# Position paper on NETWAP Methodology

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# 1. Introduction

NETWAP project is a cross border cooperation initiative included within the Priority Axis 3 “Environment and Cultural Heritage” of the Interreg Italy Croatia Programme. A very relevant partnership, from Italy and Croatia, developed an innovative waste management methodology, with the aim of providing autonomy to small and isolated communities, threatened by increasing anthropic pressure. Overall objective is to face potential environmental damages and to improve the quality of the maritime environment in selected territories of the cooperation area, through the enforcement of local communities’ awareness, capability, know-how and decision autonomy toward a sustainable waste management methodology, based on innovative technologies and procedures. Autonomy, sustainability, innovation, and people engagement are the key factors of NETWAP project success.

This position paper aims at describing challenges and potential benefits deriving from the implementation of autonomous and local waste management systems for biowaste and plastic marine litter. First an overview of regulations, targets, and the current status of biowaste and plastic marine litter are provided. Then the main reasoning for implementing the solutions proposed in NETWAP project are described. The sustainability analysis of local composting has been carried out according to a life-cycle approach to identify environmental, economic and social hotspots. Finally, recommendations (basic, strategic and tactical interventions) are proposed to help all stakeholders in the local waste management systems in making them effective and replicable.

# 2. Overview of biowaste and plastic marine litter management

The Circular Economy Action Plan - COM(2020) 11/03/2020, and related European directives, announces specific strategies to move from a linear to a circular model on a wide range of materials (plastics, textiles, food, batteries, construction, etc.) and foresees waste reduction targets as well as actions to promote reuse, repair, and recycling.

## Biowaste - policy and regulations

Waste Framework Directive – (EU) 2018/851: it sets the basic concepts and definitions related to waste management, such as definitions of waste or recycling. It introduces the waste hierarchy, the Polluter Pays principle and the Extended Producer Responsibility and sets out separate collection targets.

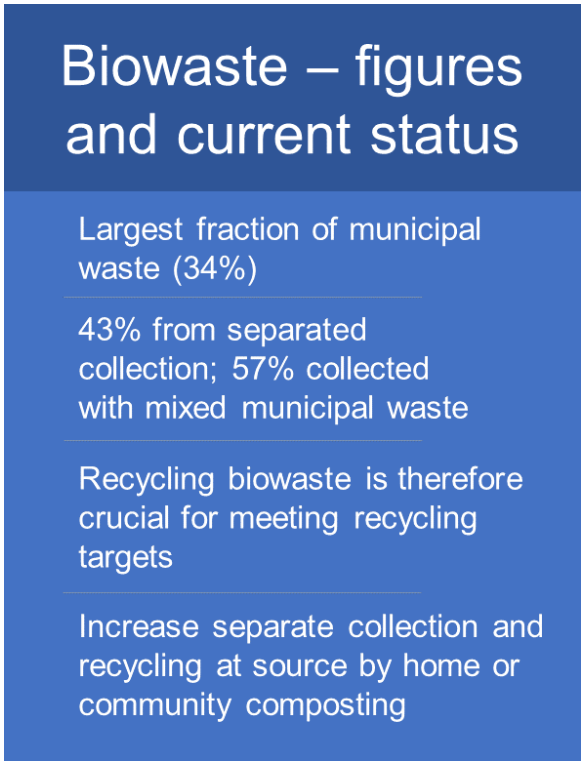
Landfill Directive – (EU) 2018/850: It aims to prevent or reduce the adverse effects of the landfill of waste on the environment. It defines the different categories of waste and applies to all landfills. It also classifies the types of landfills and obliges Member States to minimize biodegradable waste to landfills.

Fertilizer Regulation – (EU) 2019/1009: it replaces the currently valid Regulation (EC) No 2003/2003, expanding its scope to secondary raw material based, i.e. recovered and bio-based fertilising products.

Waste Framework Directive – (EU) 2018/851 imposes all Member States the following targets:

- Setting up of the separate collection by the 31st December 2023 onwards; alternatively, applying home or community composting;
- The residual biowaste in municipal mixed waste must be halved before 2030;
- Municipal waste recycling must achieve 55% by 2025, 60% by 2030 and 65% by 2035;
- Reduction of municipal waste directed to landfilling down to 10% by 2035.
- Member States must take measures to foster and encourage home and community composting as a way toward recycling targets;
- Recycling processes through composting must ensure a high level of environmental protection and result in output which meets relevant high-quality standards.

Auto composting, community composting, and local composting are more specifically defined at national level as in the case of Italy (Ministerial Decree n.266/2016). Overall, the main parameters and requirements used in the legislation for defining community composting are: maximum capacity of the facility; type of waste accepted; parameters requested for sanitation and allowed usage-users of compost.




