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THE RAWFILL CONCEPT: AN INTEGRATED METHODOLOGY AND TOOLBOX FOR SELECTING AND LAUNCHING ENHANCED LANDFILL MINING (ELFM) PROJECTS

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Introduction

RAWFILL ("Supporting a new circular economy for RAW materials recovered from landFILLs") is an INTERREG EU-funded landfill mining project, gathering partners and associated partners of North-West European regions and supported by EURELCO. RAWFILL was launched in March 2017 and will end in March 2020. The ultimate goal of RAWFILL is to allow North-Western European public/private landfills owners and managers to implement profitable resource-recovery driven landfill mining and enhanced landfill mining projects, hereunder named ELFM.[1] RAWFILL develops a cost-effective standard framework for creating landfill inventories (ELIF) based on existing experiences; an innovative landfill characterisation methodology by geophysical imaging and guided sampling; and an associated Decision Support Tool (DST) to allow smart ELFM project prioritisation. The whole concept will be demonstrated in 2 pilot sites in Flanders (Meerhout) and France (Les Champs Jouault). Additional geophysical calibration operations will take place at a few other landfills where specific information is available. More information about RAWFILL and its progress reports can be found at the project website: www.nweurope.eu/rawfill.

The ELIF will be used to describe landfills not only in terms of environmental and risk issues, but will focus on the quality and the quantity of dormant materials present in the landfills, in order to supply relevant data for stakeholders involved in ELFM projects.[2] The ELIF is the basis for the DST ranking tool and a prerequisite to assess feasibility, business plan and business cases for launching profitable projects. The DST is a ranking tool that will allow ELFM projects prioritisation based on a set of suitable physical, chemical, environmental, technical and social information. It will integrate the multiple aspects involved in ELFM projects, *i.e.* economical, technical, environmental and social factors in order to compare and classify landfills regarding their ELFM interest.

ELIF – Enhanced Landfills Inventory Framework

One main challenge for stakeholders involved in ELFM operations is to evaluate the project profitability risk based on quantity and quality of dormant resources that can be excavated and recovered from a particular landfill site. Related reliable decision elements are missing in most of the landfill inventories we have reviewed, covering the NWE region.[3] The most advanced inventories describe landfills in terms of environmental and risk issues, but give no way to evaluate, even roughly, their dormant resources potential. In most cases, even the volume of waste remains unknown and only very general information is given about the waste types present (which is very often a mixture of domestic, industrial and construction wastes).

Existing inventories, landfill mining experiences and accuracy of information

A review of inventories existing North-Western Europe is currently being written and shows that most of the inventories describe only generic information on the landfills included (name, location, ownership, sometimes periods of landfilling, sometimes waste volume estimation, *etc.*). In the most advanced inventories, environmental and risk issues are described[4] (type of wastes, physical state, presence of leachates and biogas, geology, hydrogeology and hydrology, environmental impacts surrounding population, *etc.*). Detailed information about the quantity, distribution of materials within the landfill volume and composition of buried wastes is missing.

A short review of landfill mining experiences,[5] also currently being written, focuses on the methodology used to evaluate the landfill resources potential. The study shows than in the studied cases no specific particular attention was given to the precise evaluation of resources. Other important factors lead to the decision of mining the landfill, as solving an environmental issue, recovering valuable land or performing feasibility tests. This situation is expected to change once the ELFM market will grow and, within North-Western Europe, because some mineral resources will request more attention. For sure, in a highly populated area, the economic value of land that can be reclaimed trough an ELFM project will remain a key decision factor.

Within existing information, it is difficult to estimate the level of accuracy, for example the extension of a landfill within the total area of the site, the mode of how the volume of waste was calculated (sometimes an estimation can be based on a mean height), *etc.* As this required level of accuracy is very important for launching an ELFM feasibility study, the ELIF should specify an accuracy estimation for each DST-relevant field which will be taken into account for the ranking. The least complex classification is one based on “poor/average/good/unknown” accuracy of information.

