

# **Sustainable stock management and landfills: introduction to Enhanced Landfill Management & Mining (ELFM<sup>2</sup>).**

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## **Abstract**

In 2011, OVAM started an operational programme on Enhanced Landfill Mining<sup>1</sup> (ELFM) over the period 2011 – 2015. The main goal of this programme was the development of a comprehensive policy dealing with the issue of 2.000 former landfills in the region of Flanders (Belgium).

On the 16th of October 2015, the Flemish Government approved the OVAM-memorandum on the new concept of Sustainable Resource Management of Landfills, as introduced by Joke Schauvliege, minister of Environmental Affairs. This concept, also described as Enhanced Landfill Management & Mining (ELFM<sup>2</sup>), aims at a sustainable long-term management of (mostly former) landfills, including interim use, and the valorisation of its content and surface.

## **Introduction to the policy framework in Flanders**

Flanders (Northern region of Belgium; 13.522 Km<sup>2</sup>; 6,4 million inhabitants) has expressed the ambition to take important steps towards a circular economy by 2020. A limited use of virgin materials, energy, water and land should reduce our impact as much as possible on the environment in Flanders and the rest of the world.

In implementation of the Flemish Coalition Agreement 2014-2019 (p.79: ... recovering, among other things, resources from landfills...) the Policy Note on the Environment 2014-2019 of Minister Joke Schauvliege mentions (p.55): 'A sustainable resource management of landfills, based on an integrated approach to soil remediation, must provide a substantial answer to the need for raw materials and space. To this end, I am implementing the vision on enhanced landfill mining, I am having an inventory made of high potential landfills and I am carrying out demonstration projects at landfills where soil remediation is needed.'

The note 'Vision 2050 – A long-term strategy for Flanders' also refers to ELFM as one of the strengths in Flanders when it comes to smart specialisations in the circular economy (p.42): '(...)Enhanced Landfill Mining to extract valuable resources from landfills and

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<sup>1</sup> The concept of Enhanced Landfill Mining (ELFM) was introduced and defined by Jones et al. (2013) as "the safe conditioning, excavation and integrated valorisation of landfilled waste streams as both materials and energy, using innovative transformation technologies and respecting the most stringent social and ecological criteria".

temporarily store products which contain valuable materials until recycling is economically profitable<sup>1</sup>.

OVAM as the environmental agency in Flanders dealing with the issues of Soil Remediation, Waste and Sustainable Materials Management (SMM) supports, develops and implements this transition. The concept of Sustainable Materials Management goes beyond the boundaries of traditional waste management to include the management of the complete materials cycle. Today's waste (Urban Mining) and waste from the past (Landfill Mining) should become the raw materials for a circular economy. OVAM introduced the R<sup>3</sup>P-approach (Recycling of Materials, Recovery of Energy, Reclaiming of Land and the Preservation of Drinking water supplies) to gain added value from landfills by applying the basics of ELMF.