- Biowaste is the largest single component of municipal waste, corresponding to 34% of the generated municipal solid waste in the EU-28 (around 86 million tonnes) [3];

- The level of separate biowaste collection differs considerably across Europe; however, EU-28 figures correspond to 43% of collected separately and 57% collected with mixed municipal waste;

- Because of its considerable volume and its current high landfilled rate, recycling biowaste is therefore crucial for meeting recycling targets of the EU's circular economy action (65% of municipal waste by 2035);

- To enable biowaste diverting from landfill to recycling and so its processing into fertiliser, soil improvers and non-fossil fuels, efforts should be directed to both improving separated collection and recycling at source by home or community composting;

- Composting (treatment in the presence of oxygen) and anaerobic digestion (treatment in the absence of oxygen) are currently the two most widely applied treatment techniques. But the use of anaerobic digestion is increasing due to biogas production potential as renewable energy;

- Two elements prevent a proper separated collection of biowaste: the first is the contamination of biowaste with plastics; the second is the increasing use of bags and other plastic products labelled as 'compostable' or 'biodegradable' whose treatment is not fully possible in the current biowaste plants;

- To close the biowaste circle, the compost and digestate should be of good quality and this depends on the level of separated collection of biowaste in a proper way. Moreover, compost quality management and assurance schemes should be developed and strengthen.

## Plastic marine litter - policy and regulations

Packaging and Packaging Waste directive - (EU) 2019/852: It sets out measures and requirements for the prevention, re-use and recovery of packaging wastes in Member States. Member States must ensure that packaging placed on the market complies with the essential requirements. The Directive implies the Producer Responsibility principle.

Single-Use Plastics Directive – (EU) 2019/904: It intends to reduce the consumption of this type of plastics and states that Extender Producer Responsibility is involved in the targets as well as calls the Member States to ensure separate collection. It also sets out a list of SUP products.

Plastic bag Directive – (EU) 2015/720: It is an amendment to the Packaging and Packaging Waste Directive (94/62/EC) and was adopted to deal with the unsustainable consumption and use of lightweight plastic carrier bags.

- In 2015, global production of virgin plastics was 407 million metric tons (Mt) and expected to double by 2030 and to double again by 2050; 74% of the total primary plastics production in the same year became waste (302 Mt) [2];

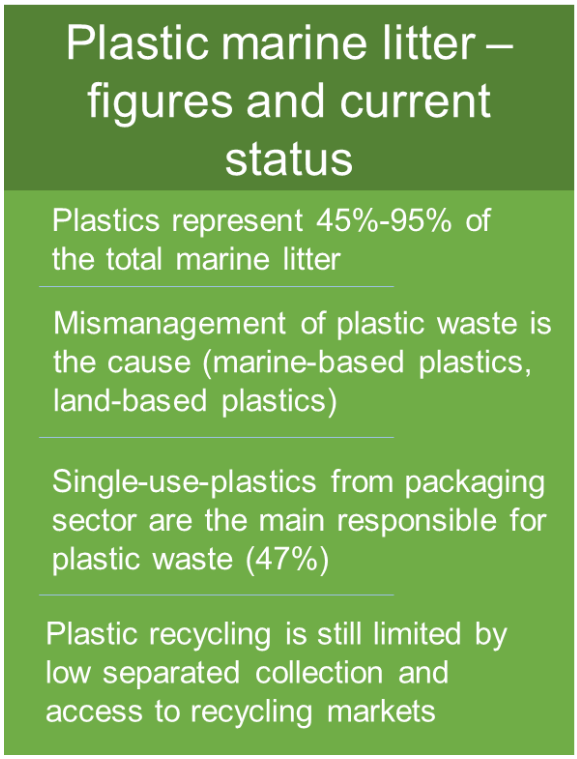
- Packaging sector is first responsible of plastic waste generation (47% of the total production);

- Data shared by the Plastic and Ocean Platform estimate that plastics represent 45% to 95% of the total marine litter (8 million Mt of plastic waste annually enters oceans);

- Plastics that enter the marine environment are already harmful as debris but their further degrade is responsible of smaller fragments production (micro- and nano plastics) that contaminate food chains and through release of harmful chemicals, are expected to negatively impact individual species and ecosystems for decades to come.

- Plastic recycling is still limited by low separated collection and access to recycling markets; in fact, only few polymers, at this moment, are considered of interest as secondary raw material (e.g.

PET, PE, PP). According to Plastic Europe, only 32% of the plastic waste collected separately is recycled, while 43% was used for energy recovery (incineration) and 25% landfilled;




- Rivers remain one of the main pathways that transport plastic waste into the oceans as a result of mismanagement of plastic waste that can occur in one of the following ways:
  i. Waste is deposited at non-sanitary landfills or dumps or not collected at all, particularly in rural areas where waste collection and management systems are missing;
  ii. Accidental and/or voluntary releases of plastic pellets into the environment from industrial sites, plastic blasting, and tire wear in terrestrial transport;
  iii. Plastics are blown into the marine environment by wind, or washed away by rainwater, from waste dumps or improperly managed landfills;
  iv. Plastics are released by sewage plants or are simply carried in wastewater in cases where there are no sewage plants.

# 3. Reasoning for implementing autonomous waste management systems in small communities

## 3.1 Pilots' identikit

The pilot projects considered small communities that could improve their waste management system by adopting local and autonomous processes. In this context small communities are considered those places with one of the following features: relatively small permanent population in small urban or rural areas, with moderate local waste production throughout the year and, in addition, significant seasonal variations in the population and consequently waste production (due to tourist inflows).

Also, according to the principle of proximity, the areas that can benefit from the outcome of this project, are:

- Coastal areas or islands (but not limited to them);
- Areas with a total population of several hundred (200-300) to several thousand (5000-8000) inhabitants spread in small urban or rural areas;
- Areas with a significant distance from the waste disposal plant (distance> 20-100 km).

