Demonstrating resource efficiency through innovative, integrated waste recycling schemes for remote areas

PAVEtheWAySTE

LIFE14 ENV/GR/000722

Deliverable:

B.5.2.B: Report on the replication of the proposed innovative recycling systems in the follower remote municipalities – the case study of Spain

Prepared under

Actions B: Implementation actions

Executive Summary

The present report was prepared under the co-financed European LIFE-Environment project "Demonstrating resource efficiency through innovative, integrated waste recycling schemes for remote areas" with acronym «PAVEtheWAySTE». The deliverable B.5.2 “Report on the replication of the proposed innovative recycling systems in the follower remote municipalities’’ is part of Action B.5 of the project LIFE PAVEtheWAySTE, entitled: “Suggestions for full-scale implementation of the project - Replicability of the project in other European countries". It consists of two deliverables, the first (B.5.2.A) one concerns the municipalities of Zacharo and Andravida-Kyllini of P.E. Ilia, while the second one (B.5.2.B), which is the present deliverable, refers to the province of Valladolid in Spain.

The purpose of this project action is to provide suggestions for the full-scale implementation of the project and for its reproduction in other municipalities which have expressed their desire to replicate it, through a thorough analysis of the transferability and reproduction of the results of the project. The objective of sub-action B.5.2 ‘Report on the replication of the proposed innovative recycling systems in the follower remote municipalities’’ is to present the prospect of the project being replicated by the follower municipalities. The prospect of implementing the Green Kiosk at the province of Valladolid in Spain has been investigated in this deliverable. The studies, taking into account the specific features of each region, examined the degree of implementation of the systems from an environmental and socio-economic point of view, highlighting its significant contribution to optimizing the existing waste management systems.

Περίληψη

Η παρούσα τεχνική έκθεση συντάχθηκε στο πλαίσιο του συγχρηματοδοτούμενου Ευρωπαϊκού Έργου LIFE-Περιβάλλον "Επίδειξη της αποδοτικότητας των πόρων μέσω καινοτόμων, ολοκληρωμένων συστημάτων ανακύκλωσης απόβλητων για τις απομακρυσμένες περιοχές" με ακρωνύμιο «PAVEtheWAySTE» (Demonstrating resource efficiency through innovative, integrated waste recycling schemes for remote areas). Το παραδοτέο Β.5.2 «Μελέτη για την αναπαραγωγή του καινοτόμου συστήματος διαχείρισης των αποβλήτων σε άλλες ευρωπαϊκές απομακρυσμένες περιοχές» αποτελεί την παρουσίαση του αντικειμένου της Δράσης Β.5 του έργου με τίτλο «Προτάσεις για εφαρμογή του έργου σε πλήρη κλίμακα – αναπαραγωγή του έργου σε άλλες ευρωπαϊκές χώρες». Αποτελείται από δύο παραδοτέα, όπου το πρώτο (Β.5.2.Α), αφορά στους δήμους Ζαχάρως και Ανδραβίδας-Κυλλήνης της Π.Ε Ηλείας, ενώ το δεύτερο (Β.5.2.Β), το οποίο και συνιστά το παρόν παραδοτέο στην επαρχία Valladolid της Ισπανίας.

Σκοπός της δράσης αυτής του έργου είναι η παροχή προτάσεων για την εφαρμογή του έργου σε πλήρη κλίμακα αλλά και την αναπαραγωγή του σε άλλους δήμους που έχουν εκφράσει την επιθυμία να το ακολουθήσουν, μέσω ενδελεχούς ανάλυσης της δυνατότητας μεταφοράς και αναπαραγωγής των αποτελεσμάτων του έργου. Στόχος της υπο-δράσης Β.5.2 «Μελέτη για την αναπαραγωγή του καινοτόμου συστήματος διαχείρισης των αποβλήτων σε άλλες ευρωπαϊκές απομακρυσμένες περιοχές» είναι να παρουσιάσει την προοπτική αναπαραγωγής του έργου σε ακόλουθους δήμους. Στο παρόν παραδοτέο διερευνήθηκε η δυνατότητα εφαρμογής του Πράσινου Περιπτέρου στην επαρχία Valladolid της Ισπανίας. Οι μελέτες λαμβάνοντας υπόψη τις ιδιαιτερότητες κάθε περιοχής, εξέτασαν τον βαθμό εφαρμογής των συστημάτων από περιβαλλοντική και κοινωνικο-οικονομική σκοπιά, αναδεικνύοντας την σημαντική συνεισφορά του στην βελτιστοποίηση του υφιστάμενου συστήματος διαχείρισης αποβλήτων.

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Acknowledgements

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The report is also available on the project's website: http://pavethewayste.eu/

The project is implemented by the following partners:

Coordinator:

Municipality of Naxos and Small Cyclades - NAXOS

Partners:

Cartif Technology Center - CARTIF

National Technical University of Athens – NTUA

Municipality of Ancient Olympia - OLYMPIA

1. Introduction

Within the context of this deliverable, a replication case study regarding a region of Tierras de Medina (Castilla y León, Spain), where the prototype system (Green Kiosk) could be installed, integrated and operated as part of the existing waste management system, has been done, ultimately aiming to achieve an integrated solid waste management scheme in this remote area.

The scenarios considered in this replication case have been the following:

- **Baseline Scenario** which describes the current Municipal Solid Waste (MSW) Management system of this case of study.
- **Project Scenario** where three prototype systems have been installed and operate complementing the existing Municipality Solid Waste Management System.

Both scenarios have been developed and assessed for 1 year, considering the data available, with their comparison being held through techno-economic and environmental basis.

1.1. Waste management regulation description

One of the greatest problems facing any modern society is to reconcile its development with the appropriate maintenance of its environment; this involves responding to the impact on the environment of the waste generated by all its activities.

In recent years, specific policies have been promoted to make resource saving and environmental conservation compatible with the sustainable development of economic activity.

In other words, the aim is to achieve adequate resource management that reduces the generation of waste and allows economic activity to grow appropriately.

This requires specific actions that can only be achieved through proper planning. Waste policy has become one of the central components of any environmental policy, with implications for basic strategies such as the reduction of resource and energy consumption, the fight against climate change and renewable energies.

In order to facilitate the necessary implementation of all these guidelines, it is necessary to integrate them into a single text that brings together all the common actions for different types of waste and allows for coordinated and effective action between all the actors involved.

Thus, the Integral Waste Plan of Castilla y León (hereinafter PIRCyL), promoted by Regional Government of Castilla y León, includes in its determinations all the wastes that are generated or treated in Castilla y León region, as provided for in the basic legislation in force, Law 22/2011:

- **Domestic waste**: Waste generated in households as a result of domestic activities. Also considered as domestic waste are those similar to the above generated in services and industries, including those generated in households from electrical and electronic equipment, clothing, batteries, accumulators, furniture and household

goods, as well as rubble from minor construction work and home repairs, rubble from the cleaning of public roads, green areas, recreational areas, dead domestic animals and abandoned vehicles

- **Commercial waste**: Waste generated by wholesale and retail trade, catering services and bars, offices and markets, as well as the rest of the service sector.

- **Industrial waste (non-hazardous and hazardous):** Waste resulting from manufacturing, transformation, use, consumption, cleaning or maintenance processes generated by industrial activity, hazardous and non-hazardous.

