Report on methodologies, research and solutions on the waste issues and involvement of civil society

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Document History

Version	Issue Date	Stage	Changes	Contributor
1.0	14.12.2025	Draft	First full draft of the document.	UNITS
2.0	16.01.2026	Final version	Final version of the document after feedback from partners.	UNITS, IPTPO, ETIFOR, Natura Histrica

Table of contents

Executive summary

This report describes the methodological framework developed and used in the Wastereduce project to acquire specific knowledge and information about the situations in the target natural and protected areas, analyze these situations and their contexts, and guide the planning of strategies and actions aimed at reducing waste and litter.

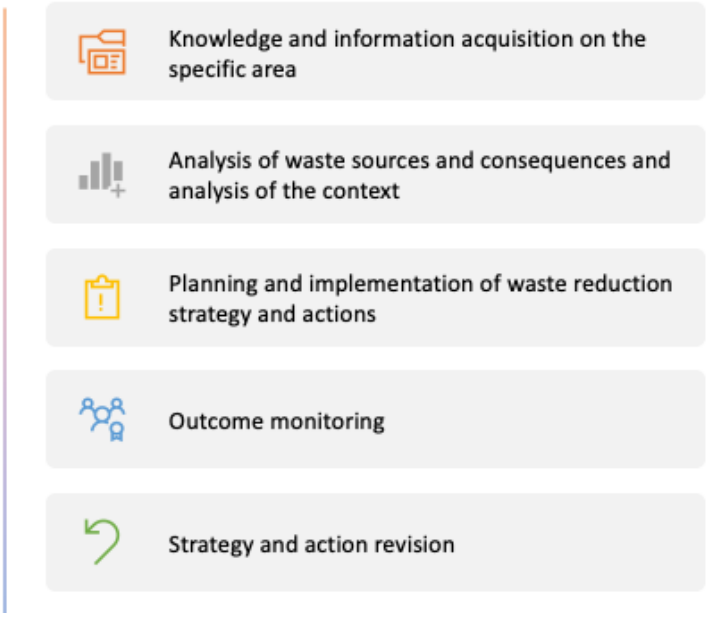
The Wastereduce methodological framework integrates the contributions from several knowledge and information sources, including feedback from stakeholders and civil society. The framework aligns with the project's participatory approach, and it represent a methodological support for planning strategies and actions.

After a brief introduction, the second section of the report presents the Wastereduce methodological framework. The third section describes the information sources and methods used to assess litter and waste status in protected areas or to gather knowledge useful for supporting subsequent planning, highlighting their specific contributions, advantages, and limitations. The fourth section explains how the framework supports planning strategies and actions, and how it could be extended and applied in other settings and projects focused on preventing waste production and reducing waste in natural and protected areas. It also summarizes the relationships between the Wastereduce methodological and participatory frameworks and the involvement of stakeholders and civil society.

1. Introduction

The reduction of waste and litter in natural and protected areas is a complex issue that needs to be addressed with knowledge-based and evidence-based strategies and actions. This requires (1) acquiring specific knowledge and information about the situation in the target areas, (2) analyzing the situation and its physical, environmental, social, economic, and normative context, using appropriate methods and scientific knowledge of the sources and consequences of waste, (3) planning and implementing knowledge-based and evidence-based waste reduction strategies and actions, (4) monitoring and evaluating the outcomes, and, when needed, (5) revising the implemented waste reduction strategies and actions. In the Wastereduce project, we followed this approach, summarized in **Figure 1**, guided by a methodological framework that allowed us to integrate the contributions from various information and knowledge sources in a consistent way.

Figure 1. Stages in the Wastereduce proposed approach.



2. The Wastereduce methodological framework

We developed and applied a methodological framework to integrate the results obtained from various information and knowledge sources consistently. This framework was essential for the first two stages of the Wastereduce approach: (1) acquiring specific knowledge and information about the situation in the target areas, and (2) analyzing the situation and its context (see **Figure 1**). The framework was also a useful guide for the subsequent planning stages.

In this report, we describe only the general framework and its components; more detailed descriptions of specific methodologies used and the information and knowledge obtained are available in separate in-depth reports (see **Table 1**, last column). Additionally, the Wastereduce participatory approach and solutions will be described in Output 2.2, and the general Wastereduce approach in Output 2.3