In relation to the amount and structure of waste, the project considered small communities with the following characteristics:

- Total annual production of municipal solid waste (MSW) from several hundred tons (150-300 t / y) to several thousand tons (2500-4000 t / y);
- The majority (60-70%) of the total annual production of municipal waste occurs during the summer season;
- Mixed municipal waste (EWC number 200301) represents a significant part (30-70%) of MSW;
- Biowaste, i.e. kitchen (EWC number 200108) and yard waste (EWC number 200201) represent the largest share of MSW (25-40%);
- Landfilling is currently one of the main options for municipal waste treatment.

NETWAP project pilots are two small villages named Ist and Fossalto, located in Croatia and Italy, respectively. Ist is a tiny island, just 9.73 $km^2$ surface, of the Dalmatian Archipelagus, and from the administrative point of view it belongs to the City of Zadar. During the past 50 years it has witnessed a slow depopulation which has halved its number of inhabitants. The Croatian Government is attempting to attract people to the island through its National Programme of Islands' Development. The island is mainly a tourist area, so a huge population variation is experienced during summer (touristic season).

However, there are no large tourist infrastructure on the island, such as hotels or camps, and most visitors are accommodated in family houses or apartments or moored / anchored in bays and harbours. The development of basic infrastructure (shops, post offices, schools) is very poor and further development of infrastructure is mostly focused on the needs related to tourism (holiday homes, restaurants, etc.).

Fossalto is a little hilltop village located at the foot of the mountain chain named "The Appenines" about 50 km far from Adriatic Sea. Fossalto belongs to Campobasso County in Molise region. Fossalto has an historical centre and rural district which is settled 2 km far from it. It is located in an agricultural area

with no touristic development; therefore, few businesses exist in terms of restaurants and bar, and no hotels are present. Their main characteristics of the two locations are listed in Table 1.

**Table 1 Main characteristics of NETWAP pilots**

| Characteristic | Ist island | Fossalto |
|---|---|---|
| Permanent population | 182 people | 1258 people |
| Seasonal population variation | Yes, up to 4000-4500 people | Yes (estimate not available) |
| Geographical classification | Island | Mountain rural area |
| Distance from waste disposal area | 20 km (by truck) and 120 km (by ferry) | 45 km (by truck) |
| MSW production | 65,62 ton/year | 128.84 ton/year |
| Separated biowaste collection | Not present | Present (43.14 ton/year) |
| Biowaste treatment | Landfill | Composting |
| Separated plastic waste collection | Present | Present |
| Plastic marine litter issue | Yes | No |

## 3.2 Expected results toward European targets and global environmental issues of concern

- **Environment preservation**: protect environment and improve sustainability of economic activities developed in small communities, particularly those located in remote areas with high natural resources and rich ecosystems. Particular attention must be paid to the sustainable development and to the reconciliation of fishing, tourism, and the environmental conservation. This need takes on a specific meaning in the case of the small islands and villages on the coast side where ecosystems can be altered by significant seasonal tourist flows.
- **Local economic development**: preserve local economic activities (e.g. touristic facilities, small farms) and provide local employment opportunities with the aim of fighting the depopulation of rural and coast side areas;
- **Contribute to waste management targets**: increase separated biowaste collection and, consequently, reduce residual organic fraction in mixed waste; promote new practices for plastic marine litter (beached plastics) collection, by means of cleaning operation by both volunteers and

municipal company responsible for the local waste management, in order to foster recycling of plastics and to reduce landfilled waste;

- **Support biowaste recyclability** to produce high-quality fertilizer, in line with Circular Economy approach;
- **Improve practicability** of autonomous waste management systems for biowaste and plastic marine litter and grow knowledge on related potential benefits.

### 3.3 Expected benefits from the small communities

- Reduce costs (e.g. waste fee) and environmental impacts related to waste transportation;
- Set up an effective and flexible biowaste separate collection and treatment directed to the touristic season;
- Increase awareness and level of commitment of local communities on environmental impacts produced by waste and on potential improvements generated by autonomous treatment solutions;
- Keep territorial attractiveness for touristic sector and provide answers to the increasing demand for more sustainable tourism (eco-tourism);
- Test practicability of local waste treatment for biowaste and plastic marine litter, so to provide insights about their transferability to similar contexts in the same region.

## 4. Solutions proposed in NETWAP project

### 4.1 Implementation of local composting

For both pilots, the implementation of local composting has been proposed with the twofold objective of improving separated collection of biowaste and treating them locally in a proper way, thus avoiding cost and impacts related to waste transportation. The main steps toward the local composting implementation are summarized in the following:

1. Analysis of current waste production and collection to quantify both the annual amount of biowaste produced and collected in the two areas and the amount fluctuation during the year.
2. Location selection which is guided by three aspects: legal property status of the land (e.g. location of the composter was selected on land under the jurisdiction of the administration that manages the composting activity); technical elements (e.g. access to infrastructure, electricity, water); possibility to preserve local communities from possible nuisance such as odours.
3. Selection of composter, in terms of technology and size, according to flexibility and treatment capacity requirements (e.g. the maximum amount of biowaste input for the composter model).

An electromechanical composter was selected for both pilots (Figure 1); moreover, auxiliary equipment should be set up such as shredder, a static tank and an electric scale.