- **Construction and demolition waste:** Waste generated in a construction or demolition site.

- **Other waste subject to specific legislation:**

- End-of-life vehicles, both those regulated and those not regulated by Royal Decree 1383/2002, of 20 December, on the management of end-of-life vehicles.
- Health care waste, subject to Decree 204/1994, of 15 September, on the management of health care waste in Castilla y León.
- Waste subject to the principle of extended producer responsibility, such as:
- Packaging and packaging waste according to the definition given by Law 11/1997, of 24 April, on Packaging and Packaging Waste.
- Batteries and accumulators, as defined by Royal Decree 106/2008, of 1 February, on batteries and accumulators and the environmental management of their waste.
- Waste electrical and electronic equipment regulated by Royal Decree 208/2005, of 25 February, on electrical and electronic equipment and the management of its waste.
- Used industrial oils as defined by Royal Decree 679/2006, of 2 June, which regulates the management of used industrial oils.
- End-of-life tyres regulated by Royal Decree 1619/2005, of 30 December, on the management of end-of-life tyres.

Therefore, the PIRCyL aims, through the development of coordination instruments foreseen with local entities, private companies and agents involved in waste management, to establish a strategic and operational framework for action in Castilla y León in the field of waste prevention and management, which complies with the following premises:

- To comply with the current legal framework and achieve the ecological objectives established in the field of waste.
- To achieve the collaboration of all parties involved in the production, consumption, generation and treatment of waste.
- To achieve the integration of the following complementary lines of action: prevention, management and economic development.

1.2. Territorial organization

With regard to the territorial organisation of the Community of Castilla y León, it covers a vast area of 94,225 km^2, in which, according to the INE (2020), it had 2,394,918 inhabitants, offering a low population density (25.5 inhabitants/km^2), the lowest in Spain, distributed over an area almost three times that of European countries such as the Netherlands and Belgium. It is also characterised by an unbalanced population model, with great contrasts between a rural environment, where small municipalities predominate, and a high concentration of the population in the provincial capitals and their metropolitan areas.

Population and demographic references aside, when analysing the Territorial Organisation of this Community, from the point of view of political, administrative and territorial organisation, it cannot be ignored the fact that Castilla y León has 2,248 municipalities (97.46% of which have a population of less than 5,000 inhabitants). Moreover, other administrative figures in Castilla y León are 239 "*mancomunidades*" (voluntary groupings of municipalities for the joint management of certain services of municipal competence, hereinafter associations), see Figure 1.

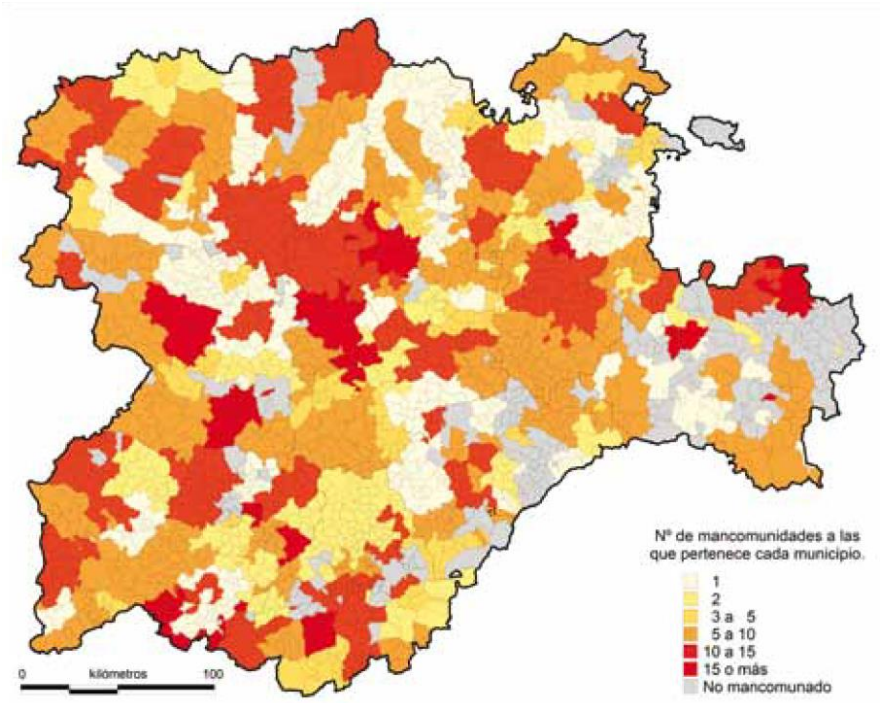


Figure 1. Number of "*mancomunidades*" in which each municipality is integrated

Source: *(Fernández, L. C. M., & Urrecho, J. M. D. (2013). Población, administración y territorio en Castilla y León: desequilibrios y desafíos del modelo de poblamiento. Ería: Revista cuatrimestral de geografía, (90), 5-30.*

2. Region description

Within this chapter, the case study *Tierras de Medina* municipalities association is described.

As mentioned in the previous section, the household waste management model in the Community of Castilla y León is based on the operation of a set of services and infrastructures for collection, transport, treatment (recovery and disposal), all of which are managed by local authorities. Figure 2 shows schematically the urban waste flow established by the current municipal model in Castilla y León. Moreover, in accordance with the PIRCyL, in the municipalities of Castilla y León there is selective collection of the different fractions of waste produced in the household sector: glass, paper and cardboard, light packaging, organic matter and residual waste, as well as, special waste stream.

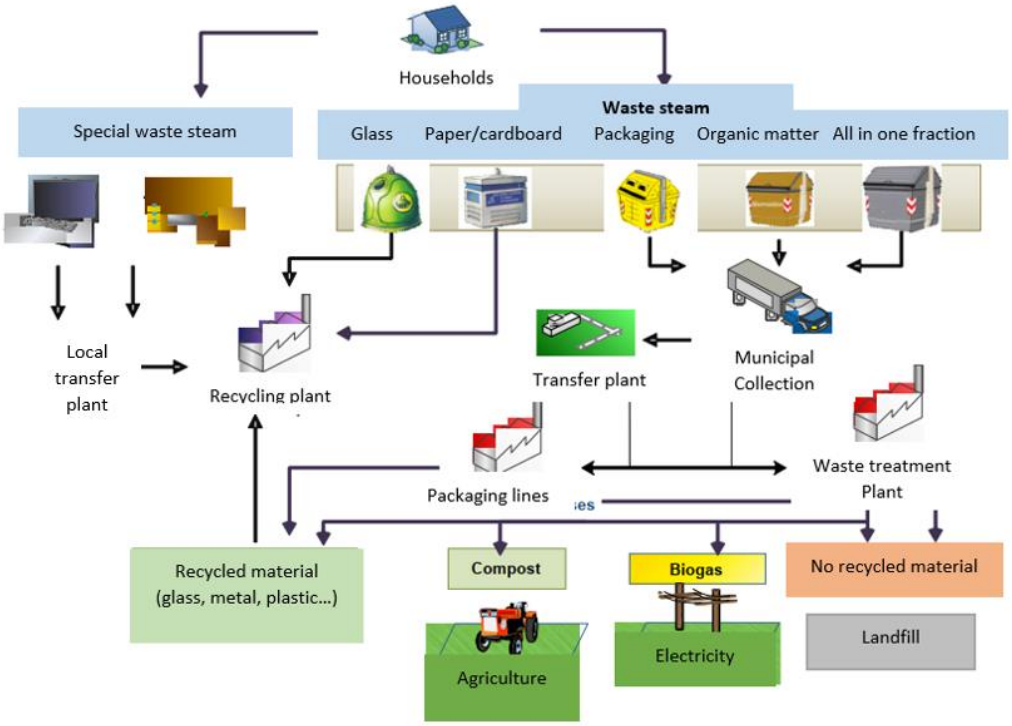


Figure 2. Castilla y Leon waste treatment flow

However, there are areas in which the selective collection system is not implemented, as in the case of certain associations of municipalities. In these cases, as is the case of the Tierras de Medina association under study, there is a non-selective collection of MSW in which the all-in-one fraction is collected in the localities of production and taken to a transfer plant, located in a contiguous area, to finally transport the waste to the corresponding waste treatment plant. Following paragraphs describe the specific characteristics of the Tierras de Medina association.