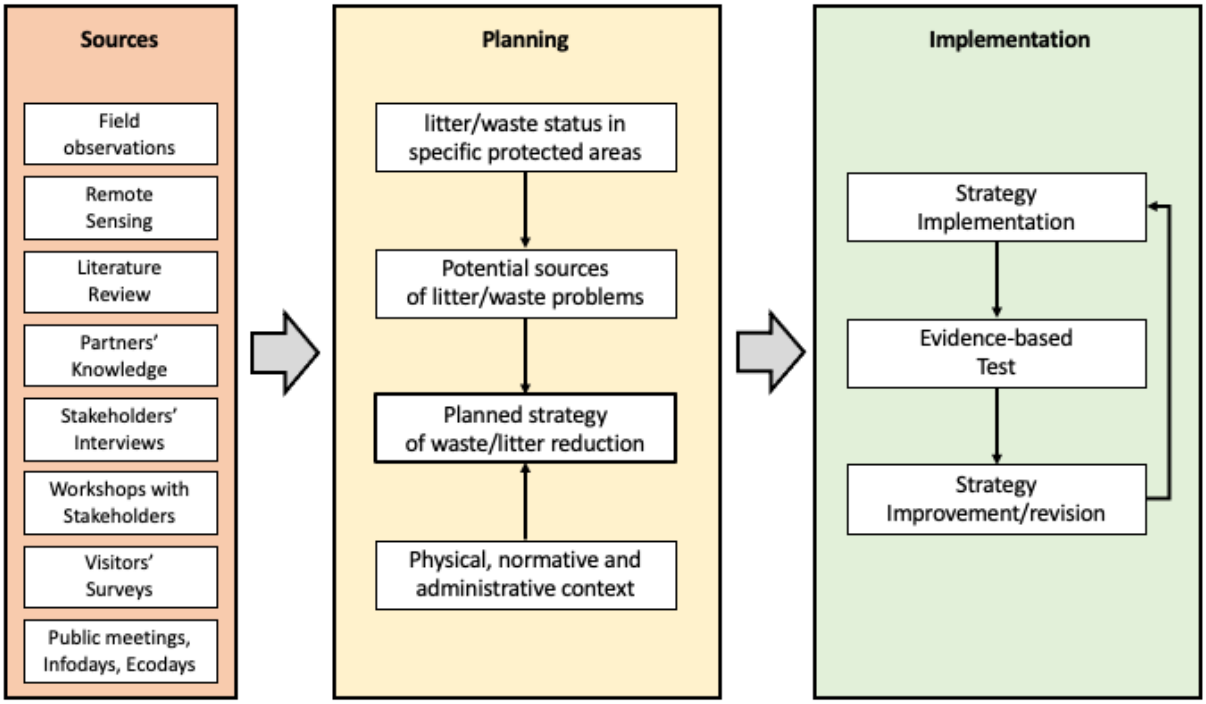
Table 1. Sources of information and knowledge for the Wastereduce methodological framework, and references to the in-depth description of specific methods and results.

Information/knowledge	Source	Methodology/results described in
• Waste situation in the target areas	**Field observation**	• **D1.8.1**. Methodology for developing/conducting questionnaires, interviews, behavioral observations • **D1.8.3**. Analysis on visitors' binning and waste abandonment behavior
• Waste situation in the target areas	**Remote sensing**	• **D1.9.1**. Methodology for identifying, marking and mapping locations where waste accumulates the most • **D1.9.2**. Database of locations where waste is systematic accumulated and types of waste • **D 2.13.1.** Conducted image analysis for the identification and monitoring of waste disposal sites • **D2.13.3.** Developed and tested method of monitoring the marine environment by analyzing satellite images
• Knowledge on possible interventions	**Literature review**	• **D1.5.1**. Methodology for the implementation of meta analysis and state of the art analysis of human behavior • **D1.6.1**. Report on the effectiveness of behavioral interventions and waste reduction communication policies and on state of the art of human behavior

• Waste situation in the target areas • Knowledge on possible interventions • Potential acceptability of interventions	**Stakeholder interview**	• **D1.8.1**. Methodology for developing/conducting questionnaires, interviews, behavioral observations • **D1.8.2**. Analysis of the opinions and attitudes of the examinees on waste reduction actions
• Waste situation in the target areas • Potential acceptability of interventions	**Visitor survey**	• **D1.8.1**. Methodology for developing/conducting questionnaires, interviews, behavioral observations • **D1.8.2.** Analysis of the opinions and attitudes of the examinees on waste reduction actions
• Knowledge on possible interventions • Potential acceptability of interventions	**Project/Practice Review**	• **D1.7.1**. Methodology for identification of strategies, policies, good practices and gaps in waste reduction • **D1.7.2**. Database of strategies, policies, and good practices in waste reduction
• Waste situation in the target areas • Potential acceptability of interventions	**Other sources**	• **D.1.10.1** Project meeting • **D.1.13.1** Workshop • **D.2.5.1** Implementation of educational/professional excursions • **D.2.10.1** Public ecological days • **D.2.10.4** Agreements with municipalities and associations • **D.2.11.1** Workshop

The Wastereduce methodological framework (**Figure 2**) identifies a series of information and knowledge sources, used to acquire knowledge and information about waste-related situations in the target natural and protected areas, as well as their physical, environmental, social, economic, normative, and administrative contexts, or to gather knowledge useful for supporting subsequent planning. Acquiring information from each source requires specific methods tailored to each source (see **Section 3**). Knowledge and information obtained with different methods were integrated to analyze the situations in the target areas and guide subsequent planning stages. The identified solutions can then be implemented, tested, and, if necessary, revised in a continuous process of monitoring and improvement.