4. Definition of organisation structure, personnel roles and responsibilities such as master composter, who takes care of the composter management. The overall organization structure and the main roles should be identified in collaboration with the local authorities and other members of the local communities. Municipalities were also supported for the drafting of the municipal regulation of local composting.
5. Set up/reshape of biowaste collection system by identifying people dedicated to the biowaste collection (if not already present), type of collections (e.g. door-to-door by means of bins) and frequency of collection (e.g. twice a week).
6. Placement of the composter on the target area and start-up activities.
7. Monitoring the composter operations during the first year; in particular quantity and quality of biowaste, process parameters (e.g. humidity, biowaste quality) and management aspects should be checked. Monitoring is a key step to set up the local composting in a proper way and to reach optimal performances.
8. Workshops, trainings, promotional materials and other engagement activities directed to members of local communities to make them familiar with local composting and separated collections, and to technic personnel about composter operation.

**Figure 1 Electromechanical composter and auxiliary equipment set up in Fossalto**

## 4.2 Procedure for plastic marine litter collection and valorisation

The pilot consisted in implementing a simple, flexible, and sharable practical procedure to coordinate manual cleaning operation by both volunteers and municipal company responsible for the local waste

management, to support plastic marine litter (beached plastics) collection and valorisation. The main steps toward the procedure development are summarized in the following:

1. Sampling and analysis of waste disposed in beaches, with the aim of identifying waste fractions and related quantities. A particular detailed analysis should be dedicated to plastics.
2. Identification of potential treatment routes for plastics. Currently, plastics collected in the beaches are classified with an EWC (European Waste Catalogue) 20.03.03 of "cleaning street residues" and as such, they are landfilled without any possibility of recovery. However, if plastic typologies could be separated, alternative recycling treatment could be identified (e.g. mechanical recycling).
3. Procedure drafting.
4. Presentation and discussion of procedure elements with stakeholders.

The key elements of the procedure are shown in Figure 2:

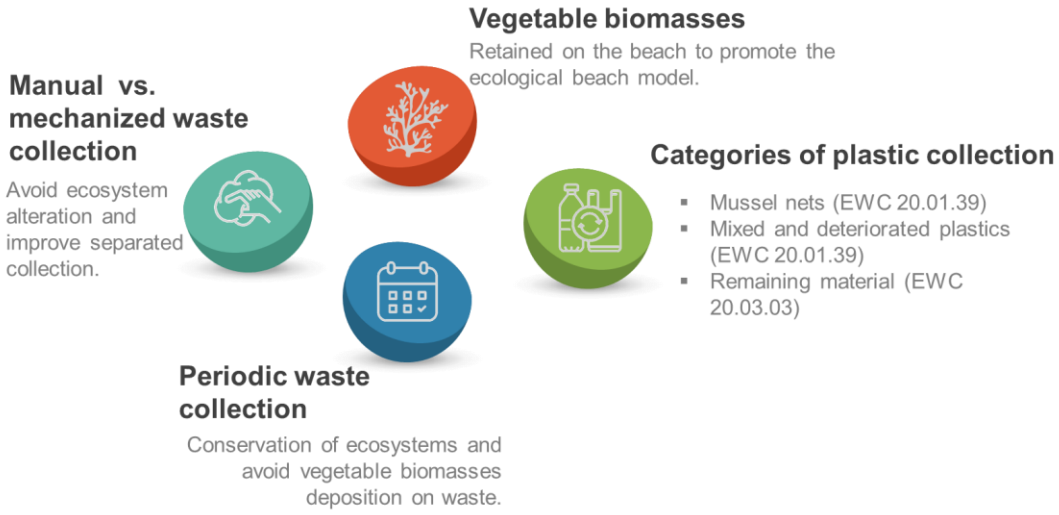



**Figure 2 Key elements of the procedure for plastic marine litter collection and valorisation**

Vegetable biomasses (wood, reed canes, seagrass wrack) should be prioritized to be retained on the beach to promote the ecological beach model. In this sense, manual waste collection (carried out volunteers or staff of companies responsible for collection) should be preferred to avoid ecosystem alteration and improve separated collection. Waste should be removed periodically, thus ensuring a clean environment that supports the conservation of ecosystems and pristine decorum of the coastal landscape and avoid vegetable biomasses deposition on waste. All events that involve volunteers should

also include and promote the value of informal and non-formal education which can be implemented through these events. It is suggested to collect plastics separately according to three categories:

1. Nets used for mussel farming. This category (EWC 20 01 39) may be mechanically recycled through process described in Figure 3 (a);
2. Other plastics usually mixed and deteriorated. This category (EWC 20 01 39) could be treated via pyrolysis through process described in Figure 3 (b);
3. The remaining material will be classified as "residues from street and beach cleaning" with EWC code 20 03 03.


(a)


(b)

**Figure 3 Treatments for valorisation of plastic marine litter from separated collection.**

# 5. Sustainability hotspot

## 5.1 Methodology

The sustainability analysis has been carried out according to a life-cycle approach by taking into account the three dimensions of sustainability: environment, economy and society. The methodologies adopted are:

- Life Cycle assessment (LCA) for the environmental dimension [4][5][6];
- Environmental Life Cycle Costing (eLCC) for the economic dimension [7];
- Social Life Cycle Assessment (S-LCA) for the social dimension [8][9].