The association is made up of a total of 31 towns and villages with approximately 35,492 inhabitants, distributed according to Table 1.

Table 1.Tierras de Medina municipalities association

Municipality	Population	Municipality	Population
Alaejos	1,379	Pozal de Gallinas	547
Ataquines	569	Pozaldez	478
Bobadilla del Campo	292	Ramiro	43
Brahojos de Medina	116	Rubí de Bracamonte	228
El Campillo	213	Rueda	1,237
Carpio	994	Salvador de Zapardiel	116
Castrejón de Trabancos	177	San Pablo de la Moraleja	112
Cervillego de la Cruz	87	San Vicente del Palacio	162
Fresno el Viejo	878	La Seca	1,059
Fuente el Sol	150	Serrada	1,103
Lomoviejo	178	Siete Iglesias de Trabancos	431
Medina del Campo	20,416	Torrecilla de la Orden	248
Moraleja de las Panaderas	43	Velascálvaro	165
Muriel	122	Villanueva de Duero	1,189
Nava del Rey	1975	Villaverde de Medina	513
Nueva Villa de las Torres	272	**TOTAL**	**35492**

Regarding to the waste management system established for all these municipalities, solid urban waste is collected in all the municipalities included in this service. Waste collection is limited to waste from domestic activities and waste produced by commercial, service and industrial activities, which, due to their nature and volume, can be assimilated to domestic waste. The waste collected each day is taken to the Transfer Plant owned by the municipality association and located in Villaverde de Medina, see Figure 3, where the waste collected each day is weighed, compacted in the transfer boxes and, from there, transported to Valladolid for treatment and disposal at the Valladolid Waste Treatment Plant. For the year 2020, the amount of waste treated, all in one, from this "*mancomunidad*" was 15,760 tonnes, i.e. 1.22 kg per day and inhabitant considering the population mentioned above.

Figure 3. Current waste management system and transfer plan location

In addition, thankfully the data provided by Waste Management Plant from Valladolid (http://www.ctrvalladolid.com/), typical waste composition considered in this assessment has been obtained. Table 2 shows this waste composition.

Table 2. Waste composition

Waste stream		**Amount (%)**	**Amount (ton)**
Organic		48,0%	7,564,925
Inorganic	Metal	7,1%	1,118,695
	Plastics	4,0%	623,296
	Glass	7,0%	1,103,218
	Paper and Cardboard	20,0%	3,152,052
Others		13,9%	2,198,074
Total		100,0%	15,760,260

Moreover, recovery ratio from Waste Management Plant for recyclable waste steams considered (glass, paper and cardboard, metal and plastic) has been 61% (https://www.valladolid.es/es/actualidad/noticias/ayuntamiento-adjudica-concesion-planta-tratamiento-residuos). In other words, 61% of the total waste managed in the waste management plant is recovered and manage in specific recycling plants

Finally, biowaste recovered by waste management plant, in both scenarios, is composted in the same facilities, thus, no transport is considered for this waste treatment. In addition, inorganic waste recovered is transported to the recycling plant located in Salamanca.

3. Designing and describing the scenarios

Within this chapter the case study of the two scenarios is **described and assessed**. Firstly, a **Baseline Scenario** which describes the current Municipal Solid Waste Management system of the case study municipalities association and, secondly, **Project Scenario** considering that three prototype systems have been installed and operated complementing the existing Municipality Solid Waste Management System.

3.1. Baseline Scenario

In previous section, main principles of current waste management system have been described. Moreover, following paragraphs analyze the specific data considered in order to develop the baseline scenario environmental assessment. Figure 4 shows the current MSW stream.

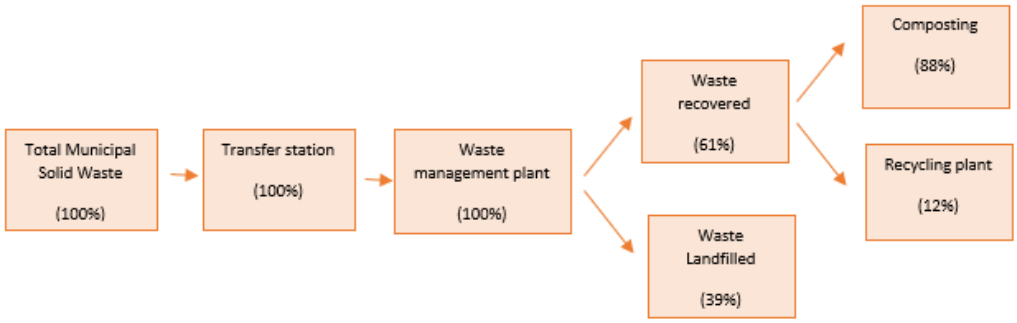


Figure 4. Baseline scenario waste management flow

Thus, considering the baseline waste composition, the total waste production and the waste flow described, the amount of each waste stream considered in baseline assessment is showed in Table 3.

Table 3. Waste management

Waste stream		Amount	Units
Total waste produced		15,760,260	ton/year
Waste landfilled		6,229,232	
Waste recovered by CTR	Biowaste	8,448,156	
	Glass	10,119	
	Paper/cardboard	595,007	
	Metal	332,256	
	Plastic	145,490	
	Packing	82,731	

Moreover, other consideration in the assessment is related to the waste transport. As commented in the previous section, transports involved in current waste management system are:

- From each municipality to the transfer plant, located in Villaverde de Medina.
- From the transfer plant to the waste management plant, located in Valladolid.
- From the waste management plant to each final disposal sites: Landfill or recycling plant

Table 4 and Table 5 shows the distances considered in the assessment.