Figure 2. The Wastereduce methodological framework.



3. Data and information sources: specific contributions and limitations

Each source of knowledge or information and associated elicitation method provided specific contributions and had certain advantages and limitations. Employing different sources and methods and integrating the results was an effective way to mitigate the limitations and provide a comprehensive view of the situations investigated.

3.1 Field observation

Description

Field observations in the pilot areas were conducted during the first stage of the project (Activity 1.8), covering the three pilot areas: Sakarun Bay, Middle Brenta River, and the West Coast of Istria. For each pilot area, two on-site observation sessions per site were held to assess the actual consequences of visitors' littering behaviors and other waste-related phenomena. These sessions took place in locations identified as particularly problematic by local project partners to provide a worst-case analysis, using observation zones as samples and monitoring the situation throughout the entire observation days.

To complete the task, the observers followed a detailed, predefined methodology and used an observation grid that allowed them to record the frequency and approximate size of different types of litter and waste in the observation zone. For waste classification, we used a combination of the system proposed by Zero Waste Scotland, which focuses on the type of human activity producing the waste, and the European classification for marine macro-litter, which focuses more on the type of waste. Observers also reported the presence of bigger amounts of waste of artificial origin (e.g., illegal dumping) or the accumulation of natural materials (e.g., seaweed), as well as other degradation issues in the observation zone that may affect the perception of the area, such as degraded buildings or unsafe places.

In addition, observers reported the presence in the observation zone or surrounding areas of items that directly or indirectly support proper binning and waste disposal, and their status, such as the presence and condition of bins, signs or indications, and video cameras. Finally, observers were asked to provide a general evaluation of the observation zones and the surrounding areas. For further details on the observation methodology and its background, see *D1.8.1. Methodology for developing/conducting questionnaires, interviews, behavioral observations*.

Contribution

The observation sessions provided an informative picture of the amount and type of waste found in the more problematic locations within the pilot areas, along with specific issues in those locations and their surroundings. They also offered valuable information on the level of environmental support available for proper binning and waste disposal. Overall, the situation was evaluated as rather problematic (Sakarun Bay) or problematic (Middle Brenta River, and the West Coast of Istria), and the environmental support as generally poor and insufficient. This knowledge was useful for identifying potential issues and suggesting interventions, and it complemented the information obtained through other methods. For further information on the observation outcomes, see *D1.8.3. Analysis on visitors' binning and waste abandonment behavior*.

Advantages

The main advantage of field observation is that it does not rely on subjective self-reports or on opinions that may be biased or reflect memory and cognitive limitations. Moreover, if correctly conducted, observation can be reliable and informative.

Limitations

In agreement with the project description and due to practical constraints, the number of observation sessions and observed locations were limited. The adopted approach represents a worst-case analysis that allows the detection of the more problematic situations, but it is not thought to offer a truly representative picture of what typically happens in the whole pilot areas. Due to the timing of project approval and start, the observations started later than originally planned, which can be considered as a forced limitation. Moreover, although observation provides useful evidence, it does not allow inferences on the causes of waste and litter.

3.2 Remote sensing

Description

The primary goal of the activities related to remote sensing was to apply advanced technologies and analytical methods to effectively detect and manage waste in the target areas of the Wastereduce project. Five selected pilot sites were selected for the study: Akvatorij zapadne Istre, Ušće Raše, Ušće Mirne, Uvala Sakarun, and Grave e Zone umide della Brenta.

A comprehensive overview of the methodological framework for this activity was developed, which focused on identifying, marking, and mapping waste accumulation in pilot-protected and Natura 2000 areas. The framework encompassed the format and storage protocols for the data

to be collected, ensuring consistency and accessibility. The development of the framework was based on a review of various methods for remote waste identification, highlighting single-parameter and multiple-parameter analysis techniques, as well as on an overview of available satellite resources and datasets. The methodologies considered encompassed a range of techniques, from expert analysis of satellite images to identify waste locations to deep learning approaches in image classification and semantic segmentation. However, it was highlighted that the selection and application of these methodologies would depend on the availability of high-resolution satellite imagery, thermal and vegetation indices, and other relevant data. For more information on the remote sensing framework see *D1.9.1. Identifying, marking, and mapping locations in pilot- protected and Natura 2000 areas where waste is systematically accumulated*.

A preliminary feasibility analysis on the project's designated pilot areas determined that a reliance on standard remote sensing techniques, such as free satellite imagery, was insufficient for this task. The spatial resolution of these sensors was inadequate for detecting the small, scattered, and often fragmented nature of waste, which includes beached marine litter and diffuse terrestrial littering. To overcome this limitation, a robust, multi-faceted methodological approach was developed, built upon two complementary pillars: the analysis of existing data from authoritative European, national, and citizen-science databases, and the execution of targeted, direct on-field surveys conducted by project partners.

