



# LAYMAN'S REPORT

LIFE06 TCY/MA/000254

**Development of Domestic Solid Waste Management Schemes for Small Urban Communities in Morocco - WASTESUM**



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### Introduction

WasteSum is a Life-Third Countries Project co-funded by the European Community with title "Development of Domestic Solid Waste Management Schemes for Small Urban Communities in Morocco - LIFE05 TCY/MA/000254" and Morocco is the beneficiary country. The coordinator of the project is the Faculty of Science in El Jadida (FSJ) while the National Technical University of Athens (NTUA) and the Municipality of Azemmour are the two partners of the project.

The project developed and established an integrated system for the management of domestic solid waste for urban communities in Morocco comprising of a national plan on solid waste management, software tools for solving the landfill allocation problem and the problem related to the collection and transfer of MSW, an Environmental Impact Assessment, a Life Cycle Analysis and relevant data-bases. This system enables the National Authorities to develop and manage cost-effective waste management schemes using a step-by-step strategic planning approach, and set priorities in the waste management area in an effective way. Since appropriate waste management systems require large investments and several governments depend on external funding sources, a strategic approach for planning and project preparation is often a precondition for financing, as well as for a successful and sustainable waste management system. The implementation of this project will assist Morocco to organise, implement and monitor strategic planning for its waste management needs. The project supports the attempts for solving the problems arising from untreated and uncontrolled waste disposal in Morocco. This system was implemented as a pilot-demonstration system in Azemmour, Morocco and constitutes the basis for training applications in the country.



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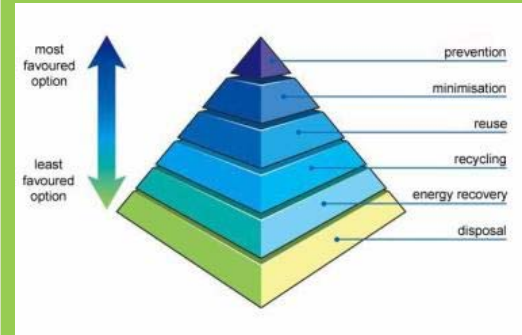
## Stages for the implementation of the project

### Assessment of the existing situation in Morocco and EU concerning domestic waste generation and management

The existing situation in Morocco regarding waste generation and composition were presented while the management schemes, systems and practices that are currently applied in the country were recorded and assessed. In addition the existing national and European legislative framework related to waste management was recorded and analyzed (content, topics that are covered, principles, priorities, responsibilities, requirements, etc.) and then, the Moroccan legislation was compared with the European one (gap analysis). Finally a review took place on waste disposal practices and success stories. Specifically, these cases included pilot programs that have been applied in various areas and countries at European and international level. A description of the programs, the systems as well as of their technical details were carried out, aiming at the acquisition of a complete picture with regard to their application.

### Development of a national plan concerning domestic solid waste management - Guidelines for the materialization of the appropriate management systems

A description and an analysis were carried out of the alternative MSW treatment systems/technologies/scenarios according to their applicability, effectiveness and viability in Morocco. Then a plan for the effective management of the domestic solid waste generated in Morocco was developed. In particular, the type of management systems as well as the number of the corresponding facilities/installations were set, taking into consideration the (i) ranking of all the alternative management systems as obtained from Action B.1 (ii) quantities of domestic solid waste that were generated at regional and national level in the country, (iii) population density of each area of the country.

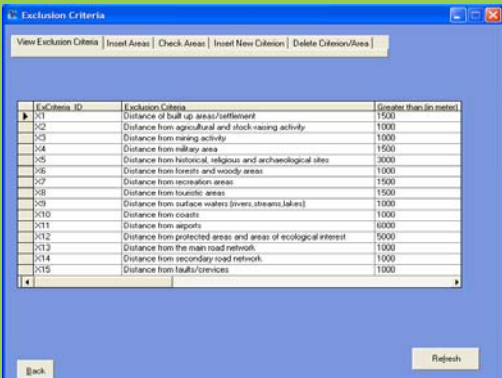
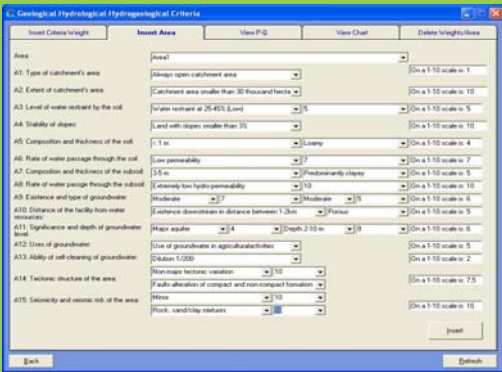