The goal of the three analyses was to identify sustainability hotspots, according to environmental, economic and social perspectives, generated by the biowaste management, and by comparing the current situation (baseline scenario) with local composting situation (NETWAP scenario). The functional unit (FU) chosen for this assessment is the treatment of 1 ton of biowaste produced in the two pilots. The system boundaries are gate-to-cradle and includes the following stages: 1) waste collection; 2) waste transportation from the village to the treatment facilities; 3) temporary waste storage (if needed); 4) waste treatment.

## Main methodological settings

LCA modelling has been carried out by means of SimaPro software and EcoInvent v.3.5 database; impact assessment considered ReCiPe Midpoint (H) method*.

eLCC has been carried out considering both internal costs and externalities. Externalities were evaluated according to the Environmental Priority Strategies (EPS) [10] approach which evaluates impacts from emissions and use of resources contributing to the following areas of protection: ecosystem services; access to water; abiotic resources; human health; biodiversity.

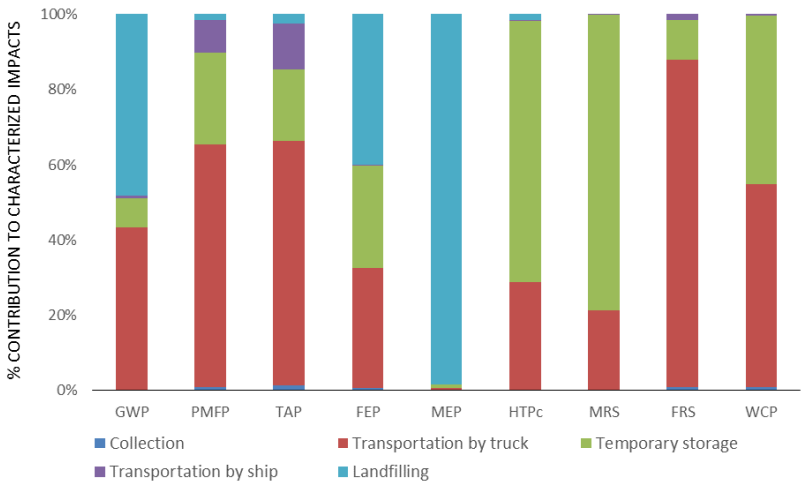
S-LCA was carried out according to the Product Social Impact Assessment (PSIA) method [9] which consists of four key components: stakeholder groups; social topics; performance indicators; reference scales to assess impact. The following stakeholder groups have been considered: users; workers; local communities; small-scale entrepreneurs. The list of social topic list has been inspired by the Handbook and UNEP Guidelines 2020 [8][9].

**GWP-Global warming potential, PMFP-Fine particulate matter formation potential, TAP-Terrestrial acidification potential, FEP-freshwater eutrophication potential, MEP-Marine eutrophication potential, HTPc-Human cancerogenic toxicity potential, MRS-Mineral resource scarcity potential, FRS-Fossil resource scarcity potential, WCP-Water consumption potential*

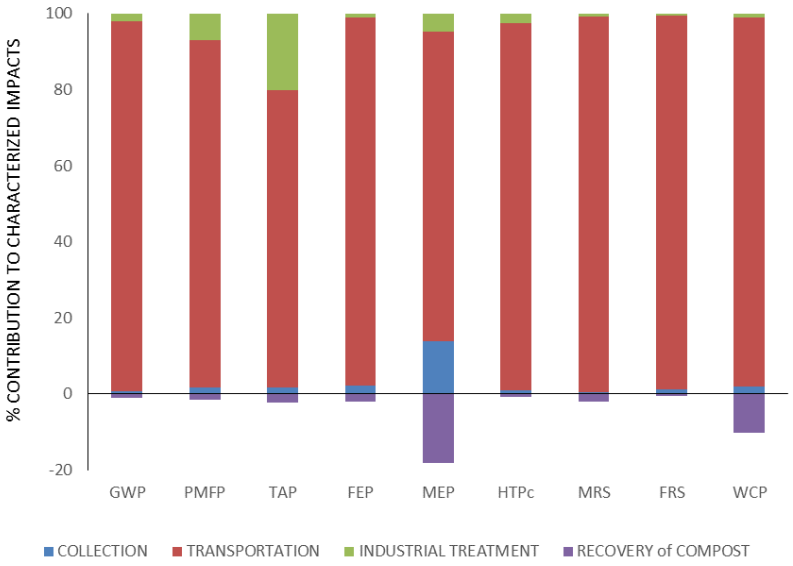
### 5.2 Hotspot's description

#### 5.2.1 Environmental hotspots

Environmental hotspots have been identified as those stages that mainly contribute to the analysed impact categories, according to the current waste management systems of the two pilots (baseline scenario) (Figure 4). Waste transportation resulted as the most important process in all the impact categories. Significant impacts are also due to the temporary storage of waste and landfilling, in the case of Ist island.




(a) Ist island




(b) Fossalto

**Figure 4 Environmental impacts of the current biowaste management systems (baseline scenario) (a – Ist island results; b – Fossalto results)**

The comparison between the baseline and NETWAP scenarios suggests that impacts reduction can be achieved along all the impact categories in both pilots. This finding is primarily due to the reduction of

impacts from waste transportation to centralized waste treatment; moreover, in the case of Ist island benefits are also produced by compost production, in alternative to the landfill disposal. The highest impact reduction is obtained in terms of Global Warming Potentials (GWP) (50-58%), Freshwater Eutrophication Potentials (FEP) (40-65%) and Mineral Resource Scarcity (MRS). An impact increase is seen only in terms of Water Consumption Potential (WCS) because of an increase in electricity consumption in composting process.