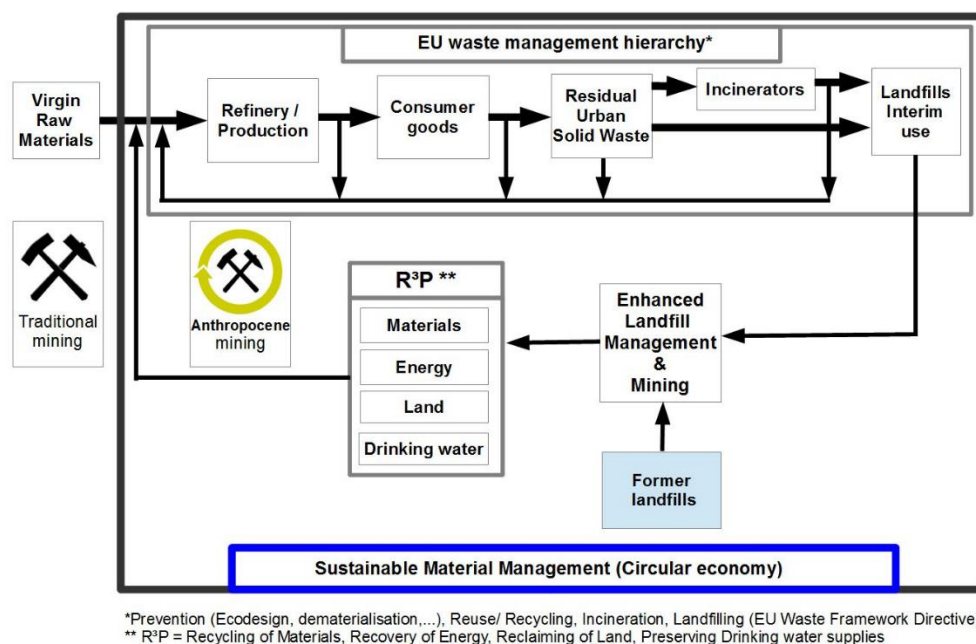


Figure 1 : R<sup>3</sup>P-concept and ELMF

However, until now there has not been an overall integrated policy for landfill sites (either in the EU or elsewhere) which comprises a systematic approach in a long-term time frame. This new concept of sustainable resource management of landfills (Enhanced Landfill Management & Mining or ELMF<sup>2</sup>) achieves this integration and hence contributes to the new policy guidelines on circular economy, sustainable development of land and mobility.

This paper comprises the vision and main objectives with respect to sustainable resource management of landfills and the links with other policies.

## **Global tendencies and challenges**

It is generally accepted that the global population is expected to reach over 9 billion by 2050. Given that by the middle of this century 70 per cent of the world's people will live in urban areas, cities need to adapt to urban expansion (S. Angel, 2011) and there is therefore an urgent need to prepare for growth and its related land requirements. This calls for a realistic projection of urban land needs and innovative responses. Rural land also needs to be managed cautiously because pressure is increasing as a result of a rising world population, climate change, declining soil fertility and the need for global food and fuel security. The divide between urban and rural is rapidly diminishing. Former remote landfills become embedded in the newly (sub)urban areas which are today interconnected by flows of goods, money, resources and people. This development demands an updated and adapted risk analysis on landfills but also offers opportunities from a resource perspective.

On the global platform, the land question is critical to the achievement of a wide range of development outcomes, including the proposed Sustainable Development Goals (SDGs). Besides SDG Goal 11: 'Make cities and human settlements inclusive, safe, resilient and sustainable' that UN-Habitat is championing, land is also implied in several other proposed goals that relate to the sustainable use of natural resources and several depend on the use of additional land resources: Goal 2 on food security, Goal 7 on energy supply, Goal 12 on production and consumption, and Goal 15 on the sustainable use of ecosystems. According to new tendencies on networking and cooperation Goal 17 becomes relevant for ELFM-consortia: 'A successful sustainable development agenda requires partnerships between governments, the private sector and civil society. These inclusive partnerships built upon principles and values, a shared vision, and shared goals that place people and the planet at the centre, are needed at the global, regional, national and local level.'

In the next 20 years, Homo sapiens, "the wise human", will become Homo sapiens urbanus in virtually all regions of the planet (UN Habitat, 2011). This 'second wave of urbanisation' is a core driver of change in the 21st century and follows the first wave of urbanisation that took place in developed countries from 1750, lasted 200 years and resulted in the urbanisation of 400 million people.

By contrast, the second wave of urbanization is projected to see over 3 billion additional people living in cities in a time-span of just 80 years, bringing unprecedented challenges to city doorsteps. Heck and Rogers (2014) state: "We are standing at the threshold of the biggest business opportunity in a century.", thus referring to the unprecedented demand on natural resources just as they were petering out. According to them, companies must systematically look at resource opportunities and by consequence, where can waste be eliminated or recycled?

In a rapidly urbanising future, it is clear that dealing with waste through conventional means could prove more expensive and environmentally damaging. Newer, low footprint waste disposal, recycling and re-use, re-design of systems and products, and

cleaner technology processes and technologies are required if the challenge of waste is to be adequately tackled. (UNEP, 2012).