The application of this integrated methodology allowed for a comprehensive assessment of waste contamination in each pilot area. This dual-source approach enabled the identification of recurring waste accumulation hotspots and provided a typological characterization of the waste found in each of the designated Natura 2000 sites. As a final product of this analysis and the creation of a comprehensive database, the data for all identified waste accumulation points were presented in both Excel (.xls) and shapefile (.shp) formats. For more information on the results see *D 1.9.2. Database of a) locations where waste is systematic accumulated and b) types of waste*.

An additional remote sensing approach was evaluated using hyperspectral data acquired by an unmanned aerial vehicle (UAV) over Sakarun Bay, one of the pilot areas. The drone survey provided hyperspectral imagery with a spectral range between 350 and 1002 nm of wavelength, from which spectral signatures of both natural and anthropogenic materials were extracted. These signatures were subsequently used to train a Random Forest classification model aimed at identifying the various materials present on the beach surface. The model exhibited limited capability in detecting small waste particles when imagery was acquired at flight altitudes of 20

and 30 m, i.e. 3,42 and 5,12 cm of spatial resolution. Improved classification accuracy was observed at a lower altitude of 10 m, with a spatial resolution of 1,71 cm; however, the performance remained insufficient to achieve a robust and reliable classification. Some natural matter is misclassified, for example some portions of Posidonia is classified as wood, and also waste materials and shadows are slightly overestimated. Therefore, there is still the need for implementation, and an increase of spatial resolution of the images is likely to improve the model accuracy.

A second classification strategy was tested using spectral libraries obtained from online repositories, which include reference spectra for 33 artificial materials, including plastic, polyester, polystyrene and fiberglass with different characteristics. In this case, a Spectral Angle Mapper (SAM) algorithm was applied to the same hyperspectral datasets used in the previous analysis. Similar to the Random Forest approach, satisfactory results were achieved only for imagery with 1,71 cm of spatial resolution, whereas acquisitions with lower resolutions yielded suboptimal classification performance.

All the detailed methodology and results of the two classification models can be found in the *D 2.13.1. Conducted image analysis for the identification and monitoring of waste disposal sites*.

Additionally, Satellite-based monitoring of pilot area Akvatorij zapadne Istre (HR1000032) was conducted in Lim Bay for the period between May and September 2024 using the Coastal Intelligence software developed by Sea Cras d.o.o. The methodology relied on a proprietary artificial intelligence algorithm designed to process very high-resolution (VHR) satellite imagery. Satellite data form multiple sources (Maxar WorldView Legion, Pléiades Neo, Planet SkySat, and Planet Dove) was used and to support interpretation of satellite-derived indicators, meteorological and oceanographic data from local monitoring stations were integrated into the analysis.

The monitoring focused on key biochemical and environmental descriptors: chlorophyll-a concentration (D5), Total Suspended Matter (TSM) (D7), and marine litter (D10). Results revealed clear seasonal patterns, particularly for chlorophyll-a, which showed increased concentrations during the spring and early summer, with the highest values detected in the more enclosed inner parts of the bay. These patterns reflect the bay's semi-enclosed geomorphology and limited water exchange, which influence biological productivity and material retention.

A notable event was detected on 9 August 2024, when surface mucilage aggregates were clearly observed in satellite imagery in the western part of the bay, at the transition zone between the open sea and the bay system. The restricted hydrodynamics and water column stratification of

Lim Bay limited the spatial spread of these aggregates, highlighting the importance of local conditions in determining spatial dynamics.

Advanced detection techniques successfully distinguished vessels and mucilage, while the detection of floating plastics proved more challenging due to false positives and the complexity of the coastal environment.

Marine litter monitoring (descriptor D10) identified the highest risk of plastic pollution at the entrance of the bay and at its easternmost section, with medium to lower risk along navigation routes and smaller coves. These risk patterns are influenced by hydrodynamic transport from the Adriatic Sea, intensive maritime traffic, and tourism-related activities. Overall, the results demonstrate the value of high-resolution satellite monitoring for identifying spatial and seasonal risk patterns, while also highlighting current limitations in detecting small plastic items in complex coastal environments.

Contribution

The primary outcome of this work was the development of a database of waste accumulation sites within the project's pilot areas. This database represents a practical resource to support cleaning operations and to identify zones that are particularly prone to waste accumulation.

A second tangible outcome of the study was a desktop application designed to process local hyperspectral imagery and generate classification maps using the Spectral Angle Mapper (SAM) algorithm, together with the spectral signatures of the reference materials. This application represents a prototype and will require further development to enhance usability, improve adaptability to different image types, and expand the reference spectral library by incorporating additional material spectral signatures to the reference spectra dataset.