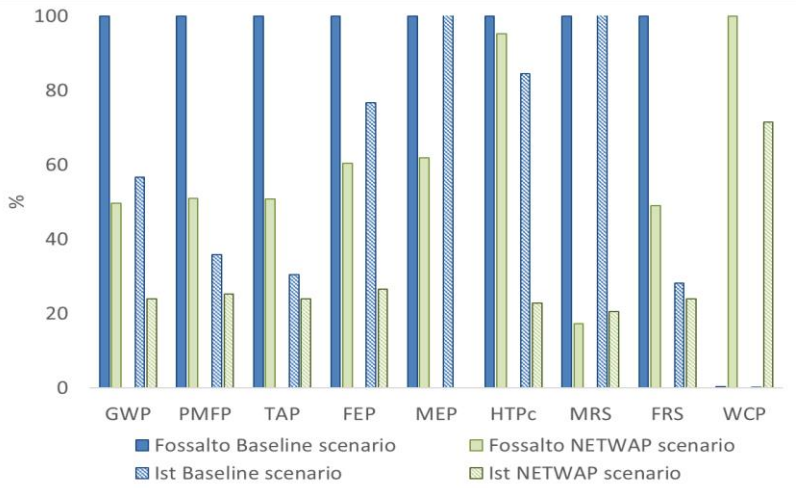



**Figure 5 Life Cycle Assessment results comparison between baseline scenario and NETWAP scenario**

### 5.2.2 Economic hotspots

Economic hotspots have been identified as those processes that mainly contribute to the internal costs and to the externalities, according to the current waste management systems of the two pilots (baseline scenario) (Table 2).

**Table 2 Internal costs and externalities of the current biowaste management systems (baseline scenario)**

| Costs | Stages/Safeguard subject | Ist island | Fossalto |
|---|---|---|---|
| Internal cost | Collection | 1280€/FU (63%) | 118€/FU (42,8%) |
| | Transportation | | 75€ (27,2%) |
| | Treatment | 739€/FU (37%) | 80€/FU (29%) |

| | | | |
|---|---|---|---|
| | Compost (income) | Not present | -2,6€/FU (0,9%) |
| | **Total** | **2019 €/FU** | **270 €/FU** |
| Externalities | Ecosystem services | 2,68 €/FU | 10,47 €/FU |
| | Access to water | 0,16 €/FU | 0,65 €/FU |
| | Biodiversity | 0,01 €/FU | 0,04 €/FU |
| | Human health | 132,54 €/FU | 473,36 €/FU |
| | Abiotic resources | 7509,17 €/FU | 5362,15 €/FU |
| | **Total** | **7644,57 €/FU** | **5847 €/FU** |

Biowaste collection, by means of compostable bags, represents the main cost in the case of Fossalto, followed by treatment cost. Cost of plastic bags is the main responsible cost item for collection cost (around 60%), while the income deriving from the production of compost is negligible.

Regarding the Ist island, the total internal costs of the baseline scenario is very high for such a small island without industrial activities. The main responsible processes are the collection and transportation via ship, followed by landfill treatment cost, and it cannot be reduced by valorisation treatments.

The total environmental damage cost for the baseline scenario in both pilots is mainly due to damages to abiotic resources, and costs are driven by the transportation phase (fossil fuels consumption) and the temporary storage of waste in the deposit station (only in the Ist island case). These two stages are also prevailing in the other safeguard subjects. The savings in the environmental costs due to the compost use as chemical soil improver are not very relevant, being lower than 4% of the damage cost in each safeguard subject. Indeed, for Access to Water, Ecosystem Services and Biodiversity, no significant environmental costs were registered.

The comparison between the baseline and NETWAP scenarios suggests that internal costs can be decreased in both pilots. In the case of Fossalto reduction of waste transportation to centralized composting plant and also to the replacement of plastic bags with bins for the waste collection are the main responsible of that. While in the case of Ist island, the reduction of waste transported via ferry and the decrease of landfilled waste will produce benefits in terms of internal cost. At this moment, cost reduction can be estimates in terms of externalities (Figure 6). As it can be observed, the introduction of local composting (NETWAP scenario) produces a reduction of externalities of around 85% in both pilots; this is mainly related to fuels saving in waste transportation.