Table 4. Transport from municipalities to Transfer plant

Municipality	**Transport to transfer plant (km)**	**Transport to transfer plant (tkm/ton)**	**Municipality**	**Transport to transfer plant (km)**	**Transport to transfer plant (tkm/ton)**
Alaejos	17.7	0.0267	Pozal de Gallinas	16.6	0.0039
Ataquines	28.3	0.0073	Pozaldez	19.8	0.0036
Bobadilla del Campo	15.8	0.0011	Ramiro	28.1	0.0000
Brahojos de Medina	13	0.0001	Rubí de Bracamonte	20.7	0.0009
El Campillo	9.5	0.0003	Rueda	19.3	0.0234
Carpio	23	0.0180	Salvador de Zapardiel	32.9	0.0004
Castrejón de Trabancos	18.5	0.0005	San Pablo de la Moraleja	33.4	0.0003
Cervillego de la Cruz	22.1	0.0001	San Vicente del Palacio	23.4	0.0005
Fresno el Viejo	25.3	0.0155	La Seca	21.2	0.0189
Fuente el Sol	24.2	0.0004	Serrada	27.5	0.0266
Lomoviejo	27.5	0.0007	Siete Iglesias de Trabancos	16.8	0.0025
Medina del Campo	10.1	3.3420	Torrecilla de la Orden	26.3	0.0013
Moraleja de las Panaderas	18.8	0.0000	Velascálvaro	19.8	0.0004
Muriel	10.9	0.0001	Villanueva de Duero	34.5	0.0387
Nava del Rey	5.6	0.0173	Villaverde de Medina	0.00	0.0000
Nueva Villa de las Torres	5.5	0.0003	TOTAL	-	14

Table 5. Transports of Baseline scenario

Concept	Units	Amount
Transport from municipalities to transfer plant	tkm	14
Transport from transfer plant to waste management plant	km	61
	tkm	
Transport from waste management plant to landfill	km	**3.2. 0**
	tkm	
Transport from waste management plant to composting plant	km	0
	tkm	
Transport from waste management plant to recycling plant	km	121
	tkm	9
Total waste transport	**tkm**	**144**

3.3. Project Scenario

Regarding the Project Scenario, in order to design it, a fixed "Recycling Percentage Value" of 25% for the year 2021 has been set. In other words, this value means that 25% of the Recyclable MSW being generated within the case study area, is being recycled through the Green Kiosk, thus, it indicates the level of participation to the prototype system by the citizens.

For instance, having 100 kg of MSW being produced where 50 kg is recyclable waste of these four waste streams, then 25% out of those 50 kg will be handled within the Green Kiosk. In other words, this fixed recycling value of 25%, indicates the level of participation to the prototype system by the citizens.

In addition, as part of the baseline scenario, the waste no recovered by the Green Kiosk is transported to the Waste management Plant increasing the waste recovered percentage of the whole waste management chain. Figure 5 shows the scheme of project scenario waste management flow.

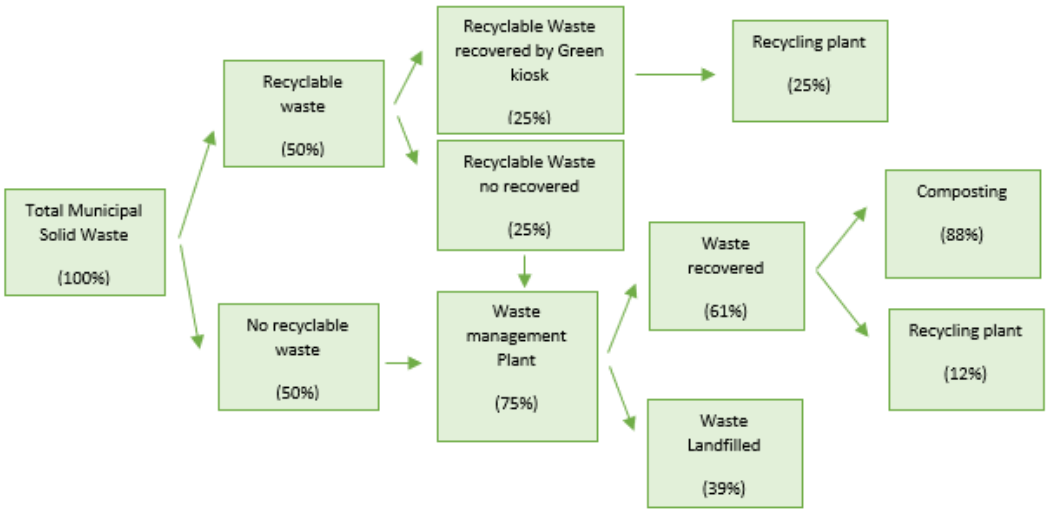


Figure 5. Project scenario waste management flow

In order to decide where the Greek Kiosks should be established, as well as the number of prototype systems able to be established and be operational, critical factors are the generation and composition of recyclable waste. This is because, it is of salient significance, that any established Green Kiosk should be self-sufficient in economic terms.

Within this context, through a series of hypotheses and calculations estimated (regarding the current situation in Greece) that each prototype system should gather and manage at least 350 kg of recyclable waste per day in order to be self-sustainable. This value of 350kg/day serves as a threshold, so as to decide whether a certain municipality or city generates sufficient recyclable waste for the system to be self-sustainable.

Thus, considering these hypotheses and the total waste production and its distribution, three Green Kiosk has been foreseen for the project scenario. One of them has been (virtually) "installed" in municipality of Nava del Rey. This location covers a population of almost 9,000 inhabitants and a waste production of 493 ton per year; 1,352 kg per day and habitant, pretty close to the minimum amount of waste production necessary for economic viability of the Green Kiosk. Moreover, due to the high-density population and high waste production, the other two Green Kiosks have been located in the same municipality, Medina del Campo. These Green Kiosks cover a population of 26,600 inhabitants and a waste production of almost 1,500 ton per year (4,045 kg per day and habitant). Figure 6, shows the municipalities covered and the location of each Green Kiosk

Figure 6. Green Kiosk distribution in project scenario

Other assumptions that have been considered for this scenario are explained below:

- Waste management plant is located in Valladolid.
- Recycling plant is located in Salamanca.
- Waste recovered by Green Kiosk are transported directly from the municipalities where they are located, Nava del Rey and Medina del Campo, to the recycling plant in Salamanca.

- Not recovered waste is transported to the waste management plant in Valladolid where will receive another recovering process (61% recovery rate). After this process, recovered biowaste is composted in the waste management plant and recyclable materials (glass, paper and carboard, plastics and metal) are transported to the recycling plant (Salamanca). Finally, not recovered waste is landfilled close to the waste management plant, thus, no transport is considered in this final disposal.

Thus, within this context, following tables show the data considered to assess the environmental impacts of this scenario.

Table 6. Recovered waste stream in Project scenario

Municipality	Waste produced (ton/year)	Transport to Green Kiosk (km)	Transport to Green Kiosk (tkm/ton)	Transport to recycling plant (km)	Transport to recycling plant (tkm/ton)	Total transport (tkm/ton)
Alaejos	77	12	0.470	73	2	5
Carpio	55	19	0.529			
Castrejón de Trabancos	10	13	0.064			
Fresno el Viejo	49	20	0.487			
Siete Iglesias de Trabancos	24	11	0.137			
Torrecilla de la Orden	14	21	0.145			
Brahojos de Medina	6	18	0.059			
Campillo (El)	12	15	0.088			
Velascálvaro	9	25	0.118			
Villaverde de Medina	28	6	0.081			
Bobadilla del Campo	16	26	0.211			
Nava del Rey	110	0	0.000			
Nueva Villa de las Torres	15	11	0.081			
Rueda	69	14	0.491			

