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WASTE PREVENTION SCENARIOS USING A WEB-BASED TOOL FOR LOCAL AUTHORITIES

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Abstract

Waste prevention is the highest ranked priority in the European Waste Framework Directive. The aim of this paper is to present the design, development and main features of a web-based tool that enables local authorities to select and implement optimum waste prevention programmes for their local conditions and to prepare their Waste Prevention Plans. The aforementioned tool, namely the WASP-Tool, is implemented as a knowledge-based decision support system which extracts characteristics and features of the waste prevention strategy models and applies multi-criteria evaluation techniques in order to facilitate decision making. It has been developed in Greek and reflects Greek and Cypriot data, context and waste prevention potential, to facilitate its use by local authorities and local administration.

Keywords: Waste prevention, decision support, WASP Tool, Greece, Cyprus

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1. INTRODUCTION

Waste prevention is interpreted in slightly or highly different ways from one place to another. Yet, on a definition level, all parties share as a starting point the concept that waste prevention underlies a complex of actions and measures taken before a material or a product is characterised as waste. According to the revised European Union (EU) Directive on Waste (2008/98/EC), widely known as Waste Framework Directive - WFD (Article 3, clause 12 & 13), these actions and measures ought to reduce the quantity of waste, the adverse impacts of the generated waste on environmental and human health, and the content of harmful substances in materials and products. Thus, waste prevention is distinct from recycling and other waste management efforts which are applied only when products and materials are inevitable or voluntarily discarded.

Waste prevention can be attained through two different pathways: strict avoidance of waste and extending a product's lifetime (European Commission, 2012). In the first case, it encompasses goals such "limiting unnecessary consumption" and "designing and consuming products that generate less waste" (European Commission, 2012). Extending a product's life includes options such as re-use (for the same purpose as it was originally designed), refurbishment and repair. "Preparing for re-use", which is ranked in the second place in the waste hierarchy, right below waste prevention, is considered by some as "contributing to waste prevention in a wider sense" (European Commission, 2012).

In order to counteract the growing waste generation, policies providing robust guidelines on waste prevention and suitable regulating framework are deemed a necessity. Lately, waste prevention has shifted to be an essential element of waste management and environmental policy frameworks, on regional, national and supranational (i.e. EU) level. To comply with the provisions of these policies, several countries have attempted to institutionalize waste prevention. In EU the WFD stipulates Member

States to prepare and introduce Waste Prevention Plans (WPP) by the end of 2013, attempts to clarify the end of waste criteria, to take measures for separate collection of biowaste and to enhance extended producer responsibility.

Although waste prevention has been the paramount objective of both national and EU waste policies for many years, insofar limited progress has been made in transforming the objective into practical action. Neither the Community nor the national targets set in the past have been satisfactorily met. Prevention measures are seldom considered as a part of waste management practice and less effort and resources go into waste prevention than into its recycling and recovery, which are placed lower in the waste hierarchy.

Against this background, the co-funded by the LIFE financial instrument "WASP Tool" project (full title: "Development and Demonstration of a Waste Prevention Tool for Local Authorities" – LIFE10 ENV/GR/622") has been elaborated, in order to investigate, demonstrate and optimise the waste prevention potential at the Local Authorities (LA) level, in the Mediterranean area, in the different geographic and waste policy context of Greece and Cyprus. More specifically, it facilitates the implementation of the WFD with respect to waste prevention, through the development of a web-based Decision Support Tool, the WASP Tool (acronym of the words Waste Prevention) that enables the participating to the WASP project Local Authorities to select and implement the optimum waste prevention programme for their local circumstances and prepare their WPP. Once the system is completed, the toolkit will provide suggestions to deliver waste prevention activities to other Mediterranean countries that face similar problems with their waste management.

The database of the "WASP-Tool" encompasses information and data of the waste prevention activities that have been implemented worldwide. The aim of this paper is the presentation of the design,

development and main features of the “WASP-Tool”.