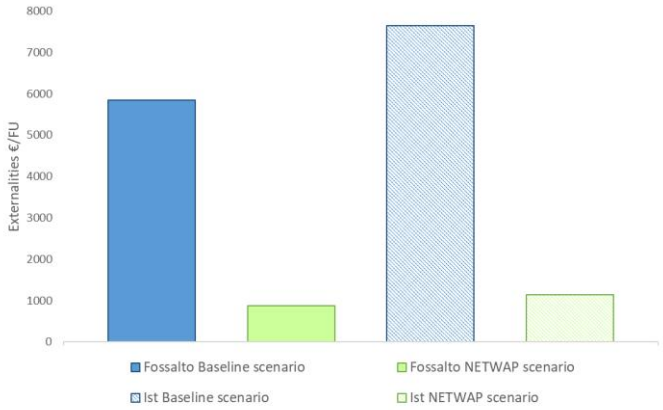



**Figure 6 Externalities comparison between baseline scenario and NETWAP scenario**

### 5.2.3 Social hotspots

Social hotspot identification consists of the identification of material[1] stakeholders and related social topics. Starting from the social topics and stakeholders proposed by S-LCA guidelines and sectorial literature, specific interviews were carried out to project partners', in representation of local communities and local authorities. This work resulted in a clear and comprehensive list of stakeholders and social topics. At this stage, social hotspot cannot be quantified but evaluated at qualitative level by considering expected effects (positive and negative) due to the introduction of local composting. Table 3 shows relevant stakeholder groups and their specific definitions according to the pilots' peculiarities. In the case of Fossalto, the relevance of local community is not evident for the moment as in the case of Ist Island where local community is represented by actors of tourism sectors. However, as the level of awareness increases, this topic is likely to become important also in Fossalto case study.

**Table 3 Relevant stakeholder groups of the current biowaste management systems (baseline scenario) and the new one (new scenario)**

| Stakeholder group | Ist island | Fossalto |
|---|---|---|
| Workers | - Workers of local company dedicated to waste management system (baseline scenario)<br>- Workers involved in the local composting plant (new scenario) | - Workers of local company dedicated to waste management system (baseline scenario)<br>- Workers involved in the local composting plant (new scenario) |
| Users | - Citizens<br>- Commercial activities (e.g. markets, restaurants)<br>- Touristic facilities (e.g. hotels) | - Citizens<br>- Commercial activities (e.g. markets, restaurants) |
| Local communities | - Tourists<br>- Port authority | Not relevant |
| Small-scale entrepreneurs | Small local farms (compost users) | Small local farms (compost users) |

[1] A social topic is considered material if one of these conditions are satisfied: if a product and its life cycle is likely to have a high positive or negative impact on the stakeholders; if the intended audience finds a topic very relevant and desires to have information on it [9].

| | | |
|---|---|---|
| Society | Aggregate of people living in a wider geographic area (at least the regional/national scale) | Aggregate of people living in a wider geographic area (at least the regional/national scale) |

In terms of social topics, both pilots identified the same list of relevant topics, but interviews suggested some differences on the nature of effects – positive or negative - that are expected from the local composting. Answers are summarised in Table 4, where colour code is used to classify answers: yellow when the effect is considered neutral (no effect); green the case of positive effect; red when the effect is negative. In some cases, it is still not possible to identify the effect that will be produced by the new biowaste management system (grey colour). The social topics excluded because considered not relevant are child labour, forced labour, privacy, meeting basic needs, land rights.

**Table 4 Relevant social topics of the current biowaste management systems (baseline scenario) and the new one (new scenario) (yellow=neutral; green=positive effect; red=negative effect; grey=don't know)**

| Stakeholder group | Social topics | Fossalto pilot case | Ist Island pilot case |
|---|---|---|---|
| Workers | Occupational health and safety | No differences are expected. | |
| | Remuneration | No differences are expected. | In the long term, workload and responsibilities of worker involved should be broadened to make the salary more justifiable. Overall, expenses still might be less than before. |
| | Discrimination | | |
| | Freedom of Association and Collective Bargaining | | As the waste management is under a public institution, it means any activity done by the institution should be done in the best interest of the public. However, relationships and responsibilities of public institutions at different levels (e.g local, regional and national authorities) could hinders the freedom of association of workers and local community. |
| | Work-life balance | No differences are expected. | This could represent an opportunity for people who wishes to stay in a remote area. Specifically, Ist island is 2 hours away by public transport, so most of the Ist residents stay in Zadar over the week and |

| | | | |
|---|---|---|---|
| | | | return to Ist on weekend. These kinds of opportunities can be beneficial for the local communities. |
| Users | Health and safety | No differences are expected. | In the long term by plastic waste reduction this might come to have a bigger impact, but we cannot say that community composting has an effect on this category. |
| | Feedback mechanism[2] | Local community is engaged and supportive of any positive development. | Population of the Ist island is engaged in maintaining the island as clean as possible, so having activities and a tangible commodity such as a composter motivates further developments. |
| | Responsible communication[3] | | Education and good communication will encourage people to put more efforts in the separate waste collection. Users are more willing to separate waste if they have reliable information what is happening with that waste latter one. |
| | Affordability | Low waste fee is expected for citizens. | Low waste fee is expected for citizens. Moreover, they may benefit from the compost and/or reduction of waste management fee. |
| | Accessibility | The same waste collection will be applied (door-to-door). | The same waste collection will be applied (door-to-door). |
| | Effectiveness and comfort | The effect will be positive; however, the start-up phase will be fundamental to identify optimal technical conditions (e.g. quality of input biowaste) and organizational (e.g. number of personnel). | The effect will be positive, because community composting requires less effort from the users than home composting. However, tourists should be properly informed and supported for the separated waste collection. |
| Local community | Health and safety | One expected risk is the odour. | |

[2] This social topic includes the concepts of "customer satisfaction" and "level of acceptance" that arose during interviews.

[3] This social topic includes also the concept of "development of environmental awareness &responsibility" that arose during interviews.