The ELIF challenge

The ELIF ambition is to supply stakeholders with an inventory framework that can be filled with suitable data, in order to evaluate the ELFM potential of the site. We are aware that it will demand lots of efforts to find, validate and encode information based on general documentary studies performed by on-site geophysical investigation. We also know that this information will remain on general level and that it will not be sufficient to design a detailed and precise business case model. But ELIF is expected to be useful to (1) demonstrate to stakeholders the interest of reliable, enhanced inventories seen from a perspective of material and energy recovery, which is a quite recent approach; (2) eliminate sites with obviously limited ELFM potential and (3) select the most promising sites where further investigations can be concentrated.

It has to be noted that RAWFILL ELIF is not a database in itself, but a database structure that will not contain information about any particular site. It will be presented as a spreadsheet and proposed to stakeholders in order to be integrated in their database structure and filled with information. Information will come first by exporting or transposing existing data and then by completing as much missing information as possible, using RAWFILL historical surveys and a geophysics imaging methodology. The challenge is to present a useful, easy-to-use, cost-effective and reliable structure that can be adopted in every NWE region or elsewhere, to build a new generation of landfill inventories focused on the principles of circular economy, sustainable development and ELFM perspectives.

Geophysical imaging

Within RAWFILL, information extracted from the landfill geophysics methodology will be described as a 3D RDM “Resources Distribution Model”, mainly based on historical documentary works and geophysics investigations on site. This study of historical documentation and geophysical imaging is set up to study the distribution of homogenous zones inside a landfill, and to link the identified zones with information about the average waste composition and physical conditions (metals, organic materials, water content, *etc.*). The RDM of a landfill, when established, will feed the ELIF fields related to “geometry” and “waste composition” sections described hereunder.

Geophysical imaging will result in a flexible combination of most modern geophysics methods, designed to precise many parameters related to the geometry of the landfill (surface, waste volume, depths), waste conditions (groundwater, biological activity, *etc.*) and waste composition (density, metal content, organic content, *etc.*). Imaging will be used to identify homogeneous zones within the landfill with some relevant contrasts and will be validated by guided sampling and analysis. Prior to geophysics operations on site, documentary works will be performed. These works can be based on a specific historical investigation methodology such as the one developed and applied by SPAQuE for Wallonian landfills and industrial sites.[6] The purpose is to obtain as much information as reasonably possible form various sources as written documents (permits and authorisations, reports, contracts, site pictures, *etc.*), testimonies of workers and neighbours, maps and aerial pictures. Historical results are related to wastes volume, wastes types, age and origin and when possible the distribution of waste types within the landfill. Historical investigations will allow to precise certain fields of the ELIF structure, and supply a guideline for more effective site investigations. However, geophysicists have to take into account that, in many cases, no historical information will be obtained at all, or some specific hazardous wastes may have been landfilled illegally and will not appear in any document.

ELIF structure

The first version of ELIF structure is currently mostly completed. It will be tested on some representative landfills, especially the ones selected within the RAWFILL project as demonstration sites. The individual landfill data sheets will also be used to develop and test the DST ranking tool. ELIF will be divided into 4 large sections: Landfill ID card, landfill surroundings, landfill geometry and specific waste information, this last section mostly based on geophysics operations. Some fields will be used by the future RAWFILL's DST in order to rank ELFM projects, while others will gather suitable information for stakeholders.

Table 1: ELIF divisions and most representative fields

Section	**Definition**	**Fields examples**
1. Landfill ID Card	All administrative information about a given landfill	Name, location, owner, operator, monitoring, aftercare, legal status, permits
2. Surroundings	All relevant data about the landfill's surroundings	Land planning, territorial strategy, current use, specific risks, geology, groundwater, access
3. Geometry	Landfill geometry, without waste information	Surface, volume, depths, stability, bottom, capping, biogas network
4. Wastes	Specific information about the landfill's waste streams	Types, density, water and gas content, temperature, estimated composition from RDM

Landfill ID card will be the easiest part to fill, even if some searches can be necessary to precise some fields. Landfill surroundings will require some completion in order to precise specific environmental and social site-related questions. As land reclamation is an important aspect for the economic feasibility of projects, specific attention will be given to the expected future of the area surrounding the landfill trough several fields coming from national/regional/local policies, as strategic territorial intelligence, land planning and existence of territorial tools to modify land use and local land pressure. Geometry will obviously cover all information related to the physical shape of the waste mass, but also information available on the bottom and capping layers and an appreciation of stability issues that can be encountered during a partial or total excavation phase. Wastes is the most complex and most important section regarding ELFM opportunities. The landfill is intended to be divided into 4 or 5 homogenous and contrasted parts that will be deducted from the RDM, in most cases it should be bottom layer (the oldest part of the landfill), top layer (most recent – and probably most documented – part) and 2 or 3 other volumes in between. Ideally, for each part precise data about surface, volume, *in situ* density, tonnes buried, water content and temperature should be measured and calculated and an indication about the waste composition should be formed, including the percentage of fine materials, which currently have limited valorisation possibilities.