2. WASTE PREVENTION TOOL (WASP-TOOL)

2.1 Overview

The core of the research concerns the development, application and demonstration of a waste prevention system, the WASP-Tool, aiming at facilitating local authorities during the selection of waste prevention strategies. The tool features a web-based interface, in order to be easily accessible by LAs and an expert system backend reasoning core, which is employed as a decision-support module to determine and propose the best waste prevention strategies in each case, based on certain criteria. The tool takes into account both local data, such as population and waste production per inhabitant, as well as LAs’ preferences concerning the overall design of their waste management policies and strategic goals. More specifically, it extracts characteristics and features of the waste prevention strategies, as identified in the previous analysis step of the project, models them, and applies multi-criteria evaluation techniques in order to facilitate decision making. It interacts with users to determine the significance of each evaluation factor and evaluates waste prevention activities accordingly. The output of the system includes a ranking of the appropriate waste prevention activities, as well as estimated results for each activity, taking into account local demographics and waste parameters.

The tool aims at assisting LAs to identify and study the waste prevention strategies that suit them best. Furthermore, the tool predicts and estimates the benefits from each waste prevention strategy for each application area and is thus able to reason about the selection of specific strategies. The tool is currently undergoing application by local authorities at a preliminary level and will be further refined based on the results of its application. The WASP Tool has been developed in Greek to reflect Greek and Cypriot waste data, context and waste prevention potential, with selected information material available in

English.

Prior to the development of the WASP-Tool, a thorough search in relevant project databases was conducted in order to identify other similar tools. The investigation revealed that there are many tools for the assessment of waste management, but few for waste prevention decision-support. The main contribution of the present tool lies in the fact that it provides an easy and intuitive interface for defining impact indicators and their significance for users, encapsulating the complexity of the multi-criteria decision making process.

2.2 Architecture

The architecture of the tool, featured in Figure 1, is modular in order to facilitate incremental development and feature extensibility (Matthies et al., 2007; Poch et al., 2004; Rizzoli and Young, 1997). It consists of a MySQL database which stores Waste Prevention Strategies models and all related data, as well as default LA data concerning the specific project application areas as well as Greece and Cyprus in general.

Figure 1 around here.

The front-end, interface and the expert reasoning core of the system are implemented in PHP & Ruby, using the corresponding application servers. The expert core consists of modules that combine Local Authority Data with Waste Composition Data to evaluate each waste prevention strategy and estimate its results, and modules for the overall evaluation, scoring and –finally- ranking of the strategies. Users can access it through any web browser, without the need to install any specialised software or libraries, as the tool is designed for non-expert users. Its prototype version is currently deployed in Harokopio University

NOC servers.

2.3 Methodology

2.3.1 Domain modelling and knowledge base

The WASP Tool knowledge base is derived from a state-of-the art review on waste prevention strategies that are found in the literature and related projects and have been applied worldwide, conducted in the previous step of the project. The knowledge base stores data concerning the environmental impact of waste prevention strategies, as identified by the state-of-the-art review.

Moreover, the knowledge base models project application areas, namely Chania (Greece), Heraklion (Greece) and Paralimni (Cyprus), which participate in the WASP Tool project, as well as default areas for Greece and Cyprus, which can be modified during execution. Such data are local-authority-specific and concern demographics, such as population and quantity of waste per inhabitant per year, and local waste composition percentages. Since each waste prevention strategy concerns only specific target materials, waste composition percentages combined with the quantity of waste per inhabitant are taken into account in order to calculate the exact impact of each waste prevention strategy indicator.