Lastly, the investigation and testing of remote sensing technologies provided a comprehensive overview of their potential applications for the detection and management of waste in natural environments. The results indicate that freely available satellite imagery and drone surveys may be ineffective when spatial resolution is insufficient to reliably detect surface waste, and these approaches can be only suitable with higher spatial detail.

Advantages

The principal advantage of the proposed approaches lies in their potential to establish a standardized methodology that integrates remote sensing technologies for waste detection and material classification in natural environments. These tools may substantially reduce the time required for waste identification and monitoring activities, while also enabling applications in areas that are difficult to access through conventional field surveys.

Limitations

The main limitation of the proposed methods is determined by the spatial resolution of the imagery used for analysis, which is the primary factor affecting waste detection capability and the spatial extent of the study area explored. As the area of interest increases, acquiring imagery with sufficiently high resolution for waste identification becomes increasingly challenging. In such cases, commercial satellite imagery may represent the only viable option, with costs directly proportional to the size of the study area and the number of images required. Conversely, UAV-based surveys involve high operational costs and require skilled personnel for proper deployment, representing an additional economically demanding solution.

3.3 Literature review

Description

The Wastereduce project activities include producing a systematic review and meta-analysis on the effectiveness of informative and behavioral interventions designed to promote waste-related pro-environmental behaviors in natural and protected areas. The methodology followed the PRISMA 2020 (Preferred Reporting Items for Systematic reviews and Meta-Analyses) guidelines and previous work in the field. Given the limited number of studies on the effectiveness of such interventions in natural and protected areas, the systematic review included not only studies targeting actual or self-reported behaviors and their consequences but also those investigating changes in behavioral intentions. To assess the generalizability of intervention effectiveness, we also included studies on waste-related behavior in public urban spaces, considering the type of environment (natural vs. urban) as a moderator in the presentation of results and/or analyses.

Following previous work in this field, we included the following types of interventions: (1) making behaviors easier to perform, such as moving recycling bins to a more convenient location; (2) providing reminders of appropriate actions, such as “put litter in the appropriate bin”; (3) providing reasons for performing a specific behavior, such as explaining that recycling is important for avoiding waste of resources and pollution; (4) providing instructions on how to perform a specific behavior, such as recycling; (5) providing feedback about past behavior, such as errors made in sorting waste; (6) providing rewards or incentives for appropriate behaviors; (7) showing others engaged in a behavior, such as community members recycling waste; (8) appealing to preexisting beliefs to encourage belief-consistent behavior; (9) asking people to make a commitment to engage in a behavior, for example by signing a pledge card; (10) asking

people to reach a specific goal, for example by carrying home the waste they produced during a visit; (11) informing people that the environment is monitored, for example via cameras or local officers; (12) combined interventions; and (13) other types of interventions. The behaviors and intentions considered include reusing containers, binning, recycling, taking personal litter away, picking up litter produced by others, signaling litter, and other behaviors. For more details on the methodology see *D1.5.1. Methodology for the implementation of meta-analysis and state of the art analysis of human behavior*.

Contribution

The work on the systematic review will be reported in January 2026, due to the very high number of records retrieved from the scientific databases that had to be screened (about 11,000). It will provide a methodologically grounded appraisal of the effectiveness of different types of informative and behavioral interventions to promote waste reduction and appropriate binning behavior at the individual level in natural and protected areas, as well as in public urban areas. The results will be reported in *D1.6.1. Report on the effectiveness of behavioral interventions and waste reduction communication policies and on the state of the art of human behavior.*

Advantages

The main advantage of systematic reviews and meta-analyses is that they provide a methodologically grounded evaluation of existing scientific evidence, in our case on the effectiveness of various informative and behavioral interventions to promote waste reduction and appropriate binning behavior at the individual level. This approach avoids the limitations of less systematic syntheses of the scientific literature or reporting based on episodic observations.

Limitations

Systematic reviews and meta-analyses may have limitations related to specific methodological choices, such as the definition of queries, selection of databases, and presence of publication bias (for details on how we addressed these and other aspects, see *D1.5.1. Methodology for the implementation of meta-analysis and state of the art analysis of human behavior*). Additionally, in our case, the available evidence appears limited because there are relatively few studies on behavioral interventions in natural and protected areas, and these focus on a limited range of intervention types.

3.4 Stakeholder interview

Description

Semi-structured interviews were conducted with representatives of institutions managing Natura 2000 sites and local stakeholders. After presenting the informed consent, the interviews focused on: (1) respondents' assessment of the general state of their area of interest (pilot area) regarding waste-related issues; (2) identification of the most problematic locations and behaviors in the area; (3) waste management measures already implemented; and (4) future measures considered useful for reducing waste and improving waste management. Participants could also provide additional suggestions, and we collected their socio-demographic information and stakeholder type (e.g., NGO, managing authority, economic actor), while preserving the anonymity of responses. The interview content and administration procedure were approved by the Ethics Committee of the University of Trieste.