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|---|---|---|---|
| | Access to material and immaterial resources | | This initiative was one of several ideas the local residents had in mind when thinking about their island preservation. |
| | Community engagement | The new waste management system will increase awareness in terms of environmental sustainability of the territory. | As there is a noticeable discrepancy between the tourists and the local community, especially related to waste disposal, these sorts of activities support engagement because they indicate some positive changes can be done, especially when related to the public institution. |
| | Skill development | | |
| | Contribution to economic development | | This is one aspect that has an immediate effect. It creates local employment opportunity, and it can provide mutual interest between several islands. |
| Small-scale entrepreneurs | Access to service and inputs | Compost as a soil improver. | Compost as a soil improver. |
| | Women's empowerment | | |
| | Health and safety | | |
| | Fair trading relationships | | |
| Society | Public commitments to sustainability issues | | |

## 6. Recommendations for stakeholders and conclusions

Potential environmental, economic and social benefits can be reached through the implementation of local waste management systems for biowaste and plastic marine litter. However, autonomous management systems in small communities need a natural transition phase during which both technical and organizational aspects could be optimized. A full and effective operation of local composting and plastic marine litter management can be achieved by combining the following elements:

- to provide continuity to activities according to a continuous process of constant improvement;
- to grow trust on members of local community;
- to strengthen awareness about reasonings and objectives, according to short and long-term perspectives.

All the actors involved should play a role in the right direction; for this purpose, some recommendations are provided for each stakeholder group.

## 6.1 Policy makers (national and local authorities)

- To be engaged in **public commitment to sustainability issues.** Policy makers at different levels shall be at the forefront of finding and supporting new systems/technologies that could promote sustainability in their territories and local communities. In this sense they make an agreement to local communities, and other territorial stakeholders, whose fulfilment can be evidenced in a transparent and open way. Typically, this will take the form of performance improvement targets and public reporting of progress, that should be disseminated through website, promotional materials, or other means.
- Develop **awareness campaigns** upon environmental and socio-economic sustainability targets and opportunities tailored to police makers, companies, trade and professional associations, citizens, etc. Contents should make reference to the European framework and targets about environmental objectives set by European member states (e.g. Sustainable finance taxonomy - Regulation (EU) 2020/852), and also to the specific waste management sector;
- Organise **dissemination activities** (e.g. training and awareness-raising) to inform and to enhance the **level of acceptance** of new waste management systems. Citizens and local communities in general express high and positive expectations toward more sustainable waste management systems; however, the level of acceptance depends on the level of engagement during all the process of implementation;
- Set up **systems for monitoring progresses** of the new waste management and objectives achievement to prevent/solve occurring problems/risks and grow trust on local communities. Objectives could be measured according to the expected temporal scope:
    - short-term expectations are about waste fee reductions and waste systems optimization;
    - mid- and long-term expectations are about economic growth of the area (e.g. eco-tourism, local employment) and the activation of a path of improvement on the environmental sustainability of the area.
- Promote the implementation of a multi-stakeholder roundtable to discuss and to support **transferability** of successful experiences of local and autonomous waste management systems to similar locations;
- Set up specific **regulatory action** for EU Member States to promote an ecological transition across Europe **to reduce marine litter** and waste production derived from beach cleaning operation;

- Create **economic incentives** to support extra cost related to waste separation service applied to of marine litters (e.g., contribution of the central governments, subtracted from the burden of state concessions);
- Adopt proper systems for beached vegetal biomasses management by European countries rapidly (e.g., according to the model of ecological beaches);
- Develop and/or promote a generalised approach and standardises quantification and labelling of territories characterized by high values in terms of commitment to environment preservation and quality of life, with the aim of improving attractiveness;
- Decision-making process shall be supported by detailed impact assessments based on a **life cycle approach and the three pillars of sustainability** - social, economic and environmental - in order to have a comprehensive view about potential benefits/risk and to avoid burden shifting;
- Increase efforts on developing knowledge and methodologies to evaluate **environmental impacts of marine litter, especially plastics, by means of Life Cycle Assessment** methods and tools, according to the recent UNEP and the Life Cycle Initiative activities about Life Cycle Approach to Plastics Pollution [12] and the Marine Impacts in LCA (MariLCA) project [13].

## 6.2 Companies (waste management, touristic facilities and small local farms)

- Develop and deliver **training sessions for companies and professional operators involved in the waste management** systems about practical actions and potentials benefits deriving from local waste management systems and separate waste collection applied to the cleaning of coastal areas;
- Create **incentives** (e.g., tax credits, reduction of the state fee, rewards in the scores of tenders or environmental certification) to support operators who separate the waste collected along the coast and manage the beached vegetable biomass instead of disposing them;
- Deliver training activities for actors in the tourism sector about potentials benefits produced by actions for environment protection, and, in particular actions regarding waste management. Improvement of territorial attractiveness and paving the way for **sustainable tourism** (e.g. eco-tourism) should be the key elements to be discussed;
- Provide dissemination activities (e.g. training and awareness-raising) to **inform small local farms about application and use of compost** as soil improvers, and to explore more sustainable agricultural techniques;

### 6.3 Citizens and local communities

- Develop dedicated **dissemination activities** towards citizens and local communities' members to facilitate **early-adoption of proper actions** related to waste sorting and to support acceptability and trust on the new waste management systems;
- Provide dissemination activities to **inform about expected benefits** (e.g. local employment, waste fee reduction) and progresses toward their achievement.

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