2.3.2 Statistical analysis and normalisation

Since indicators that describe each waste prevention strategy are highly diverse, both in value ranges and in semantics, WASP Tool performs statistical analysis resulting in normalisation steps, in order to be able to express all indicators in a uniform way and consequently utilise them to produce meaningful evaluation and ranking of the available strategies. Normalisation is first performed using the variation rate, calculated for each value as $\left(value - \overline{X}\right)/ S$, where the mean value and standard deviation are defined as:

$$\overline{X} = \frac{x_1 + x_2 + ... + x_\nu}{\nu} = \frac{1}{\nu} \cdot \sum_{i=1}^{\nu} x_i \qquad s_2 = \frac{1}{\nu} \sum_{i=1}^{\nu} \left(x_i - \bar{x} \right)^2 \qquad s = \sqrt{s^2} \ .$$

Consequently, the values are expressed as a percentage, using the variation coefficient, defined as

$$CV = \frac{s}{\bar{x}} \ .$$

2.3.3 Expert core and decision support process

After the normalisation steps, the decision support process can proceed. The decision support process in each execution of the system combines a specific local authority model, either default or user-defined, with all applicable waste prevention strategy models. Applicable waste prevention strategy models in this case are all models which concern target materials that the LA wishes to include in the waste prevention program.

Consequently, a score is calculated for each waste prevention strategy model, using multi-criteria evaluation techniques. The LA user is able at this point to customise the significance of each factor by modifying the weight assigned to it; therefore, they have control over the criteria that will be used for evaluation and ranking of the waste prevention strategies. In order to ensure the soundness of the results, the final weights are normalised, adding up to 1. Finally, the output of the system is a ranking of the strategies, corresponding to these specific parameters, taking into account the weights and the evaluation of each waste prevention strategy for each indicator in a multi-criteria evaluation process. The output also includes the estimated results for each activity, taking into account local demographics and waste composition parameters.

3. DEMONSTRATION OF WASP TOOL APPLICATION

In this section, the application of WASP Tool will be demonstrated. Note that, based on the requirements of the LIFE10 ENV/GR/622 project, the WASP-Tool, after its development, should be applied in the three participating local authorities (Chania and Heraklio in Crete and Paralimni in Cyprus), with the ultimate goal being the selection of the most suitable waste prevention actions and the development of Waste Prevention Strategies.

By typing wasptool.hua.gr in any web browser, the introductory page of the tool appears.The execution of the tool starts by entering the name of the country (either Greece or Cyprus), the prefecture that the municipality belongs to, and the name of the municipality, using dropdown menus (see Figures 2a and 2b). The user can introduce the names of new municipalities in the lists of each prefecture. Then, the population and the waste generation per capita for the LA under scrutiny are filled-in by the user (Figure 2c). Then, in the next online form, the breakdown of the waste is introduced (Figure 2d). The waste breakdown is introduced in the following six categories: biowaste, paper, metals, plastics, glass and other. The sum of the categories should sum up to 100.

Figure 2 around here.

As an example, the input data introduced for the two participating local authorities from Greece (i.e., Chania and Heraklio in the island of Crete), are presented in Table 1. Based on these data, the data from the knowledge base of the WASP tool, and the user input regarding the relative weight of each assessment indicator, the prevention strategies will be ranked for each municipality.

Table 1 around here.

The cornerstone unit of municipalities is the household. Waste prevention in the household level can be implemented via various activities. Based on the review of relevant literature, the most practiced are the following (Nessi et al, 2012; Schneider, 2013; Zorpas and Lasaridi, 2014): food waste prevention; home composting; prevention of excessive packaging; using of multiple-use carry-bags; reduction of paper use at offices; repair and reuse of clothes, shoes, furniture; repair and upgrade of electronic and electrical devices; and, buying second-hand products.

Therefore, the next step is the user to select the target materials. By default, all waste materials suitable for prevention are selected. The waste materials targeted are: home biowaste (food and garden), home biowaste (foodwaste), commercial biowaste (food and entertainment), non-returnable bottles and packaging containers, plastic bags, office paper, advertising material/paper, furniture, electrical and electronic appliances, clothing and shoes.

Each waste prevention strategy modelled includes indicators. In the following screen, the relative weights for each indicator are assigned. such as reduction of the produced waste quantity (tn/year), potential CO_2 reduction (kg/year), waste diverted from landfilling (tn/year), implementation cost (5-year in €), number of employment positions created, implementation difficulty (scale 1-3), required citizen behavioural change (scale 1-3), appropriateness for application on a local level (scale 1-3). Moreover, the target materials (for example biowaste, metal, plastic etc) for each waste prevention strategy are also indicated.