RAWFILL's DST – Decision Support Tool

Estimations pointed out that there is a huge number of landfills in the EU (350,000 to 500,000).[7] Most of these landfills are no longer operational and descriptions of the content and environmental risks are not always available. In order to deal with such a large number of landfills and their uncertainties, a phased approach is required and *ad hoc* choices cannot be part of a long term sustainable management. Therefore, RAWFILL will introduce a 2-level Decision Support Tool.

The RAWFILL DST is a ranking tool that will allow ELFM project prioritisation based on a set of suitable physical, chemical, environmental, technical and social information. It will integrate the multiple aspects involved in ELFM projects, *i.e.* economical, technical, environmental and social factors. The DST will help stakeholders to take suitable decisions. A generic structure of relevant information to handle is presented hereunder, mostly under "risks", "drivers" and project "scales" (we see that ELIF information is treated as "actions" as well as the geophysical imaging).

RAWFILL's DST will operate at 2 levels:

- "Selection": a first level of quick screening to identify landfills with *a priori* interesting potential but which need further historical investigations and geophysical survey.

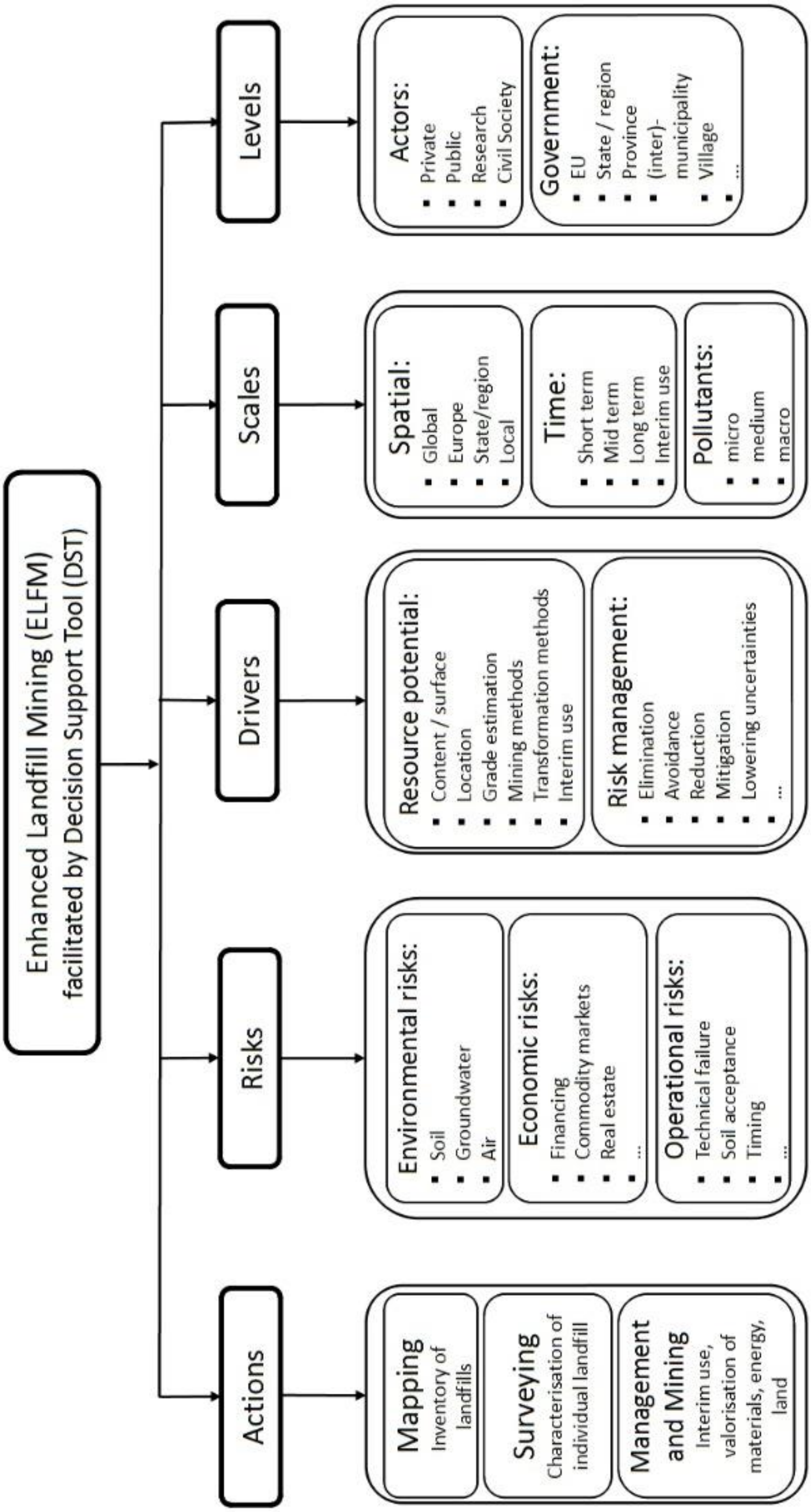

Figure 1: Overview of relevant aspects for an ELFM DST

- “Ranking”: a prioritisation tool to rank pre-selected and fully investigated landfills of economic interest for raw material recovery purposes. This second level of the DST is a more dynamic model integrating the landfill in its physical, economic and social environment, including safety aspects of the operations.

The DST will be built based on a table of suitable ELFM indicators extracted from the most relevant ELIF fields, for which a specific weight will be given. Not all fields will be relevant for DST; only those necessary to rank landfills on an ELFM point of view will be considered. The link between data collection, data storage and DSTs is presented hereunder[8] when several databases are used to manage landfill information, which is the case of OVAM. RAWFILL ELIF can be positioned at the level of “landfills database” and can be fed by several datasets, including the ones from geophysical imaging that have to be added on digital form. RAWFILL DST can be added as an additional tool that will treat suitable data extracted from ELIF datasheets.