According to those global challenges, sustainable resource management should be a major component of future policies in order to create a healthier and safer environment for a growing population.

## **EU policies on natural resources and land use**

By the Europe 2020-programme, the EC introduced a strategy for smart, sustainable and inclusive growth. Europe 2020 puts forward three mutually reinforcing priorities:

- Smart growth: developing an economy based on knowledge and innovation.
- Sustainable growth: promoting a more resource efficient, greener and more competitive economy.
- Inclusive growth: fostering a high-employment economy delivering social and territorial cohesion.

The Flagship initiative for a Resource Efficient Europe supports the shift towards a resource-efficient and low-carbon economy. The Roadmap to a Resource Efficient Europe outlines how we can transform Europe's economy into a sustainable one by 2050, taking into account the interdependencies.

The General Union Environment Action Programme to 2020 “Living well, within the limits of our planet” emphasizes the transition to a circular economy. On December 2<sup>nd</sup> 2015, the EC adopted a new Circular Economy Package to stimulate this transition. In a circular economy, the value of products and materials is maintained for as long as possible. Minimising waste production and reducing the mining of virgin natural resources contributes to this objective and lowers the externalities on the different levels.

Land is a multifunctional resource and the amount available to be used for different purposes is relatively fixed (EIEP, 2013). Mark Twain already noticed this reality when he stated: “Buy land, they ain’t making it anymore”. Land take is a process of significant relevance in the countries of the EU. Land take is defined as the “Change of the amount of agriculture, forest and other semi-natural and natural land taken by urban and other artificial land development” (EEA, 2013). In 2011, the European Commission put in evidence that an important milestone for the EU should be to reach the goal of no net land take by 2050, and to take under strict control the impact on landtaking processes of the EU policies in the new Structural Funds programming period (2014–2020).

During the conference ‘Land as a resource’ (June 19th ,2014), the EU-commissioner of environmental affairs declared: “ Efficiency in land and soil management is one of the main challenges facing our society. This challenge can only be met if we act to address the factors underlying it. In particular, we need to acknowledge that land is a finite resource, and use it first and foremost for as many purposes as possible – economic, social and environmental. Secondly, we need to avoid its wastage, including by preventing land degradation. Thirdly, we actively need to restore its functions once the

land is degraded and encourage land recycling, in particular by supporting the regeneration of brownfields.”. Landfill sites as a specific kind of brownfields, could be addressed within that regeneration process.

### **State of the art in Flanders**

For many years, Flanders has been an exemplary region when it comes to waste recycling. Over the last decade, 70% of household waste is collected separately, reused and/or recycled. Less than 2% of MSW ends up at landfills. For industrial waste a similar trend can be observed. These successful results have led to a situation where only 28 licensed landfills remain operational in Flanders in 2015. On the other hand, there are 2.033 former landfill sites (OVAM inventory, 2015). Most of these were closed before 1977 (mergers of municipalities) or 1984 (end of transition measures to more severe regulations). Even though the size of each landfill site is usually limited to less than 1 hectare, the total landfill area is estimated at 88 km<sup>2</sup>, i.e. the surface area of a major Flemish town. These are often underused sites, and this in a densely populated region with high pressure for land. Therefore, there is a need for a general vision on the redevelopment possibilities of landfill sites which are currently rather static storage places for problem materials, sometimes part of an aftercare phase.

Recent research conducted by OVAM has shown that (former) landfill sites represent more than a potential source of pollution and neglected land. The recovery of the waste stored and the underused space are no longer unrealistic scenarios. The total surface area of more than 80 km<sup>2</sup> indicates the importance of this potential space. Thanks to the technological developments and in view of the strong need for a healthy environment and materials, landfill sites could offer solutions instead of constituting a threat. There is added value for several policy areas and policy levels.