For each indicator, the relative weights range from 1 to 5. By default, in the initial dialogue screen, each indicator is set at the value of 3 (see Figure 3). Based on the relative weights set by the user, the program ranks the available prevention strategies, presenting the top five in the next screen of the tool. The final

execution step of the WASP tool, is the generation of the final report in the form of a pdf file. For instance, Table 2 presents the results of the prevention potential in the municipality of Heraklio by applying the strategy of home composting. The user can start the execution of the tool at any step, by just clicking in the WASP Tool logo found on every screen of the tool.

Figure 3 around here.

Table 2 around here.

Based on the recommendations of the WASP tool, the top four waste prevention strategies in the output ranking list will be implemented in the three participating local authorities (see Table 3). The actual results of the implementation will be used as feedback for the refinement of the WASP-Tool during the last trimester of the project. The WASP-Tool will be adapted to contain real/updated data and experiences from the implemented pilot demonstration projects.

Table 3 around here.

4. CONCLUSIONS

The design and major features of the WASP Tool have been presented. The WASP-Tool is designed to facilitate local authorities in selecting suitable waste prevention strategies and estimating the expected results, providing an easy and intuitive interface for expressing the significance of each evaluation factor for each local authority, encapsulating the complexity of the multi-criteria decision making process.

This is the first time that a waste prevention decision support tool is developed and implemented via

identification and evaluation of different waste prevention activities using Life-Cycle thinking for municipalities. It is of particular interest here to test the utilisation of the WASP tool in two countries that share many similarities, characteristic of the Mediterranean space (tourist areas with wide fluctuation of population, large islands, Mediterranean climate and similar food preparation habits), however, still having many differences in their population sizes, the economic conditions, the structure of their administration and waste management systems, and potentially other social and cultural factors that may influence consumption and attitudes towards waste. The toolkit can help produce or update a waste prevention strategy to other Mediterranean countries that face similar problems with their waste management system.