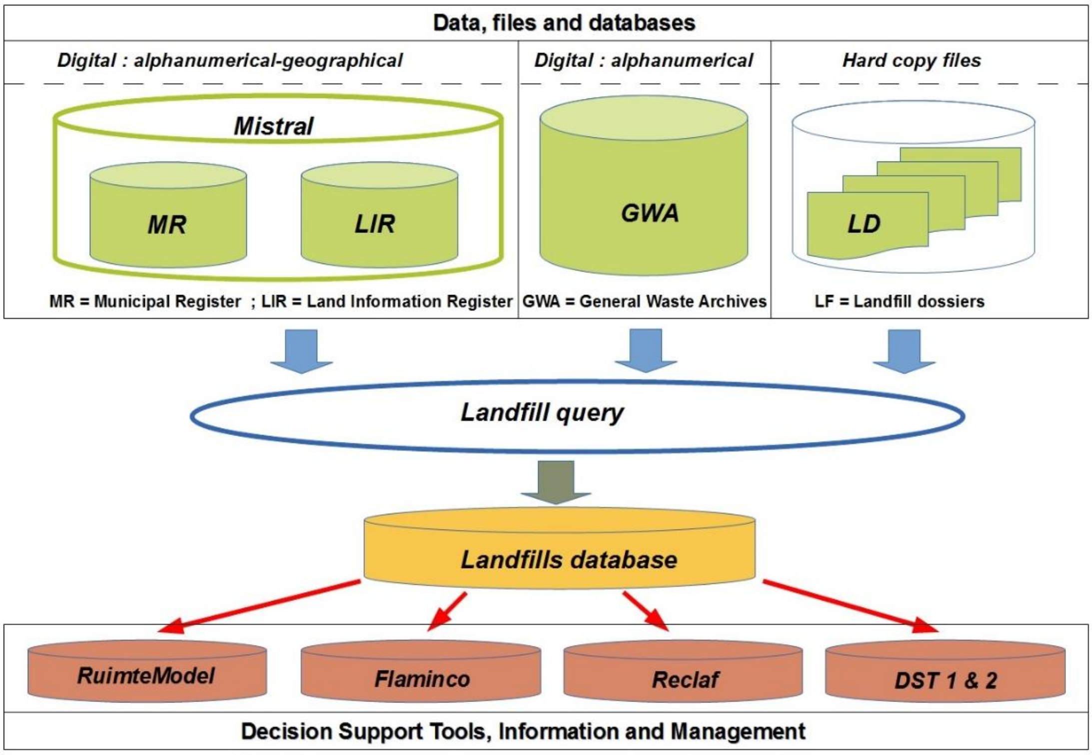

Figure 2: Link between data collection, data storage and DSTs within OVAMs structure

Main future users of the DST will be landfill owners, developers and investors in charge of landfill mining projects. But also public bodies could use these DSTs as part of their tasks in the field of policy making and data management of landfills. OVAM developed the FLAMINCO-DST[9] where a set of non-financial parameters are used to undertake a multi-criteria analysis in order to prioritise landfills for ELFM.

The RAWFILL DST will deliver reliable information about the feasibility and the costs and benefits of a planned landfill mining project. The reports will provide information on the degree of uncertainty of the knowledge on the landfill composition, the potential recovery of resources/land and the necessity of remediation actions. In the new approach, ELFM-projects are seen as business cases, where the decision to undertake a landfill mining project is considered as an investment decision making process. A. Winterstetter[10] proposed a coherent concept in which different technical, environmental and socio-economical parameters are integrated to determine the mining-potential of a specific landfill. The method is in line with the United Nations Framework Classification for Resources (UNFC[11]) which is applicable on geogenic resources. In a cooperative project (RECLAF[12]) between the TU Wien and OVAM this method was tested with success on specific Flemish landfills. The RAWFILL partners will develop an integrated method on mapping and surveying, which will feed the DSTs and deliver information to guide the future actions on landfills.

References

1. C. Neculau and R. De Rijdt, “The RAWFILL concept”, minutes of RAWFILL kick-off meeting, Liège, 7th June 2017