Table 6. Recovered waste stream in Project scenario

Municipality	Waste produced (ton/year)	Transport to Green Kiosk (km)	Transport to Green Kiosk (tkm/ton)	Transport to recycling plant (km)	Transport to recycling plant (tkm/ton)	Total transport (tkm/ton)
Lomoviejo	10	19	0.094	89	8	11
Cervillego de la Cruz	5	15	0.037			
Rubí de Bracamonte	13	11	0.069			
Moraleja de las Panaderas	2	9	0.011			
San Vicente del Palacio	9	12	0.056			
Ramiro	2	18	0.022			
Muriel	7	24	0.084			
Ataquines	32	17	0.276			
Salvador de Zapardiel	6	28	0.092			
San Pablo de la Moraleja	6	22	0.070			
Fuente el Sol	8	15	0.063			
Seca (La)	59	13	0.391			
Serrada	61	19	0.603			
Medina del Campo	1133	0	0.000			
Pozaldez	27	11	0.147			
Villanueva de Duero	66	26	0.884			

Table 7. No recovered waste stream

Municipality	Waste produced (ton/year)	Transport to CTR (km)	Transport to CTR (tkm/ton)	Waste to recycling plant (ton/year)	Waste to composting (ton/year)	Waste to landfill (ton/year)	Transport to recycling plant (tkm/ton)	Total transport (tkm/ton)
Alaejos	536	61	54	21	150	9	4	70
Carpio	386			15	108	6		
Castrejón de Trabancos	69			3	19	1		
Fresno el Viejo	341			13	95	5		
Siete Iglesias de Trabancos	167			6	47	3		
Torrecilla de la Orden	96			4	27	2		
Brahojos de Medina	45			2	13	1		
Campillo (El)	83			3	23	1		
Velascálvaro	64			2	18	1		
Villaverde de Medina	199			8	56	3		
Bobadilla del Campo	113			4	32	2		
Nava del Rey	767			30	214	12		
Nueva Villa de las Torres	106			4	29	2		
Rueda	481			19	134	8		

Table 7. No recovered waste stream

Municipality	Waste produced (ton/year)	Transport to CTR (km)	Transport to CTR (tkm/ton)	Waste to recycling plant (ton/year)	Waste to composting (ton/year)	Waste to landfill (ton/year)	Transport to recycling plant (tkm/ton)	Total transport (tkm/ton)
Lomoviejo	69	61	54	3	19	1	4	70
Cervillego de la Cruz	34			1	9	0.5		
Rubí de Bracamonte	89			3	25	1		
Moraleja de las Panaderas	17			1	5	0.3		
San Vicente del Palacio	63			2	18	1		
Ramiro	17			1	5	0.3		
Muriel	47			2	13	0.8		
Ataquines	221			9	62	4		
Salvador de Zapardiel	45			2	13	0.7		
San Pablo de la Moraleja	44			2	12	0.7		
Fuente el Sol	58			2	16	0.9		
Seca (La)	411			16	115	7		
Serrada	429			17	120	7		

Table 7. No recovered waste stream

Municipality	Waste produced (ton/year)	Transport to CTR (km)	Transport to CTR (tkm/ton)	Waste to recycling plant (ton/year)	Waste to composting (ton/year)	Waste to landfill (ton/year)	Transport to recycling plant (tkm/ton)	Total transport (tkm/ton)
Medina del Campo	7,933	61	54	305	2,214	126	4	70
Pozaldez	186			7	52	3		
Villanueva de Duero	462			18	129	7		
Pozal de Gallinas	213			8	59	3		

4. Scenario comparison

In order to assess and compare the aforementioned scenarios, a monitoring protocol has been established and thus, a list of factors (techno-economic, environmental) has been calculated for each one of the scenarios. Afterwards a brief summary of this overall conclusions is exposed.

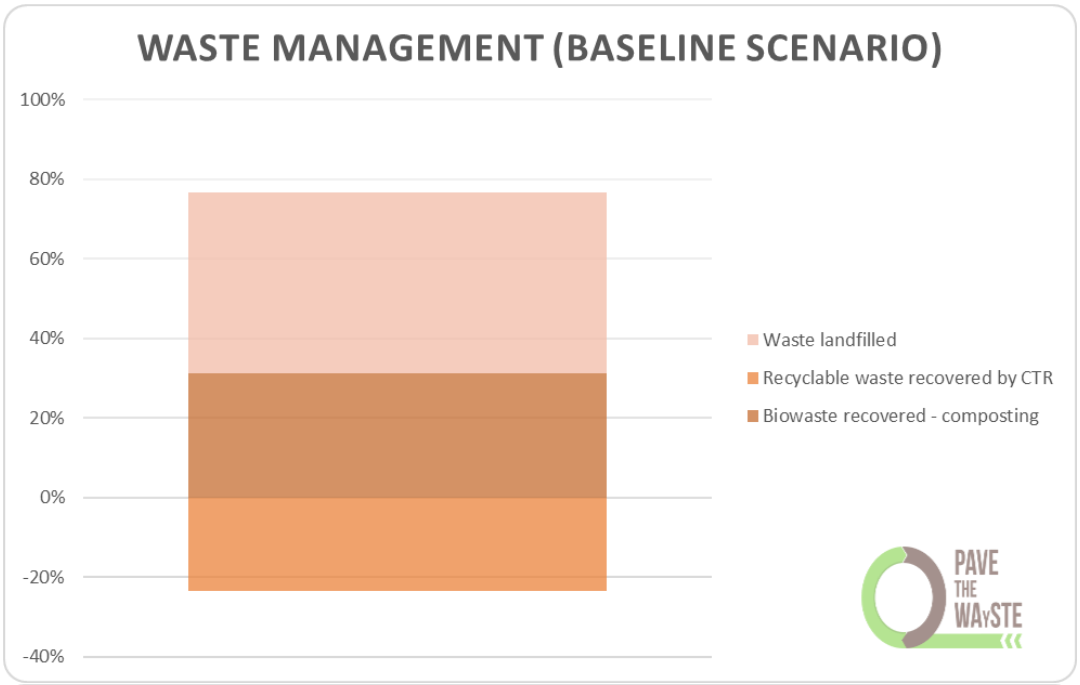
4.1. Environmental assessment

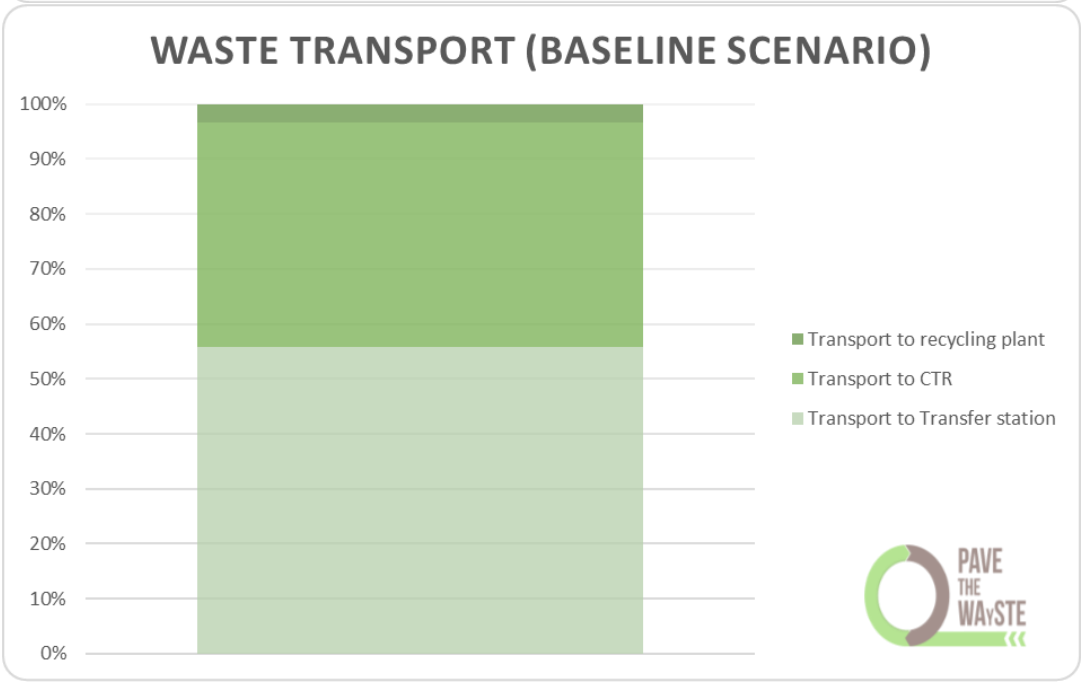
This section presents the environmental profile of each scenario assessed. These results are presented considering the main processes involved in whole waste management: waste transport and waste management.