EU hierarchy on waste management



Development of software tool to support waste management decision-making

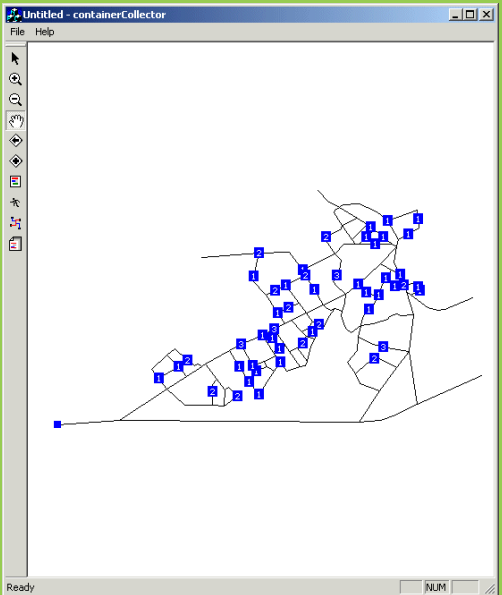
A set of software tools were developed in order to support waste management planning and decision making. A specific software tool, which can be used for the examination of alternative potential sites in terms of their suitability for construction and operation of a landfill, was designed and developed. This software tool is based on a multi-criteria analysis approach and the examination of alternative potential landfill sites is based on the use of geological - hydrological - hydrogeological, land planning, environmental, technical and economic parameters - criteria. Moreover, a software tool was developed for solving the Vehicle Routing Problem in the case of urban waste container collection and transfer to the landfill site for the case of Azemmour municipality. The software generates automatically the optimum vehicle routes for the collection of MSW containers which minimize simultaneously the vehicle costs and the total distance traveled by the vehicles. Along with the software tools appropriate operational manuals were developed in a user - friendly, tangible and simple way in order to be easily handled by the users.



Snapshots of the landfill selection software tool

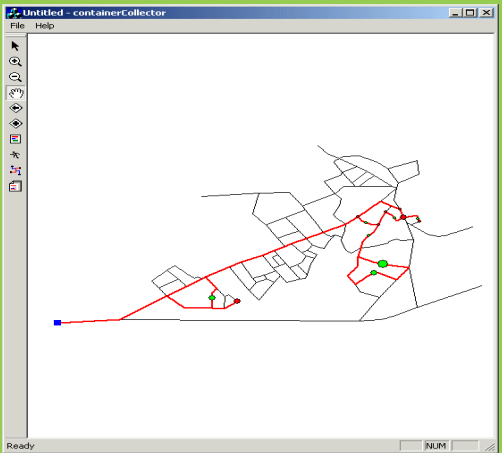
Demonstration of the developed software tool for the management of waste in the municipality of Azemmour in Morocco

The software tools that were developed for landfill site allocation as well as the routing optimisation of the collection and transfer of the domestic solid waste to the landfill site were demonstrated at the Municipality of Azemmour in order to optimise their operation, to test further their efficiency and to achieve the highest level of applicability.



Preparation of Environmental Impact Assessment (EIA) and Life Cycle Assessment (LCA)

The EIA and LCA studies focused on two case scenarios, the first one is the baseline scenario which corresponds to the existing situation with respect to solid waste management in Azemmour and the second one is based on a proposed MSW management plan for the region under investigation. The current condition of the MSW management in the municipality of Azemmour involves an uncontrolled landfill site (does not support leachate and biogas collection and treatment), in Oulad Rahmoune, 17 km southeast of the city of Azemmour while the proposed scenario includes sorting of MSW at source, composting an average of 70% of biodegradable wastes, and deposition of the residue in El Jadida's Landfill, which is 20 km northeast of Azemmour's city. It is assumed that (i) composting takes place at Oulad Rahmoune, which from 2006 is used as an uncontrolled landfill (ii) rehabilitation of the landfill will take place (iii) leachate will be collected and treated aerobically and (iv) biogas will be collected and used as an energy source.



