE) producer compliance schemes – (alternatively referred to as ‘producer responsibility organizations’ PROs) including from Romania via Ecotic, Environ, and Rorec organizations. In 2014, its member organizations reported collection, proper de-pollution, and recycling of more than 1.7 million tons of e-waste (Huisman et al., 2015). In Romania, there are 8 authorized PRO’s by the Ministry of Environment which play a key role in e-waste collection and treatment activities across Romania.

(i).Ecotic – is the first Romanian ‘producer responsibility organization’ related to e-waste management (founded in 2006) covers the interests of over 600 EEE producers and importers (<https://www.ecotic.ro/despre-noi/>). This organization introduced the “Green Stamp” (2007) which later became remuneration to cover the cost of WEEE collection, re-use, recycling, recovery and disposal, and consumer awareness costs based on a fee in the sale of EEE products. These activities need to be funded by EEE producers, according to national legislation (art 28-32 of GEO 5/2015). The amounts of e-waste have increased since 2013, from 8978 tons to 23 390 tons in 2018 (of which 1300 tons of hazardous compounds were extracted from e-waste) according to their last activity report (Ecotic, 2018). The same report points out that the main

contributors in e-waste collection flow supervised by this organization are retailers/shops (49%) and e-waste operators (43%) compared to public authorities/sanitation operators (1 %). Washing machines (35.1%) and refrigerators (29.6 %) are dominant categories of e-waste collected followed by IT&C (12.9 %) and TV& monitors (11.5 %) as revealed by the Ecotic report (2018).

(ii) Recolamp – a non-profit organization which supports the collection and recycling activities of e-waste derived from the used lighting equipment (category 5) in Romania since 2007 (<https://recolamp.ro/>). This association is a member of Eucolight, the European network of organizations engaged in e-waste management activities associated with lighting equipment, promoting the principles of the circular economy. Recolamp has over 13 000 collection points varying from companies, retail networks to local authorities and institutions.

Recolamp collected 946.97 tons of lighting equipment e-waste (48.57 % of producers sales in the last 3 years) in 2017 and 3650 tons during 10 years of activity in this sector (Recolamp, 2017). Individuals could consult a list of locations for each county/city where the used lighting equipment can be collected in a safe manner (<https://recolamp.ro/locatii-colt-verde/>).

(iii). Environ - is a member of WEEE Forum which manages legal responsibilities associated with the e-waste fraction for over 600 EEE producers and importers. This non-profit organization supervises 4000 e-waste collection points (companies, retailers, supermarkets, schools, local authorities, and other institutions). The 10 years activity report of this organization points out some key figures: 50000 t of e-waste collected (average 25 t per day); served over 700 companies and performed over 100 awareness and collection events; ecological education activities in 1100 schools (Environ, 2017).

(iv) EcoPoint aims to the development of an e-waste collection system that allows selective storage e-waste items generated by households. Thus, special recipients were placed in proximity areas of end-users - networks of shops, educational institutions, administrative institutions, commercial companies with specific activities, housing assemblies (<https://eco-point.ro/>)

(v) RoRec association initiate the campaign “ Recycling Patrol” a widespread national education program in schools (90000 preschooler children, pupils, students, 3000 teachers) collecting 2500 t of e-waste (<https://www.rorec.ro/despre-noi/realizari/>)

Eco-one and Ecolighting collect are another 2 non-profits organizations besides CCR LOGISTICS SYSTEMS RO S.R.L. (company) involved in e-waste management activities as licensed PRO's.

#### 5.4 Municipal source-separated e-waste collection points

Cities should be more responsible in providing separate waste collection centers where household e-waste flow could be brought by inhabitants, otherwise, the collection targets of this waste fraction will not be achieved only based on retailers and producer responsibility organizations efforts. There is some pilot project in this direction which must be further expanded in other cities and towns. Piatra Neamt city has two civic amenity sites (CAS) located in two districts (Darmanesti and Maratei) as part of an integrated municipal waste management system funded by the ISPA program. These sites offer a proper collection infrastructure for diverse items of household waste including e-waste, oils, batteries, construction and demolition wastes, furniture and other bulky items, etc.

Ecoviron association implemented in 2011 the project “Ecorampa” a separate waste collection center, which is exclusively powered by an alternate energy source in Bucharest city (Sector 1). The ten waste streams that can be collected at this center are: paper and cardboard, plastic, white glass, colored glass, ferrous and non-ferrous metals, tires, e-waste, bulbs, and lamps, used batteries and textiles (Ecoviron, 2011). Iasi city has a modern facility (since March 2016) for separate collection items resulted in households (small and bulk e-waste fractions, lamps, batteries, metals) as shown in figure 3 with a diverse range of other waste types (garden waste, construction and demolition waste, papers and cardboard, plastics, glass, aluminium cans, textiles, oils, detergents, paints, adhesives ) free of charge for individuals. This facility was financed via Green Industry Innovation Programme (Norway Grants) with a partnership between Ecotic organization, City Hall and Salubris SA (public urban waste operator).