Respondents were recruited by project partners through personal contact (email or phone call). The interview was administered online using the Qualtrics platform, and respondents received a link to access the interview, which they could complete at their convenience. Procedures and methodological details are presented in *D1.8.1. Methodology for developing/conducting questionnaires, interviews, behavioral observations*. For analyzing responses to open-ended questions, a classification scheme was developed to group them into a manageable number of meaningful categories and responses were classified according to this coding scheme by two expert raters.

Contribution

The results regarding stakeholders' landscape perception and degradation ratings were consistent with visitors' assessments (see **subsection 3.5**), highlighting littering, occasional waste, and accumulations of natural origins as common issues in the pilot areas. As in the pilot area surveys, illegal dumping of garbage was identified as a more significant issue in the Istria area.

Stakeholders identified visitors as the primary source of littering, while residents were more frequently cited as responsible for illegal dumping. Stakeholders attributed waste-related problems to several individual and structural factors. According to them, the most problematic locations were those highly accessible to people due to the large number of visitors, as well as more remote or forested areas where inaccessibility hinders cleaning efforts and regulatory oversight.

Stakeholders were not very satisfied with the information and education strategies implemented in the pilot areas and emphasized the need for improvements, particularly in providing information to visitors and residents through appropriate signs and other promotional materials. Consistent with survey findings, stakeholders rated the provision of instructions as a highly effective strategy. However, unlike visitors, they also considered requesting commitments from visitors to be among the most effective measures.

Stakeholders generally reported low satisfaction with the implemented structural strategies. Improving waste collection and cleaning services was identified as one of the most effective strategies, along with imposing fines or other sanctions. The structural strategies rated as most effective in the visitor surveys – increasing the number of bins and optimizing their placement – were also rated highly by stakeholders in the Sakarun and Istria areas but considered less effective in the Brenta area. Conversely, controls were regarded as particularly important in the Brenta area, while stakeholders in the Istria area identified the provision of portable containers, waste signaling tools, and incentives as particularly effective measures. Some stakeholders also suggested that promoting "no trace" policies – encouraging visitors to leave no traces in the environment and take their waste with them – would be the preferred strategy in natural and protected areas. For further information on the visitor survey results, see *D1.8.2. Analysis of the opinions and attitudes of the examinees on waste reduction actions*

Advantages

The main advantage of stakeholder interviews is that they provide insight into the informed and specific points of view of individuals who operate in the relevant area of interest. This can reveal issues or aspects that may go unnoticed when using other methods.

Limitations

The main limitation of stakeholder interviews is that they may reflect subjective or biased views, as well as reflect personal or group interests. Other limitations include the small sample size, which may not be representative of all relevant stakeholders, and the qualitative and descriptive nature of the results.

3.5 Visitor survey

Description

The online survey was designed to collect visitors' perceptions, opinions, attitudes, and self-reported behaviors related to waste reduction and disposal in the natural and protected areas

of the project, as well as more generally in natural and protected areas in Croatia and Northeast Italy. The first goal of the survey was to understand visitors' perceptions of these areas, their waste-related behaviors while in the areas, and their suggestions for new or improved waste-reduction measures. The second goal was to identify the psychological and environmental factors that significantly promote or hinder correct waste-related behaviors, to inform proposals for specific interventions aimed at reducing waste production and improper disposal.

The Ethics Committee of the University of Trieste approved the informed consent, survey content, and administration procedure. The visitor survey included two data collections. The first data collection gathered self-reported measures of psychological and individual factors, as well as evaluations of potential interventions related to waste behaviors in natural and protected areas in Croatia and Northeast Italy. The second data collection focused on the project's pilot areas, involving only visitors to these locations, and assessed knowledge about Natura 2000 areas, self-reported psychological and individual factors associated with waste-related behaviors, contextual factors (such as perceived availability of waste-related facilities), and evaluations of possible interventions. For further details on the survey methodology and its theoretical background, see *D1.8.1. Methodology for developing/conducting questionnaires, interviews, behavioral observations*.

Contribution

The survey results showed that participants were generally satisfied with their visits and evaluated them positively. Littering, occasional waste, and accumulations of natural origin were perceived as relatively common issues. Illegal dumping of garbage was identified as a concern specifically in the Istria area, while other degradation-related issues were reported as less frequent.

Respondents reported frequently using reusable containers, recycling when appropriate bins were available, and taking their personal litter away when bins were not present. However, they estimated that only about half of other visitors engaged in these behaviors. Respondents also indicated that they often disposed of waste in mixed-waste bins when recycling bins were unavailable and reported infrequent engagement in behaviors such as picking up or drawing attention to others' waste. These two behaviors were also perceived as more unpleasant and difficult compared to other waste-related behaviors. The perceived ease of performing pro-environmental waste-related behaviors and their past frequency were the strongest predictors of visitors' future intentions to engage in these behaviors. Intentions related to specific behaviors were also influenced by awareness of environmental consequences, moral norms, and perceived response efficacy. Visitors' evaluation of informative and structural measures

already implemented in the pilot areas varied with the area, but generally showed that the measures could be improved.