Snapshots of the container collector software tool

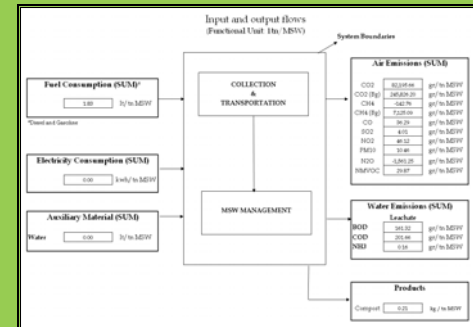


The overall aim of this EIA study, is to provide information on the nature and extent of environmental impacts arising from the current situation of solid waste management in the Municipality of Azemmour in Morocco, and to recommend appropriate mitigation measures to control the potential environmental impacts. The following table presents the results obtained from the two aforementioned case scenarios.

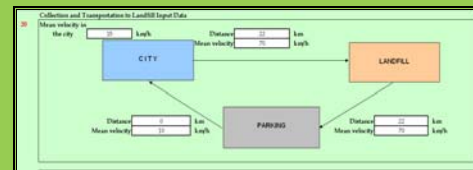
Baseline Scenario - Oulad Rahmoune Landfill				
Capacity	335,574 t <sub>n</sub> MSW			
Gas Emissions	Metha	Carbon	NMVOC	Total emissions
Mg	35,058	78,702	821	122,506
Leachates	16,031.72 m <sup>3</sup>			
Total BOD	641,268 kg			
Total COD	801,585 kg			
Total NH <sub>3</sub>	801 kg			
Proposed Scenario - El Jadida Landfill and Composting				
Capacity	155,209 t <sub>n</sub> MSW (landfill) and 197,539 t <sub>n</sub> MSW (composting)			
Gas Emissions	Metha	Carbon	NMVOC	Total emissions
Mg	3,174	80,835	177.8	84,777
Leachates	5,689.77 m <sup>3</sup>			
Total BOD	123,034 kg			
Total COD	153,793 kg			
Total NH <sub>3</sub>	123 kg			

In the proposed scenario, biogenic CH<sub>4</sub> emissions decrease, automatically leads to non-biogenic CO<sub>2</sub> emissions increase, due to biogas combustion where biogenic CH<sub>4</sub> and other Non-Methane Volatile Organic Compounds (NMVOC) are oxidized to CO<sub>2</sub>. However, climate change potential results are dramatically decreasing, due to the fact that CH<sub>4</sub> has a climate change potential 21 times more than CO<sub>2</sub>. N<sub>2</sub>O emissions are also increasing due to composting, but in a life cycle way of thinking, the total N<sub>2</sub>O emissions are decreasing due to environmental off-set benefit from fertilize substitution by compost.

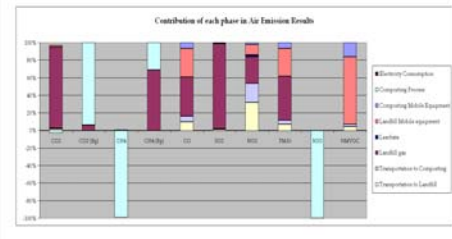
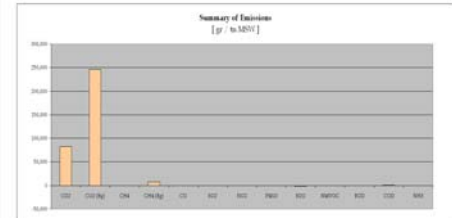
To successfully implement an LCA assessment an appropriate LCI databases was developed for the quantification of air and liquid emissions resulting from the collection and transportation of MSW, landfill operation, biogas production and treatment, leachate production and treatment and composting process. Based on this database the two case scenarios were examined concluding that the environmental effects with respect to climate change, photochemical oxidation and eutrophication impacts were significantly lower to the proposed scenario in comparison to the current condition in terms of MSW management in the municipality of Azemmour.