A particular focus is given to e-waste fraction as part of the project “Steps for WEEE” co-financed by Norway grants (covering 90% of costs) and implemented by Ecotic organization during 2015-2016.

This project provided 15 street e-waste collection points in Bucharest city (Sector 3) to increase the population responsibility for proposal disposal of smaller e-waste items (more info <https://www.ecotic.ro/proiecte/steps-for-weee-proiect-al-organizatiei-ecotic-cofinantat-de-norway-grants/>).

SIGUREC network - <https://www.sigurec.ro/> - this is a modern collection system using smart and easy to use automatic containers for dry recyclables and e-waste types (eg. batteries, light bulbs, neons) as well as a waste pick-up service from households for larger items





Figure 3. E-waste collection facilities within collection center of Iasi City

The recyclables are sorted, counted and weighed automatically and users receive a bounty depending on the types of waste and their quantities. The wastes collected are further sent to specific recycling companies. This system derived from a collaboration of various stakeholders such as private sectors (retailers, Green Group, Econpaper, Romcarbon SA) Ministry of Environment, local authorities and recycling companies. Sigurec Prime is a smart collection station for recyclables (plastic bottles, plastic bags, paper and cardboard, polystyrene, another packaging) which include also the ESCALE machine for e-waste (lighting bulbs, batteries). Sigurec In - These are interior machines, which can be found in large retail outlets where some e-waste items could be also collected. SIGUREC systems collected 14 136.81 t of e-waste so far and these collection stations are available in several urban areas (<https://www.sigurec.ro/ro/locatii-sigurec>).

### 5.5. Support for special e-waste collection events and environmental awareness

Local authorities should be responsible to initiate or support several e-waste collection events in both smaller urban areas and rural communities due to the precarious current waste management facilities. These events increase the awareness towards separated e-waste collection behavior among individuals and on the other hand, to support e-waste diversion from municipal waste

bins (which ultimately are disposed of in landfills) and to combat illegal dumping practices. A survey shows that 42.29% of interviewed people responded that dispose of WEEE using the formal system, while 29.25% dispose of in the informal system so the formal system needs to be further expanded (Colesca et al., 2014).

The Ecotic organization launched in 2018 a new event named “Clean communes” dedicated for e-waste collection in rural areas. Thus, 23 tons of e-waste were collected across 36 communes in 9 collection events while 25 campaigns in urban areas collected 42 tons of e-waste associated with “Clean cities” program (Ecotic, 2018). The number of the educational and informing campaign has considerably grown in the latter years stimulating e-waste collection from households (Lates and Moica, 2016).

There is a web map of e-waste collection points in Romania (see <https://undereciclam.ro/map/?county=&city=AIUD>) for each county and the urban area where reliable information can be found by interested individuals or economic agents. Also, organizations like Ecotic developed applications for mobile phones (e.g. ECO RADAR) to know where are the closest e-waste collections are located (see <https://www.ecotic.ro/puncte-de-colectare/>) with national coverage. Such tools help individuals to take quick decisions where and when to dispose of their e-waste items.

## 5.6. Certified treatment facilities

The European Standardization Organizations defines European standards relevant for e-waste flow concerning the collection, transport and treatment activities which are listed at the following link: [http://ec.europa.eu/environment/waste/weee/standards\\_en.htm](http://ec.europa.eu/environment/waste/weee/standards_en.htm). The implementation of such standards will provide a homogenous set of sustainable practices related to e-waste management activities. A recent study at EU level suggests the adoption of such quality standards (WEEELABEX, European standards on WEEE collection, transport, and treatment) and strictly enforce the requirements for proper treatment as given by Article 8 and Annex VII of the WEEE Directive (Kling et al., 2017).

CENELEC is the European Committee for Electrotechnical Standardization and is responsible for standardization in the electrotechnical engineering field (<https://www.cenelec.eu>) which could help the EEE producers to provide suitable, resource-efficient, and environmentally friendly design products and sustainable e-waste treatment practices.

CENELEC or WEEELABEX standards are legally required in one form or another (Belgium, France, the Netherlands, Ireland, Slovenia) or implemented by agreements between producers and take-back systems as in Italy or Czech Republic (Cenelec, 2017). Despite the fact, there are no further legal requirements to ensure proper treatment in Romania some treatment facilities obtain additional quality standards such as WEEELABEX certification. In 2015, Remat Holding and GreenWEEE International were the first companies to obtain such standards in Romania (Ecotic, 2015).