Regarding baseline scenario, waste management contributes to the total environmental impact in more than 85%. Within the waste management options, landfilling is the option that involves the higher environmental impact. On the other hand, recyclable waste recovered by waste treatment plant contributes in the reduction of the environmental impact of this scenario due to the impact avoided by the no manufacturing of new raw materials. These results are showed in Table 8 and Figure 7.

Table 8. Baseline scenario environmental impact

Process		Impact	Units
Waste transport	Transport to Transfer station	17.8	kg CO_2 eq./ton
	Transport to CTR	13.0	
	Transport to recycling plant	1.07	
Waste management	Biowaste recovered - composting	112.4	
	Recyclable waste recovered by CTR	-84.3	
	Waste landfilled	163	
TOTAL		223	


WASTE MANAGEMENT (BASELINE SCENARIO)
100%
80%
60%
40%
20%
0%
-20%
-40%
Waste landfilled
Recyclable waste recovered by CTR
Biowaste recovered - composting
PAVE THE WAYSTE


WASTE TRANSPORT (BASELINE SCENARIO)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Transport to recycling plant
Transport to CTR
Transport to Transfer station
PAVE THE WAYSTE

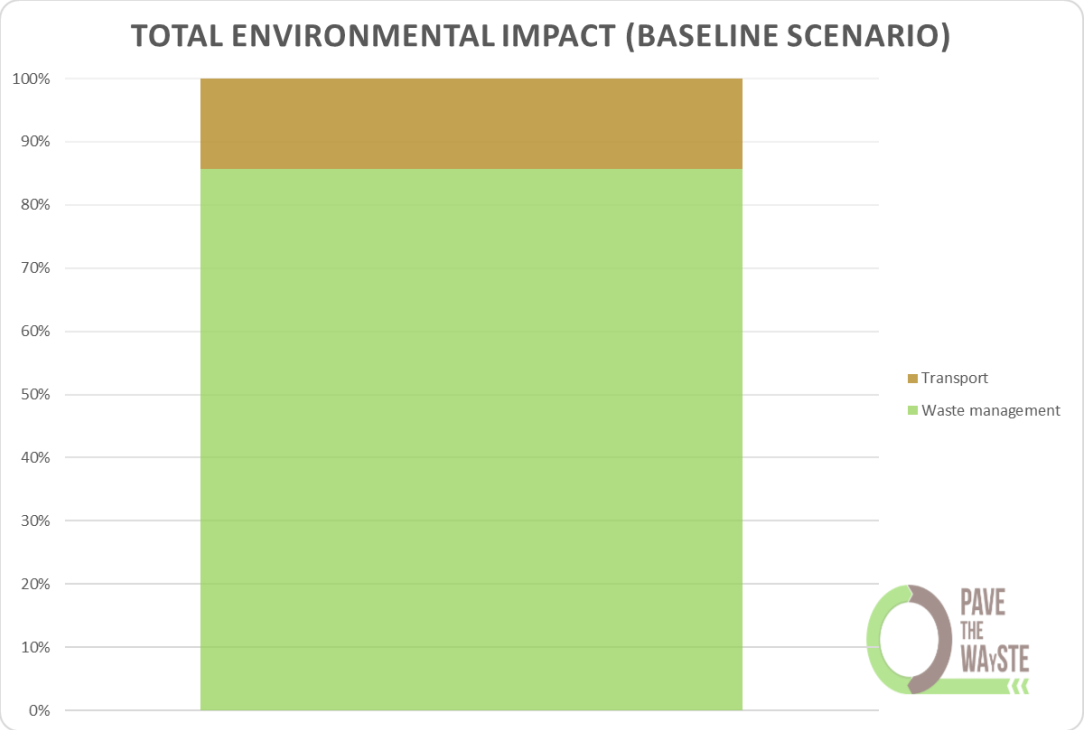
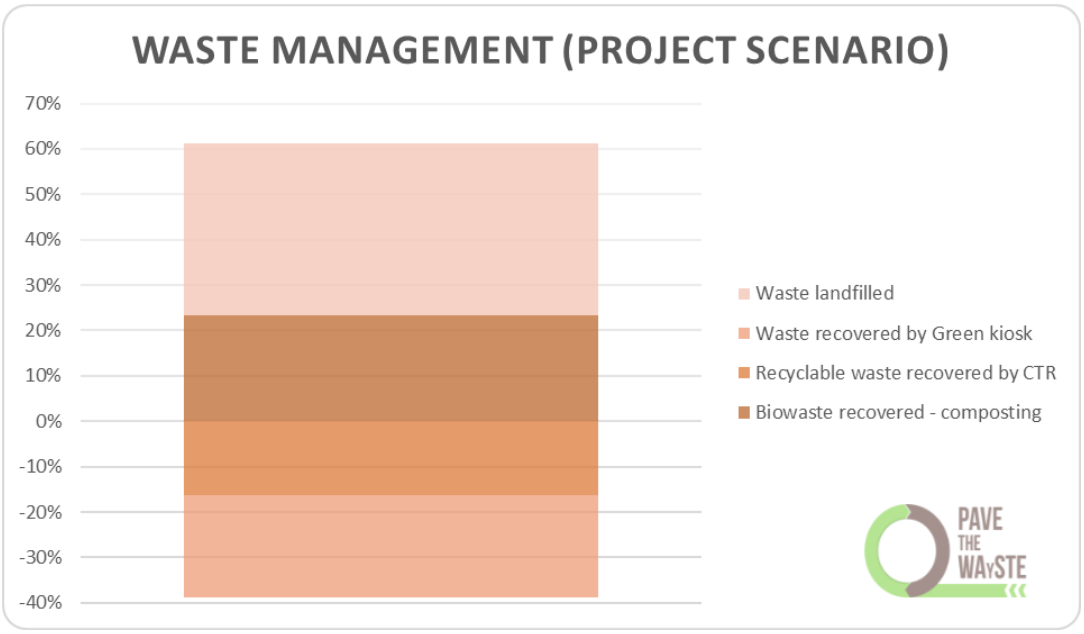