### **Preliminary OVAM research**

Over the past years (2012-2015), during the development of the new vision on sustainable resource management of landfills and the ELFM-concept, OVAM has carried out various studies on the different aspects such as data gathering, characterization of landfilled material and the potential of valorisation and redevelopment. In this context, pilots have been performed in addition to basic research on economic, legal and technological aspects.

OVAM (Wille et al., 2013) has introduced a method which can be summarised as consisting of three main axis: an inventory of landfill sites in Flanders (Mapping), a detailed characterisation of individual landfills (Surveying) and potential extraction/valorisation of landfilled material and the site (Mining). This simplified breakdown is in line with the work process in geogenic mining and enables OVAM to get

a good appreciation of the available supply (resources) and mining potential (reserves) (cfr. UNFC,2009).

An additional component which is less relevant in traditional mining is the cost in the case of non-mining, i.e. the soil remediation costs. A former landfill remains a source of pollutants which can pollute the environment and pose potential risks to human health and groundwater supplies. According to international guidelines and legislation, long term monitoring is foreseen but not on an eternal scale. Although Monitored Natural Attenuation is an accepted and wide spread applied soil remediation concept, entirely in situ mineralisation of landfilled material will mostly not be a realistic scenario within a time span of decades. Therefore, aftercare remains necessary and the costs of the this long term monitoring is seldom fully estimated.

Within the context of globalisation, sustainable development and the circular economy, there is also debate on the so-called externalities (external costs), which are not – or insufficiently – taken into account in traditional mining when the environmental impact is calculated. In economic research, these are pointed out in the social cost-benefit analysis, but further research is necessary in order to better estimate the impact of these phenomena.

Where the technical aspects are concerned, experiments and tests have been (or are being) performed for each component in order to gain practical experience. On a global level only very limited information is available. The OVAM research has already resulted in a number of important findings, which have led to concrete achievements.

The proposed method (Mapping, Surveying, Mining) has been tested, with positive results. A start has been made to translate this approach into the standard procedures of soil remediation. Additional test projects must enable us to refine and provide better support for these technical environmental guidelines. The usefulness and value of this method was also reflected in the drawing up of the first version of a decision support model (Flaminco) (Behets et.al, 2013). Thanks to this development, OVAM is able to assess the 2.000 landfill sites in a structured manner.

An additional inventory in the field has been started. On the one hand, the existing data files are being completed and validated and, on the other hand, additional landfill sites are being located. With a view to the characterisation of individual landfill sites, tests have been performed at approximately ten locations. To this end, diverse geophysical techniques have been applied and their potential applications have been studied. This research is being continued with a view to drawing up a code of best practice for landfill site surveys in the framework of ELM.

Separation tests are performed because these allow OVAM to gather important information about the average composition and quality of the disposed material. An additional effect is that those tests provide opportunities for the development of more

efficient separation technology. Table 1 provides a schematic overview of OVAMs test projects.

| Objective          | Description                     | Result                                       | Location        |
|--------------------|---------------------------------|--|-----------------|
| Characterisation   | Geophysical prospection         | Geometry of landfill                         | West Flanders   |
|                    | Geophysical prospection         | Geometry of landfill assessment # techniques | Limburg         |
|                    | Geophysical prospection         | Geometry of landfill assessment # techniques | Limburg         |
|                    | Geophysical prospection         | Geometry of landfill assessment # techniques | Flemish Brabant |
|                    | Geophysical prospection         | Density of landfill                          | East Flanders   |
|                    | Remote sensing                  | Filling history                              | Flemish Brabant |
|                    | Remote sensing                  | Temperature measurements                     | Antwerp         |
| Waste to Materials | Off site: excavation/separation | # flows                                      | West Flanders   |
|                    | Off site: excavation/separation | coal   | Limburg         |
|                    | Off site: excavation/separation | # flows                                      | Antwerp         |
|                    | Off site: excavation/separation | # flows                                      | East Flanders   |
|                    | Off site: excavation/separation | # flows                                      | East Flanders   |
|                    | On site: leaching               | recyclates                                   | confidential    |
| Waste to Energy    | Off site: excavation/separation | RDF  | West Flanders   |
|                    | On site: gas extraction         | Methane                                      | # projects      |
|                    | On site: solar panels           | Electricity                                  | # projects      |
| Waste to Land      | Excavation/(partial) removal    | Residential living                           | West Flanders   |
|                    | Excavation/(partial) removal    | Industrial area                              | Antwerp         |
|                    | Excavation/(partial) removal    | New landfill space                           | Antwerp         |
|                    | Solidification                  | Salix cultivation                            | West Flanders   |
|                    | Isolation/processing of waste   | Industrial area                              | East Flanders   |
|                    | Isolation/processing of waste   | Container terminal                           | East Flanders   |
|                    | Isolation/processing of waste   | Buffer basin                                 | Flemish Brabant |