GreenWEEE is a major player in the recycling sector of Romania which aims to recover all materials in e-wastes and finding solutions to their introduction into new production flows (<http://greenweee.ro/>). The WEELABEX excellence standard covers all e-waste handling, sorting, treatment, and recycling operations, including auditing all organizational and management processes. In February 2009, this company inaugurated the only recycling line in Romania designed to treat refrigeration appliances in line with international standards BATRRRT (Best Available Techniques of Recovery, Recycling, and Treatment) as well as recycling lines for IT equipment and small IT appliances (GreenWEEE, 2019). In ten years of activity, the company claims to recycle over 8 million items of e-waste (refrigerators, TVs, LCD, mobile phones etc) within 2 recycling plants (Buzau and Campia Turzii since 2017) which have the total treatment capacity of 100 000 e-waste per year with 400 employees and a business of over 20 million Euros in 2018 (GreenWEEE, 2019). This company is a member of the EERA (Electrical Equipment Representatives Association) and part of Green Group Romania.

Green Group Romania is the biggest integrated recycling park in South-Eastern Europe (<https://www.green-group.ro/en/>), integrating the operations of six companies specialized in the collection and recycling of waste while 2 two of them are dedicated to e-waste fractions such as GreenWEEE and GreenLamp Reciclare for recycling of used lighting equipment.

Green Lamp Reciclare SA claims to be the only recycler in Romania which is using an in-house distillation process in order to separate fluorescent tubes components and other discharge lamps such as high-intensity discharge lamps (HID). Greenlamp Reciclare can recover the mercury residuals from the phosphor powder by using the Superior Distiller, this facility has a WEELABEX certification (Greenlamp, 2019).

Remat Holding is authorized to collect and treat all 10 categories of e-waste and has several special treatment plants focusing on metal wastes. Shredder Plant is dedicated for end of life vehicles (ELVs) and large e-waste appliances with a capacity of 30-50 t per hour. Eden plant process aluminum and copper electric caldrons of all sizes of e-wastes (capacity 2-4 t per hour) with a crushing capacity up to 4mm, separation of ferrous, non-ferrous, and non-metallic fractions by shredding, magnetic separation and pneumatic transport (Remat Holding, 2019).

This company has a treatment and dismantling plant for monitors and TVs (ranging 8-40 inch) with a capacity of 30 pieces per hour and the materials resulted from dismantling activities of e-wastes are further recycled or disposed of (<http://rematholding.ro/colectare-si-valorificare-deseuri-reciclabile/#DEEE3>). This company has a widespread recycling activity including e-wastes, scrap metals (ferrous and non-ferrous), non-metallic wastes, batteries and accumulators and hazardous wastes.

## 5.7 Innovative approach for recycling and re-use of e-waste

Reconnect is a project made by “Asociatia Ateliere Fara Frontiere (AFF)” which aims to collect the e-waste and to turn into reconditioned IT equipment. These are further donated to the schools through the EDUCLICK computer donation platform. This association claims to collect 1010 t of e-waste of which 30 % were prepared for reuse and 70 % were processed for the material recycling purpose (AFF, 2019).

The innovative approach of this project is social inclusion through recycling and treatment e-waste activities of vulnerable and marginalized individuals (18 employed persons) combined with social and psychological support gaining the necessary competencies to make an easier transition towards labor market. This project shows social, economic and environmental benefits to the community building a success story towards sustainability. Poverty and marginalized communities are significant social issues in Romania which lead to an increasing rate of school dropout among the young. Throughout this project, 13,891 IT equipment has been refurbished and donated to over 2,000 schools and associations all over the country, serving 415,000 beneficiaries from disadvantaged communities in Romania. Also, this project helped to recycle 603 t of e-waste (AFF, 2019). This initiative points out the key role of environmental and social NGO's in promoting integrated and sustainable e-waste management activities with a positive impact on the community. Besides retailers, municipalities and recycling companies, such NGO's could further support recycling activities related to e-waste stream. Such projects could act as a catalyst to the improvement of current e-waste collection schemes in Romania neglected so far by municipalities and to increase the responsibility level of e-waste holders.

## Conclusions

The chapter points out the current challenges associated with disposal activities of e-waste stream (illegal dumping, open burning, landfill of e-waste) and collection schemes which need to be further developed across urban and rural areas. E-waste diversion from municipal bins and urban landfills towards recycling companies and treatment facilities should be a priority for central and local authorities besides EEE producers and importers. E-waste collection targets are difficult to achieve without a proper formal e-waste collection infrastructure with wide geographical coverage. There is a large informal sector in Romania, therefore, the real magnitude of e-waste flows in Romania is difficult to assess. The chapter points out several pathways for sustainable practices starting from better statistical data, better law enforcement, and monitoring activities; expansion of e-waste collection schemes via ‘producer responsibility organizations’ (PROs), retailers, and municipal e-waste collection centers; developing of e-waste collection campaigns in smaller urban areas and rural communities; certified treatment facilities; actions for stimulating environmental awareness among citizens and innovative projects among stakeholders. This chapter reveals the best practices in e-waste management sector from Romania and the role of non-profit organizations in such endeavors. Their efforts provide the necessary steps towards a circular economy approach of e-waste management activities.

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