Respondents identified practical instructions on how and where to dispose of waste as the most effective informative strategy and highlighted the critical role of waste bins. Increasing their availability and optimizing their placement were considered the most effective measures. Improving waste collection and cleaning services was also rated as highly effective. The perceived effectiveness of other structural strategies varied depending on the pilot area.

The results suggest that to promote visitors' correct waste-related behaviors in natural and protected areas, including the Wastereduce pilot areas, it is important to make these behaviors easier to perform through interventions that improve environmental support and provide specific information on how to carry them out. However, the peculiar characteristics of each area should be considered when designing structural interventions. For further information on the visitor survey results, see *D1.8.2. Analysis of the opinions and attitudes of the examinees on waste reduction actions*.

Advantages

The main advantage of visitor surveys is that they allow an understanding of visitors' perceptions of the investigated areas, the barriers they perceive to engaging in pro-environmental waste-related behaviors, the drivers of these behaviors, and the perceived effectiveness of possible interventions.

Limitations

The main limitation of visitor surveys is that they rely on self-reported behavior and intentions, which usually show only a moderate correlation with actual behavior. Other limitations concern sample representativeness and the validity and reliability of the scales used in the survey. However, it is reassuring that our results were consistent across the areas investigated and that we used validated instruments that proved to be reliable.

3.6 Project/Practice review

Description

Project partners implemented an initiative to systematize existing evidence-based knowledge on strategies, policies, and good practices in waste reduction. They contributed to data collection by providing cases relevant to the Wastereduce project and belonging to five categories: (1) laws, directives, and regulations; (2) plans and policies; (3) strategies and

innovative strategies; (4) good practices; and (5) financing strategies. Collected documents and data should be produced by institutional bodies (e.g., public authorities, agencies, associations) and address good practices, challenges, and gaps in waste management, ideally focusing on waste reduction in vulnerable coastal areas, protected areas, and Natura 2000 sites.

The partners identified 21 cases through internal and external desk research. These cases were documented using a case documentation form and evaluated according to the methodology and criteria specified in advance, including relevance for waste management in protected or Natura 2000 areas, relevance for the Wastereduce project, achievement of objectives, measurability of results, impact on policy making, level of implementation and transferability, and clarity of documentation and reporting. Detailed data collection and evaluation methods are described in *D1.7.1 Methodology for identification of strategies, policies, good practices, and gaps in waste reduction* and in *D1.7.2. Database of strategies, policies, and good practices in waste reduction*.

This process resulted in the creation of a database of good practices in waste management at the European level, which accompanied *D1.7.2 Database of strategies, policies, and good practices in waste reduction*.

Contribution

A significant contribution of the project/practice review is represented by the systematization of knowledge on strategies, policies, and good practices in waste reduction carried out by project partners. This background knowledge was useful to support planning of the waste reduction strategies and initiatives, leveraging previous experience in similar projects.

Advantages

The deliverables produced by project partners have a systematic nature and contribute to build a knowledge base on strategies, policies, and good practices in waste reduction. Moreover, the systematic evaluation of cases both according to established and internationally accepted criteria and the specific relevance for the Wastereduce allowed to weight the evidence in relation to its quality and relevance for the goals of our project.

Limitations

The structured contribution offered by project partners with the produced deliverables may reflect only a part of the available knowledge, due to the limitations desk research and the unassessed reliability of evaluations.

3.7 Other sources

Description

Other sources of knowledge and information included meetings with stakeholders, project partners, and interested public. Workshops with stakeholders were organized to present and discuss the Wastereduce project and its activities at various stages of development. Regular project meetings facilitated the exchange of knowledge and information within the group of partners, who also cooperated in carrying out activities and producing deliverables. Public meetings, such as infodays and ecodays, along with educational initiatives and participation in third-party events and scientific meetings, made it possible to reach a diverse audience – local residents and visitors, students, and scholars – and to receive questions and feedback. A detailed description of these initiatives is available in the periodical Wastereduce project reports. Refer to Table 1 to find a list of the relevant deliverables.

Contribution

The contribution of some of these sources is more difficult to evaluate, given the informal and non-standardized nature of information and knowledge acquisition during some initiatives. Workshops with stakeholders made it possible to integrate the information obtained from the interviews, while meetings with the general public and visitors provided additional insights into citizens' perceptions. Meetings with scholars and project partners were useful for exchanging knowledge about the information acquired in the project and for discussing potential strategies and actions from a multidisciplinary perspective.