ACKNOWLEDGEMENTS

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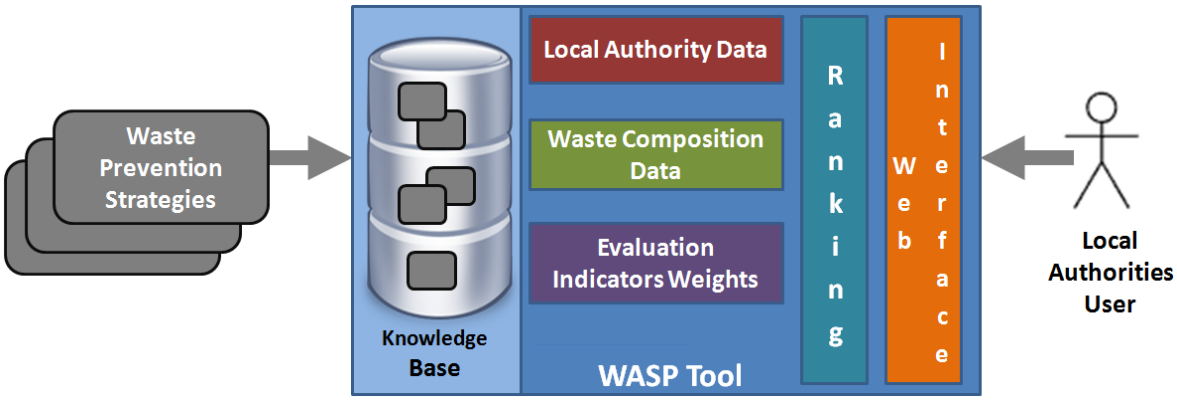
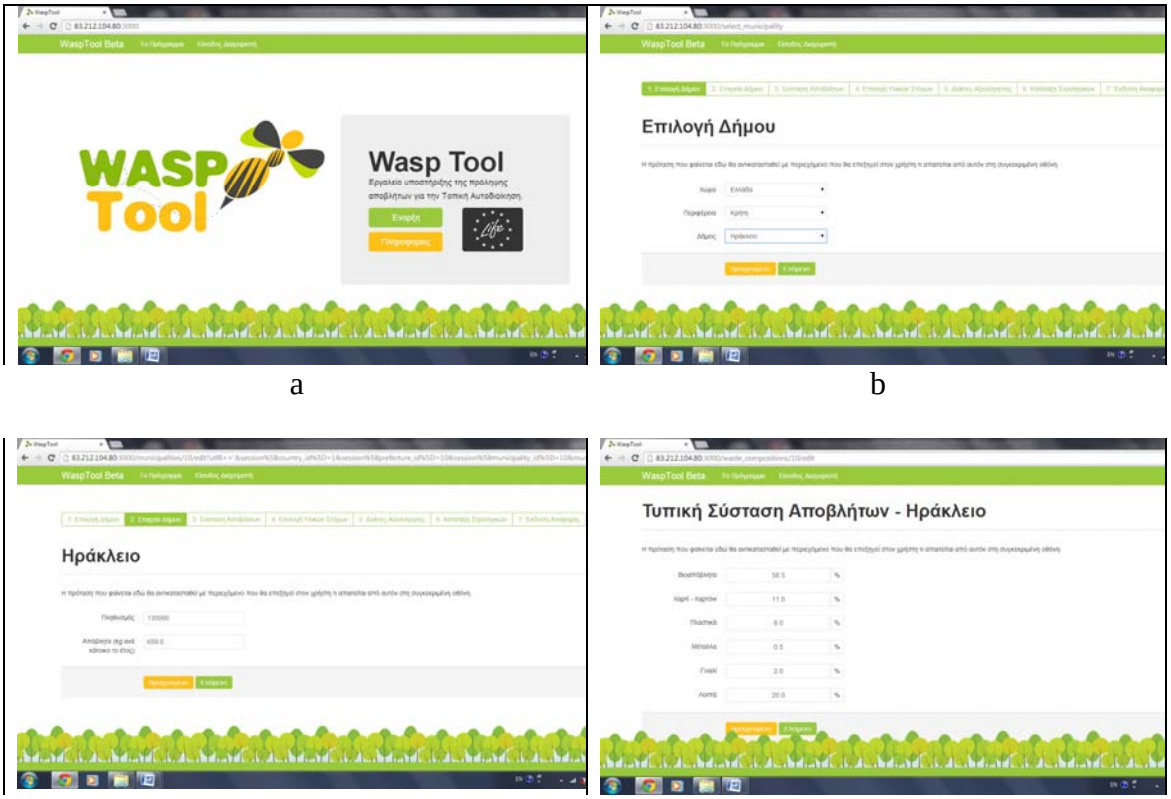


Figure1. Architecture of the WASP Tool.



a b

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Figure 2. Screenshots of the input data required by WASP Tool.