General Data Input		MSW Composition Data Input		MSW Amounts in Composting Input	
City Name	Assessment	Type	Rate	Type	Rate
Year of Data Collection	2008	Food	35	Food	70
Waste & Landfill Data Input		Paper and cardboard	8	Cardboard	40
Waste Density (kg/m <sup>3</sup> )	120	Wood	2	Wood	10
Total MSW production (t)	32,000	Other	8	Other	40
Waste Flaring (%)	0	Plastics	2	Plastics	10
Waste Rate Reduction Treatment (%)	0	Other	2	Other	10
Climate Data Input		Climate	0	Climate	0
Mean Annual Temperature (°C)	17	Other	0	Other	0
Mean Annual Precipitation (mm)	100	Other	0	Other	0



Emission Results										
Pollutant	unit	Transportation (Landfill)	Transportation (Composting)	Landfill gas	Landfill	Composting	Composting Process	Biogas	Biogas	Other
CO <sub>2</sub>	g/t <sub>n</sub> MSW	1,010	88.4	6,762.0	5.0	1,010.0	522.0	1,010.0	0.0	12,200.0
CH <sub>4</sub>	g/t <sub>n</sub> MSW	0.0	0.0	23,660.0	1,010.0	0.0	0.0	23,660.0	0.0	24,670.0
N <sub>2</sub> O	g/t <sub>n</sub> MSW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO	g/t <sub>n</sub> MSW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H <sub>2</sub>	g/t <sub>n</sub> MSW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO <sub>x</sub>	g/t <sub>n</sub> MSW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PM <sub>10</sub>	g/t <sub>n</sub> MSW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PM <sub>2.5</sub>	g/t <sub>n</sub> MSW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SO <sub>2</sub>	g/t <sub>n</sub> MSW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO <sub>2</sub>	g/t <sub>n</sub> MSW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SO <sub>x</sub>	g/t <sub>n</sub> MSW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO <sub>2</sub>	g/t <sub>n</sub> MSW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO <sub>x</sub>	g/t <sub>n</sub> MSW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0



Snapshots of the LCI database



## Results of the project for potential target groups

The outcome of the project has a great impact to all the actors involved in the field of MSW management in Morocco. In particular:

Public: Raising public awareness for the most beneficial waste management systems aiming in the protection of the environment and public health.

Local authorities: Local authorities have in their possession a robust set of software tools which enables coherent decision making in regard to the integrated solid waste management and planning at local level and thus minimizing the environmental impacts resulting from inefficient MSW management.

Private companies: Private companies can benefit by investing in the development of systems for the collection, transportation, treatment and disposal of waste.

Public Authorities & decision and policy makers: They are provided with guidelines on the harmonization with the EU policy in regard to MSW management. They are also provided with a set of tools for selecting appropriate MSW management technologies/techniques which are very useful in updating national strategies in regular basis.



## Cost benefits

Morocco is facing serious problems associated with the poor management of solid waste which must be urgently addressed to avoid any further degradation of the environment. With a predominantly urban population (51%), waste management in Morocco is characterized by poor collection practices and the presence of uncontrolled landfills within residential areas and peripheral districts which adversely affects the development of economic activities and tourism. The significant impact of poor solid waste management on the degradation of and cost to the environment has subsequent impact to tourism development. With poor solid waste management practices costing 0.5 percent of GDP, Morocco had one of the highest costs in the Middle East and North Africa region, compared to 0.2 percent in Egypt and 0.1 percent in Algeria, Lebanon, Syria and Tunisia. The methodology and the set of tools provided within the framework of WasteSum project shall set the bases for the development of integrated and sustainable MSW management in urban communities that will aim towards the closure of uncontrolled landfill sites and the development of appropriate systems for the sustainable collection, transfer, treatment and disposal of MSW.