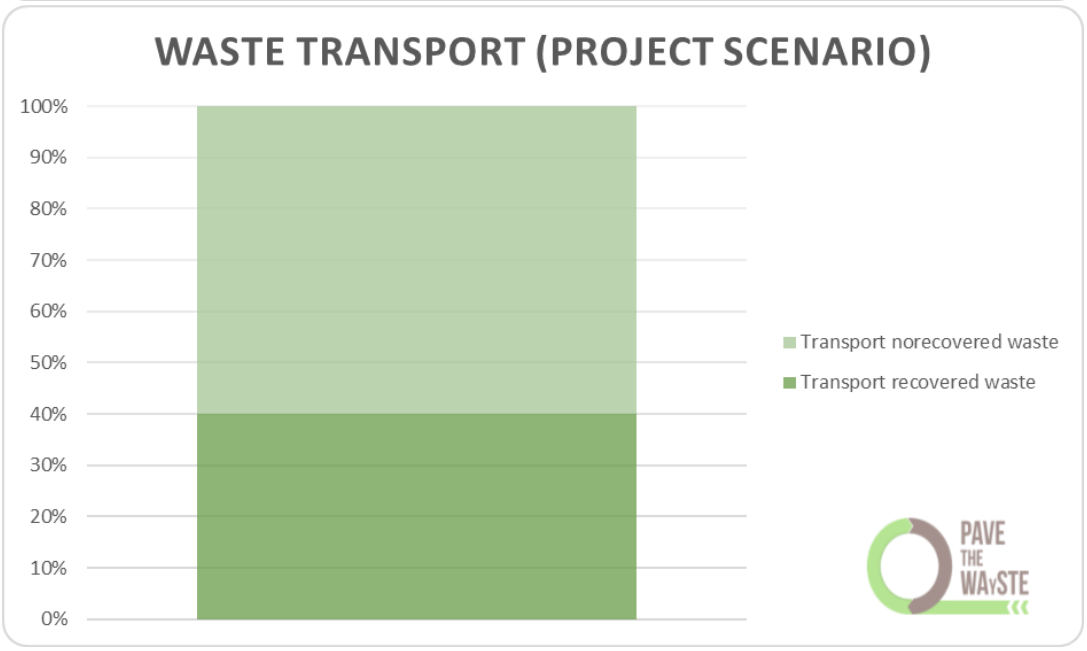
Figure 7. Baseline scenario environmental impact representation

In the same way, project scenario environmental impact results are showed in Table 9 and Figure 8. As same as baseline scenario, waste management is the process that more contributes to the total environmental impact, 67% of the total impact. In this scenario, due to Green Kiosk operation, waste recovered increase the environmental impact reduction.

Table 9. Project scenario environmental impact

Process		**Impact**	**Units**
Waste transport	Transport recovered waste	18,6	kg CO_2 eq./ton
	Transport no recovered waste	28,0	
Waste management	Biowaste recovered - composting	98,6	
	Recyclable waste recovered by CTR	-68,4	
	Waste recovered by Green kiosk	-94,9	
	Waste landfilled	158	
TOTAL		140	


WASTE MANAGEMENT (PROJECT SCENARIO)
70%
60%
50%
40%
30%
20%
10%
0%
-10%
-20%
-30%
-40%
Waste landfilled
Waste recovered by Green kiosk
Recyclable waste recovered by CTR
Biowaste recovered - composting
PAVE THE WAYSTE


WASTE TRANSPORT (PROJECT SCENARIO)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Transport norecovered waste
Transport recovered waste
PAVE THE WAYSTE

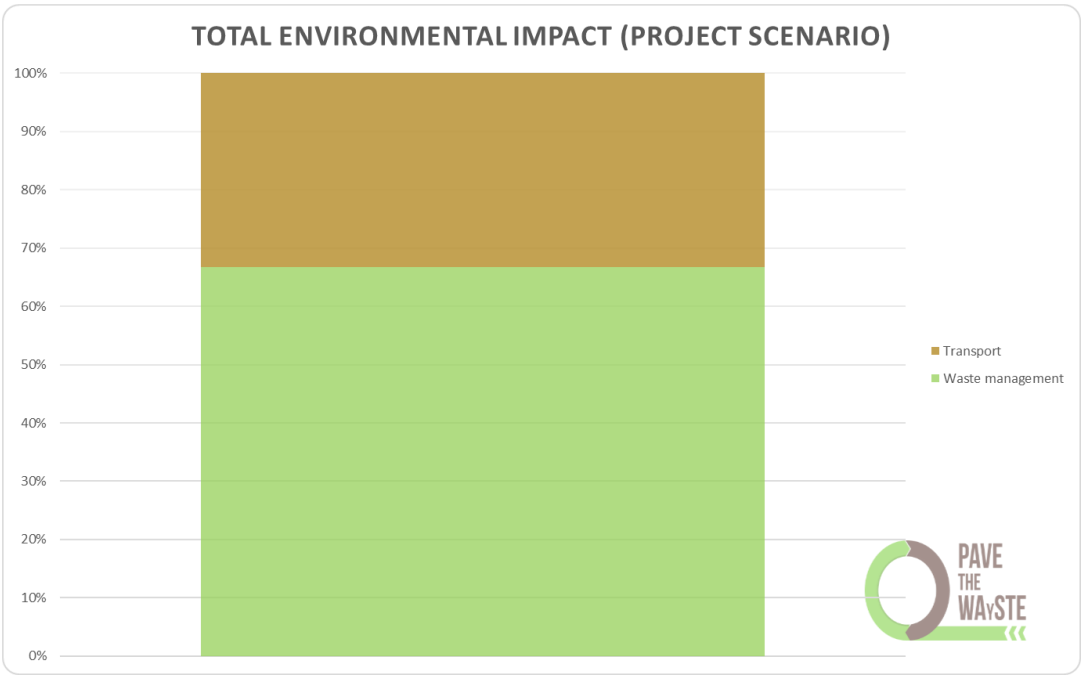


Figure 8. Project scenario environmental impact representation

Finally, Table 10 and Figure 9 show an environmental comparison between both scenarios considered. In this way, the main conclusion is that, due to the Green Kiosk operation, the environmental impact of the waste management in "Tierras de Medina" municipality association is decreased 82 kg CO_2 eq per ton of waste management. In other words, 1,295 ton CO_2 eq. are avoided per year in this region due to the waste separation at source carried out Green Kiosk operation.