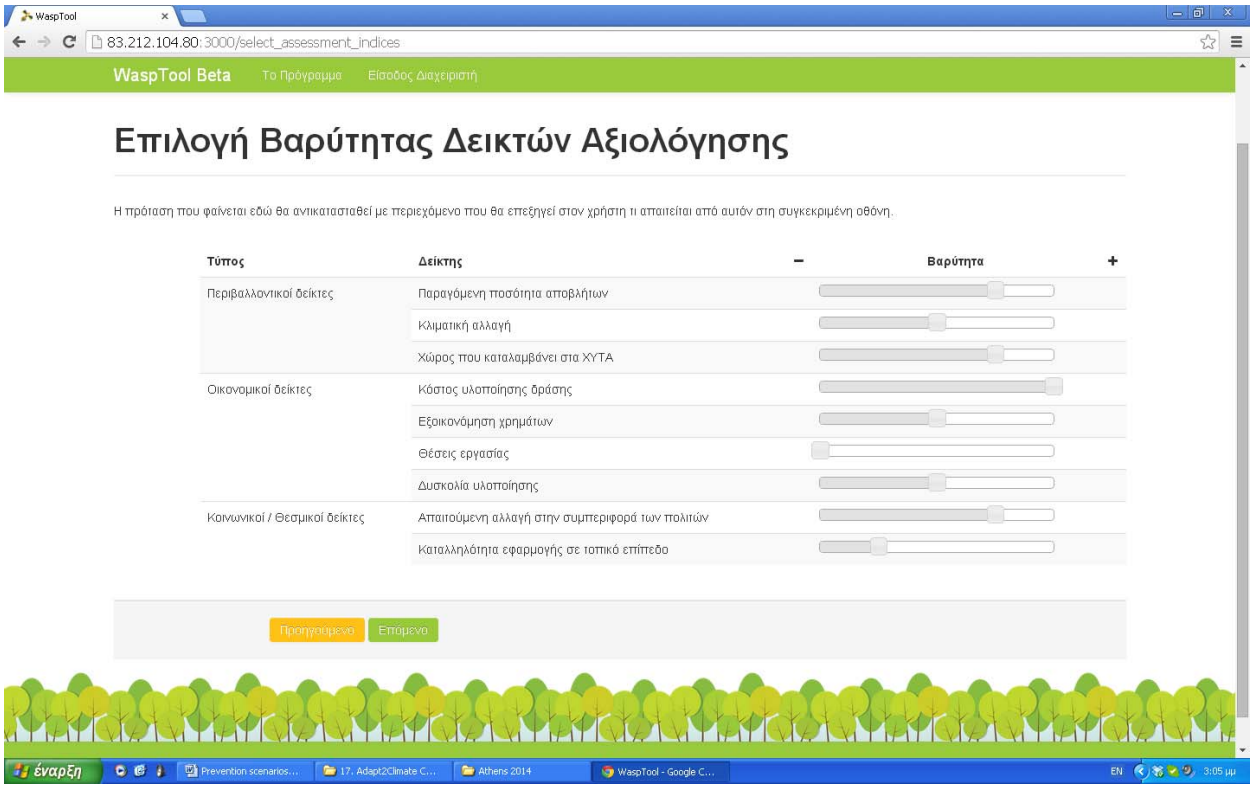

Figure 3. Assignment of the relative weight for each indicator.