2. C. Neculau and R. De Rijdt, “Enhanced Landfills Inventory framework within RAWFILL project concept”, in 16th International Waste Management and Landfill Symposium, 2 - 6 October 2017, Sardinia, Italy, 2017.
3. Deliverable of WPT1/Activity 1: analysis of current inventories structures.
4. Deliverable of WPT1/Activity 2: analysis of current LFM experiences.
5. E.g. SPAQuE, Auditsite® or OVAM’Flaminco.
6. SPAQuE, Historical study, an innovative methodology, http://www.spaque.be/documents/HistoricalstudyLD.pdf
7. W. Hogland, M. Hogland and M. Marques, “Enhanced Landfill Mining: Material recovery, energy utilization and economics in the EU (Directive) perspective.”, in *Proceedings of the International Academic Symposium on Enhanced Landfill Mining*, 4-6 October 2010, Houthalen-Helchteren, Belgium, p. 233-245, 2010.
8. OVAM database structure for landfills management.
9. P. Van den Bossche, N. Bal, T. Behets, L. Umans and E. Wille, “Determination of the potential of Landfill Mining and the need for remediation of landfills in Flanders.”, OVAM, 2013. http://www.ovamenglish.be/enhanced-landfill-mining-elfm
10. A. Winterstetter, “Mines of tomorrow - Eine neue Methodik zur Bewertung und Klassifizierung von anthropogenen Ressourcen”, Dissertation, Institute für Wassergüte, Ressourcenmanagement and Abfallwirtschaft, TU Wien, 2016. http://iwr.tuwien.ac.at/anthropogene-ressourcen/publikationen/akademische-arbeiten/
11. UNECE, “United Nations Framework Classification for Fossil Energy and Mineral Resources 2009.” United Nations, 2010, New York, Geneva.
12. A. Winterstetter, D. Laner, E. Wille, P. Nagels, H. Rechberger, J. Fellner, “Development of a resource classification framework for old landfills in Flanders (Project RECLAF)”, in *SUM2016, 3rd Symposium on Urban Mining*, IWWG, Bergamo, Italy, 2016. http://iwr.tuwien.ac.at/anthropogene-ressourcen/publikationen/konferenzbeitraege/