Table 10. Scenarios comparison

Scenario	**Climate change (kg CO2 eq./ton)**		
	Waste management	**Transport**	**Total**
Baseline scenario	191	32	223
Project scenario	94	47	140

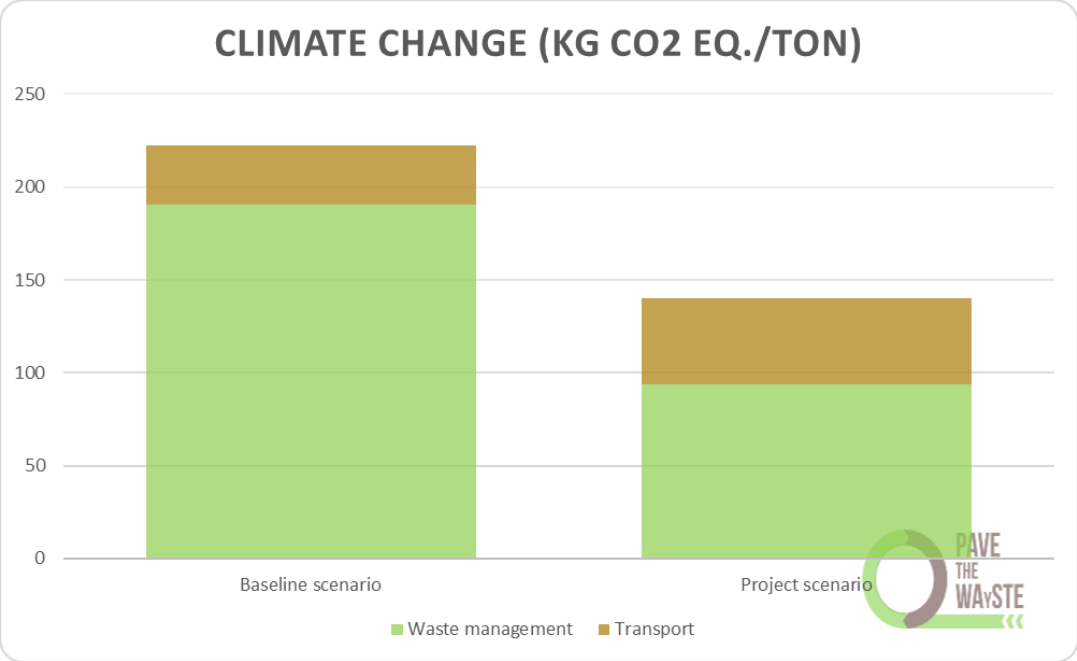


Figure 9. Scenarios comparison representation

4.2. Techno-economic assessment

In this section a comparison study regarding the reduction of the waste management cost due to the Green Kiosk installation in this case of study has been done.

Regarding current waste management treatment cost, it has been updated in year 2021. Table 11 shows the new cost per ton of waste treated by Valladolid waste treatment plant.

Table 11. Waste treatment cost

Stream	Cost	Units
Organic fraction	25.00	€/ton
Inorganic fraction	53.89	
All in one fraction	63.47	

Source:https://www.valladolid.es/es/actualidad/noticias/ayuntamiento-adjudica-concesion-planta-tratamiento-residuos

The new waste treatment cost encourages separation at source, which is key to achieving environmental objectives. Thus, for the treatment of one ton of organic fraction, the cost is 25€ (currently almost 46€) while the price for the treatment of "all-in-one" waste will be 63.47€ (currently 22€). This will mean that local authorities that deliver poorly segregated waste will face a much higher treatment cost.

On the other hand, in order to calculate the reduction of the waste management, the expenses stemming from the operation of the Green Kiosks (**project scenario**) have been considered. Moreover, regarding the installation and construction costs that precede the operation of the Green Kiosks (and comprise a substantial initial amount), these have been excluded from this economical assessment, thus, it has been assumed that the Green Kiosks

are already installed and fully operational, as well as, the waste treatment plant in the baseline scenario. Table 12 describes each cost pertaining to the operation of a Green Kiosk for a whole year. Operational cost has been calculated considering an 8 hours operation for five days a week, where the operator stays within the Green Kiosk for 4 hours so as to receive the recyclable material and treat it accordingly, and the remaining four hours the operator could leave the Green Kiosk in order to collect more material from local enterprises, restaurants, super markets etc.

Table 12.Green Kiosk operational cost

Concept	**Amount**
Personnel	15,000.00 €
Annual Subscription to the Electronic Platform	397.80 €
Electricity	332.64 €
Consumables & supplies (bags, gloves, etc.)	3,340.00 €
TOTAL	19,070.44 €

Moreover, regarding the reduction of the waste management cost, profits derive from selling the recovered recyclable material to the corresponding industry have not been included in either scenario. Thus, considering the operational cost and the waste managed by the Green Kiosk in one year (1,970 ton) the cost of managing 1 ton of waste by green kiosk is 9.68€.

Regarding waste management treatment, the assumptions considered in this economic study have been the same as in the environmental assessment. Thus, in the baseline scenario it has been considered that all the amount of waste produced in one year (15,760 tons) is treated as an “all in one” fraction by the waste treatment plant from Valladolid. On the other hand, due to the Green Kiosk installation, project scenario gets to manage a 13% of the recyclable waste steam produced in the studied region. In other words, 1,970 tons of recyclable waste is managed by Green Kiosk and 13,790 tons are treated as “all in one fraction” in the waste management treatment plant.

Therefore, considering this economical factor and waste production and composition of each scenario explained previously, the results obtained are the following:

<table>
<tr><th rowspan="2">Scenario</th><th colspan="2">Waste management system</th><th colspan="2">Management cost (€/ton)</th><th rowspan="2">Annual cost (€)</th><th rowspan="2">Annual savings (%)</th></tr>
<tr><th>Green kiosk</th><th>Waste treatment plant</th><th>Green kiosk</th><th>Waste treatment plant</th></tr>
<tr><td>Baseline scenario</td><td>0%</td><td>100%</td><td rowspan="2">9.68 €</td><td rowspan="2">63.47 €</td><td>1,000,303.70 €</td><td rowspan="2">13%</td></tr>
<tr><td>Project scenario</td><td>13%</td><td>88%</td><td>875,265.74 €</td></tr>
</table>

5. Conclusions

Community of Castilla y León offers the lowest population density (25.5 inhabitants/km²) in Spain. Additionally, it is also characterised by an unbalanced population model, with great contrasts between a rural environment, where small municipalities predominate, and a high concentration of the population in the provincial capitals and their metropolitan areas. Far from the main cities, the dispersion of the population and its concentration in small administrative units give waste collection a more rural character. Furthermore, a difficult access at certain times of the year, together with disperse population, are factors that make some areas of Castilla y León a municipal waste treatment challenge.

Castilla y León is comprised of 9 provinces, being one of them Valladolid. Valladolid City Council showed interest in the waste management model proposed in the LIFE PÂVEtheWAySTE (PtW) project with the Green Kiosk being the core of this model. Valladolid Province had already implemented a mobile "clean point" with the same philosophy that the "Green Kiosk", this is why provincial waste manager detected passible synergies with the PtW project and expressed interest in collaborating in project actions as a follower territory with a letter of intent.

After a detailed analysis of the Province of Valladolid, Tierras de Medina was selected as the area where a PtW replication study would be implemented. Tierras de Medina municipalities association shows a population model with a medium size municipality, Medina del Campo with a population of 20,416 inhabitants, and another 28 municipalities around it and contributing with the 42% of the total population of these municipalities association.

At this point, and considering the current waste management plan established in this Region, see Figure 2, an environmental and techno-economical comparative assessment has been carried between both, the current waste management model and a potential scenario where the Green Kiosk were implemented. As a result of the environmental assessment, considering the data and assumptions presented in this deliverable, the project scenario (i.e. the implementation of the Green Kiosk model in this region), shows an environmental burdens reduction due to the efficient separation at source carried out by this system. Moreover, in the case of the techno-economic assessment presented in this report, it shows a reduction in the waste management annual cost. In addition, the annual savings are 13% in comparison with current waste management system, not including here the profits derived from selling the recovered recyclable material to the corresponding industry.

In conclusion, Green Kiosk model implementation in this region shows a reduction in environmental and economic impacts which could be a starting point to implement this system in regions with low population density.