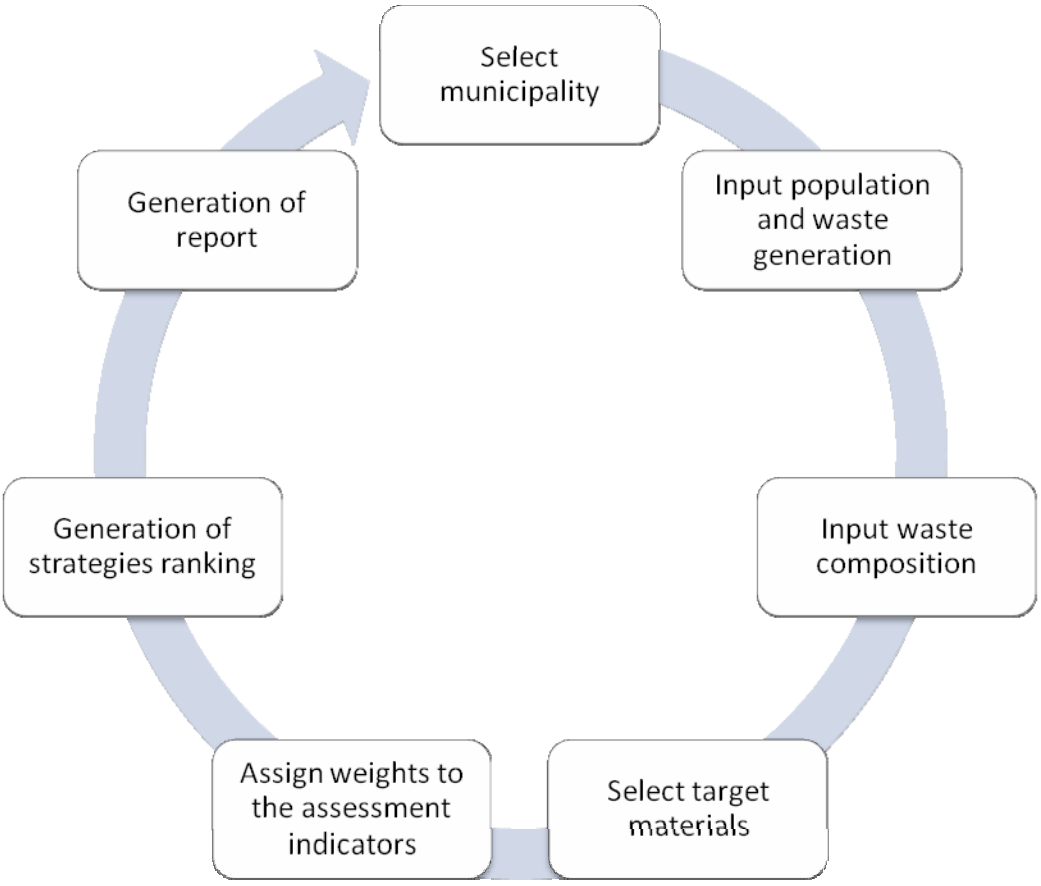

Figure 4. Overview of the execution algorithm of WASP Tool.

Table 1: Input data for the two local authorities in Greece.

	Chania	**Heraklio**
Population	108,300	167,800
Waste Generation	491	526.5
Waste Composition (%)		
Biowaste	41.0	58.5
Paper/Cardboard	19.7	11.0
Plastics	12.6	8.0
Metals	2.5	0.5
Glass	3.4	2.0
Other	20.8	20.0

Table 2. Output data from the WASP Tool on the assessment indicators for the application of home composting in Heraklio, Crete.

STRATEGY TITLE	**HOME COMPOSTING**				
STRATEGY TYPE	REDUCTION				
TARGET MATERIAL	BIOWASTE (**263 kg/cap.year food waste and garden)**				
TARGET GROUP	**167,800 residents**				
APPLICATION AREA TYPE	URBAN/RURAL				
ACTION ASSESSMENT INDICATORS	Environmental indicators	**WASTE GENERATED**	BEFORE	tn/year	**44,200**
			AFTER	tn/year	**32,904**
		CLIMATE CHANGE (Reduction potential of CO_2 eq.)	BEFORE	tn/year	**-**
			AFTER	tn/year	**3,928.9**
		LANDFILL VOLUME	BEFORE	m3/year	**58,933**
			AFTER	m3/year	**43,872**
		DIVERSION FROM LANDFILL	BEFORE	tn/year	**-**
			AFTER	tn/year	**11,296**
	Financial indicators	**COST OF STRATEGY IMPLEMENTATION**	AFTER	€/year	**3,859,469**
		SAVINGS DUE TO LANDFILL DIVERSION		€/year	**282,388**
		JOBS CREATED		Per year	**168**
		DEGREE OF IMPLEMENTATION DIFFICULTY	AFTER	1:High 2: Average 3:Low	**3**
	Social / Political indicators	**% REQUIRED CHANGE IN CITIZENS' BEHAVIOUR**	AFTER	1:High (>70%) 2:Average (45-65) 3:Low (<40%)	**2**
		FEASIBILITY OF APPLICATION AT THE LOCAL LEVEL	AFTER	1: High 2: Average 3: Low	**1**

Table 3. The waste prevention strategies that were derived by the WASP-tool for the participating municipalities.

Ranking	Chania	Heraklio	Paralimni
1	Food waste prevention campaigns		
2	Home composting		
3	Promotion of reusable shopping bags		
4	Exchange library	Clothes and shoes collection kiosks	Promotion of a refillable water bottle