**Table 1: OVAMs test projects**

### Landfills, land and stock management

The metropolitan axis Paris-Brussels-London represents about 80 million inhabitants and is still expanding. The Belgian Planning Agency pointed out that the population in Flanders will grow from 6 to 7 million people and its composition will also change. Moreover 300.000 dwellings over the next 15 years and 650.000 by the year 2050 will be needed. This demand on housing capacity is one of the major challenges in this rather

densely populated region. An additional strain on the environment and natural resources must be avoided. The integration of (former) landfills and the development of more sustainable and resource efficient cities are the main challenge in the policy making of sustainable stock management of landfills.

This city-concept is built on the idea that cities are complex networks of interlocked infrastructures that bring resources in, use the resources to provide services generate wealth, and dispose of wastes that are generated by consumption, the so-called city's metabolism (Smaoun & Gil, 2013). However, the potential integration of (former) landfill sites into the 'metabolism' of the expanding cities used to be seen as a major problem because of its adverse effects on the environment. OVAMs ELFM-programme attempts to point out that landfill sites are not a part of the problem but rather a part of the solution: focus on detecting opportunities instead of problem solving.

### **Current policy insights**

The waste legislation and landfill policy are based on European directives which, besides waste prevention, are aimed at a maximum reintroduction into the materials cycle. Within the existing waste hierarchy, the landfilling of waste is the last and least preferable option. In this respect, the EU policy uses Lansink's ladder, in which the following order of preference is established: waste prevention, reuse, recycling, incineration (with energy recovery) and landfilling. The last two options are described as final disposal and imply that the waste is finally removed from the cycle.

This permanent storage is an important constraint. Therefore, the construction and operation of landfill sites is aimed at reducing the harmful impact on the environment as much as possible. Since the 1980s, this has resulted in a location siting policy (less vulnerable areas with a natural hydrogeological barrier are preferential) and, on the other hand, in a waste-oriented approach. In the latter case, the dump material is isolated by means of containment and drainage layers. There is also the possibility for highly leachable waste to be stored in even more isolated zones or to be additionally immobilised. These measures are aimed at reducing the impact.

In cases where protective measures are absent, are failing or are not having the desired effects, soil remediation is the safety net. The general tendency in remediation concepts is to focus on repairing or installing the capping – the so-called IBC approach (Dutch for Isolatie, Beheersen en Controleren; Containment, Maintenance and Monitoring). These concepts are not aimed at the recycling of the dump material and the landfill area. In some cases the aforementioned practices are even a barrier, resulting in both the content and the surface area of landfill sites remaining un(der)used. The new approach is to treat the (former) landfill sites as dynamic reserves. This approach fundamentally differs from traditional visions on waste management and the remediation of landfill sites.

The approach proposed by OVAM is based on the ELFM concept which was developed in Flanders and expanded with a management component (ELFM<sup>2</sup>). The main objective



is the maximum reintroduction of the landfill sites into the materials cycle and as space in order to contribute to a sustainable resource management. Three important elements can be distinguished in this process: the content of the landfill, its surface area and its surroundings. The properties of the interaction between these three elements direct the sustainable resource management in time and space.