## **Environmental benefits**

- The project developed a methodology for the evaluation of different alternative solid waste management schemes that can be assessed for any given area, based on its characteristics, for the management of MSW in an environmental beneficial, economically viable and socially acceptable way.
- Currently the prevailing method of waste management in Morocco is through the deposition of the collected MSW to official dumping sites without any sanitary measures, or on unofficial wild dump sites. The project provides a robust software tool that enhances the landfill allocation process in that the most appropriate landfill sites for the safe disposal of MSW is selected. Landfill siting is prerequisite for the minimization of the environmental impacts resulting from the construction and operation of sanitary landfills.
- The project also contributes towards sufficient collection and transportation of the MSW generated. It also optimizes the vehicle routes for the collection of MSW containers which minimize simultaneously the vehicle costs and the total distance traveled by the vehicles thus minimizing the emissions resulting from the operation of the vehicles.
- The project has provided a set of software tool which have a decision supporting/making role for the integrated sustainable management of MSW in urban communities. These tools can be effectively utilized by decision makers in order to suggest appropriate measures to the relevant competent authorities for the environmental beneficial, social acceptable and cost effective management of MSW resulting in substantially less adverse effects to the environment in relation to the baseline case scenario.
- Provides a permanent and environmentally friendly solution for the problem of waste management
- Promotes the harmonization with EU policy, legislation and priorities in the field of waste management.

## **Social benefits**

The potential large scale application of the project findings can have significant social benefits with respect to human health and employment status in Morocco. The findings of the program can be used as a decision support and decision making tools that will be the base for a coherent and integrated sustainable solid waste management that will eventually lead to the efficient management of waste in consistent with the EU waste policy. This shall lead in improving the life quality of Moroccan citizens through appropriate collection, transportation, treatment and disposal of MSW. Therefore environmental problems arising from the uncontrolled dumping of MSW which directly (littering the environment) or indirectly (contaminating groundwater) influence the life quality of people shall be minimized. The initiation of appropriate management systems/schemes for the effective and sustainable management of MSW shall give rise to numerous job and market opportunities in Morocco. These employees could be engineers, consultants, technicians, agriculturists, waste collectors, drivers etc.



## Replicability and transferability

The project presents high reproduction potential in the sector of generation and management of solid waste in Morocco, since at present there is no system for the treatment of waste in Morocco. The Moroccan strategic plan for the management of solid waste anticipates, among others, the operation of systems /technologies/ processes, covering the needs of Morocco. The outcome of the project will be very useful for the development of such techniques at local and national level, providing all the necessary know-how, expertise, techniques and technologies.

Also, the project presents high social-economical potential, since the implementation of the project results in:

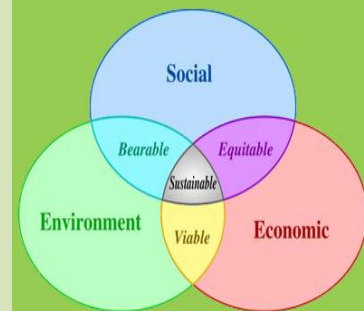
- The protection of the environment in Morocco
- The protection of public health from the uncontrolled and inappropriate disposal of waste
- Reduction in demand on land space for landfilling due to the fact that a high amount of solid waste generated in Morocco could be recovered and reused
- Market creation in several commercial sectors
- Employment opportunities will arise from the operation of the proposed system in the environment sector

Furthermore, any other country or geographical area with similar characteristics could utilize the outcome of the project in order to establish appropriate waste management systems. Finally, this methodology could be developed and implemented for solving similar waste management problems. Therefore, the project implementation could be used as a guide for the management of domestic solid waste in Morocco and elsewhere. In that it must be mention that the World Bank has granted Morocco a loan (\$132.7 million) to manage solid waste in the country's localities. The loan is designed to support the 2008-2012 phase of the ten-year solid waste reform, known as the national programme of the household waste management (PNDM). The funding will back solid waste strategic planning and enhance the performance of the country's municipal solid waste sector.

In addition the Moroccan government has launched an ambitious national program to establish:

- Service and disposal standards for urban areas
- Quantitative goals for collection coverage (90 percent by 2021)
- Introduction of sanitary landfills (100 percent of urban areas equipped by 2021),
- Closure and rehabilitation of 300 existing open dumps, and the promotion of solid waste reduction, and recovery

Therefore the findings of the WasteSum project shall be of substantial value to the new Moroccan waste policy by enhancing decision making processes towards the development of integrated and affordable solid waste management systems and mitigating negative impacts of MSW sector on public health and the environment.





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Development of Domestic Solid Waste Management Schemes for Small Urban Communities in Morocco



**Beneficiary Faculty of Science in El Jadida**

**Municipality of Azemmour**



**National Technical University of Athens**