Advantages

The main advantage of using these other sources of information and knowledge is that they may provide further insight from a variety of different viewpoints. They can help integrate the knowledge and information acquired through more structured methods, such as interviews, surveys, observations, and literature reviews.

Limitations

The main limitations of these other sources of information and knowledge are that the samples of attendees for some initiatives may not represent the reference population, and information acquisition in some cases is neither systematic nor structured. Moreover, the subjective feedback obtained may be biased or reflect personal or group interests. As a result, the information obtained should be critically appraised.

4. Contribution of the framework and integrated methodology

This section explains how the Wastereduce methodological framework contributed to planning, and strategy development as well as how it could be extended and applied in other settings and projects aimed at preventing waste production and reducing waste in natural and protected areas. Finally, the relations between the Wastereduce methodological and participatory frameworks and stakeholders and civil society involvement will be summarized.

4.1 Wastereduce methodological framework, participatory framework, and strategy development

The information and knowledge obtained from various sources about the target areas and their contexts were integrated using the Wastereduce methodological framework. This served as a starting point for developing a cross-border strategy based on a participatory approach, aiming to create a tailored waste management strategy for the three project pilot areas: Medio Brenta in Italy, Sakarun Bay, and the Istrian Coast in Croatia.

The participatory methodological framework, described in *D 1.11.1 Participatory methodological framework for the WASTEREDUCE strategy*, provided each partner with guidance and instructions to begin building and developing the strategy components. The participatory methodological framework aligned with both European regulations and the unique local contexts of each area – governance structures, economic activities, and environmental conditions – ensuring effective integration of waste management practices.

According to the participatory methodological framework, after delineating priorities and strategic objectives, a comprehensive analysis of the situation in a target pilot area allows the establishment of strategic goals, such as identifying key areas for intervention or the type of intervention to apply, ranging from increasing visitor awareness and improving communication to implementing technical assets for waste disposal. Goals need to be ranked by priority, and respective deadlines need to be established.

To facilitate strategy design, the participative framework also proposed classifying potential interventions or lines of action as sermons (education and information), sticks (policy, regulation, surveillance), and carrots (incentives and ways to encourage better behaviors), asking each partner to define at least one objective for each category. Partners were also invited to specify how they intend to finance their lines of action. According to the participatory methodological framework, monitoring and reporting activities are essential processes for evaluating the effectiveness of actions taken to address unsustainable waste management (see

also **Figure 1**). Monitoring and reporting should use valid and reliable measures of specific indicators for each objective. Project partners developed and tailored their strategies to their specific pilot areas, as detailed in *D1.11.2 Report on the developed strategies for each pilot area*.

A fundamental aspect of the participative framework is active stakeholder engagement within the territorial context from the initial phase, including defining the vision, strategic objectives, and lines of action. Various types of stakeholders need to be consulted and their feedback gathered to ensure shared decisions with lasting impact, which was done during the Wastereduce project.

4.2 Generality and potential extension of the Wastereduce methodological framework

The general aspects of the Wastereduce methodological framework and the Wastereduce participatory framework can be easily applied to other settings and contexts with some adaptations. This is a significant strength of the Wastereduce project, and we hope it will benefit other projects and initiatives. However, it remains essential to tailor the approaches to the specific characteristics of the local area and context, and to involve local actors and stakeholders from the outset, which could also serve as a general guideline.

The methods and instruments developed and used in Wastereduce can serve as valuable starting points for future projects and initiatives that can leverage the set of deliverables and data produced. This includes the observation methodology and grid, the visitor survey, and the stakeholder interview. Future projects and initiatives can also benefit from the knowledge gained on remote sensing methods and measures, the effectiveness of behavioral interventions, and the review of previous projects and practices.

The limitations of the knowledge and information sources and methods described in **Section 2** were mitigated by using multiple sources and methods, which we consider a particular strength of the Wastereduce approach. Single methods could be improved by addressing different aspects that have been previously identified.

According to our evaluation, promising avenues for extending the methodological framework include (1) refining remote sensing technologies to fully realize their potential for remote monitoring; (2) partnering with schools and environmental organizations so that systematic and periodic observation sessions can be paired with cleaning days after appropriate training of observers and cleaners; and (3) developing and testing highly usable apps that implement the observation protocols.

4.3 Relationships between the Wastereduce methodological and participatory frameworks and the involvement of stakeholders and civil society

There are strong connections between the Wastereduce methodological and participatory frameworks and the involvement of stakeholders and civil society. Visitors to target areas were consulted through the visitor survey and had the opportunity to receive the Wastereduce project newsletter to stay informed and involved in project activities. Citizens could actively participate during infodays, cleaning days, and educational initiatives. Stakeholders were interviewed, received the project newsletter, and participated in workshops at different stages of the project's progress. The general public was continuously informed about project activities through press conferences, press releases, and social media. Social media also enabled interaction with the project team and more active involvement. Periodic project reports provide a complete list of activities, and Table 1 refers to the relevant deliverables.