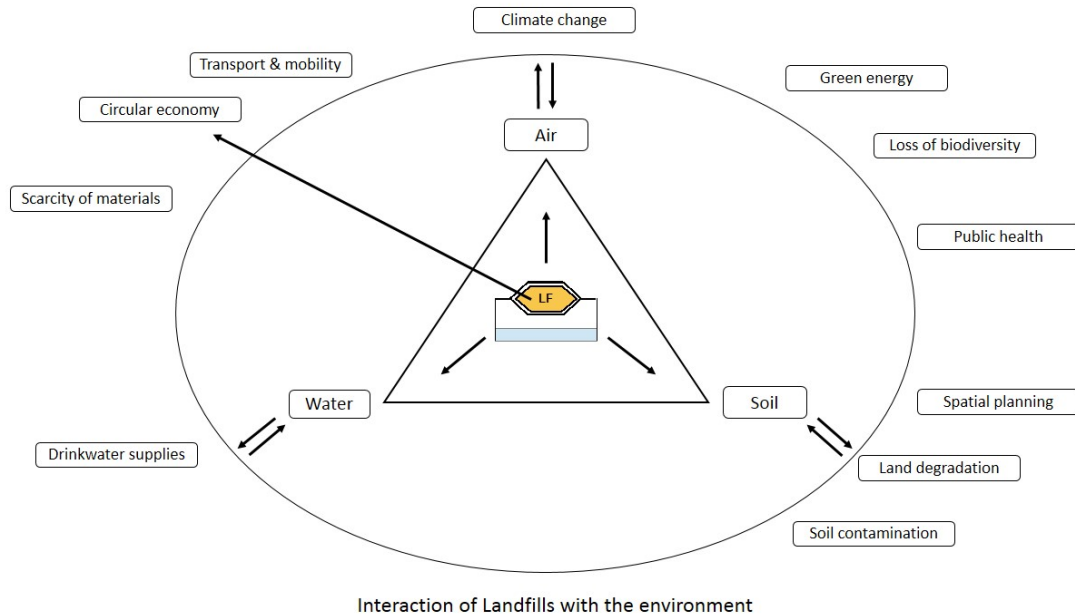


Figure 2 : Landfills and its interactions

This breakdown also shows the possible contributions to the transition to the circular economy. Material recovery must be supported by a broader material flow analysis and its effects are felt at the EU level, especially when it comes to the supply of scarce and valuable raw materials. The spatial impact has a rather regional character and fits into the ambitions to reduce the occupied space (Green paper on the spatial policy plan for Flanders). The preservation of drinking water supplies has a rather local impact, but the supply of drinking water has been indicated as a future bottleneck worldwide. From a global perspective, landfills can contribute to the climate problem with the production of greenhouse gases. However, the contribution from the Flemish landfills is limited thanks to the waste policy on organic flows (landfill ban for organic waste, policy on fermentation and composting,...) and landfill degassing (followed by energy recovery or, if no longer possible, flaring, so that methane is transformed into less harmful CO<sub>2</sub>).

This list corresponds to the trend analysis as described in Vision 2050 on various points and, in addition, offers solutions which perfectly fit into the development paths proposed in this note. In the past, OVAM has amended the representation of the cycle with the reintroduction of waste from landfills. However, the current proposal for sustainable resource management of landfills goes even further than materials supply and management and also provides an answer to other needs and threats.

## Principles and main objectives in the development of the vision

In order to maximize the chances of success of this programme, it will follow the structure of approved and ongoing initiatives as closely as possible. This way, resources will be optimized and various actions will be integrated or reinforced. This method comprises following constraints and conditions:

- fitting into existing governmental budgets;
- detection of common elements with other policy initiatives;
- following existing policy guidelines and similar initiatives as closely as possible (e.g. circular economy, inventory in vulnerable areas, investigation of contaminated land, open space platform);
- fitting into current legislation as much as possible;
- maximum cooperation and integration with external partners.

Figure 3 summarizes these versatile aspects and points out the differences between landfills in a linear and circular economy.

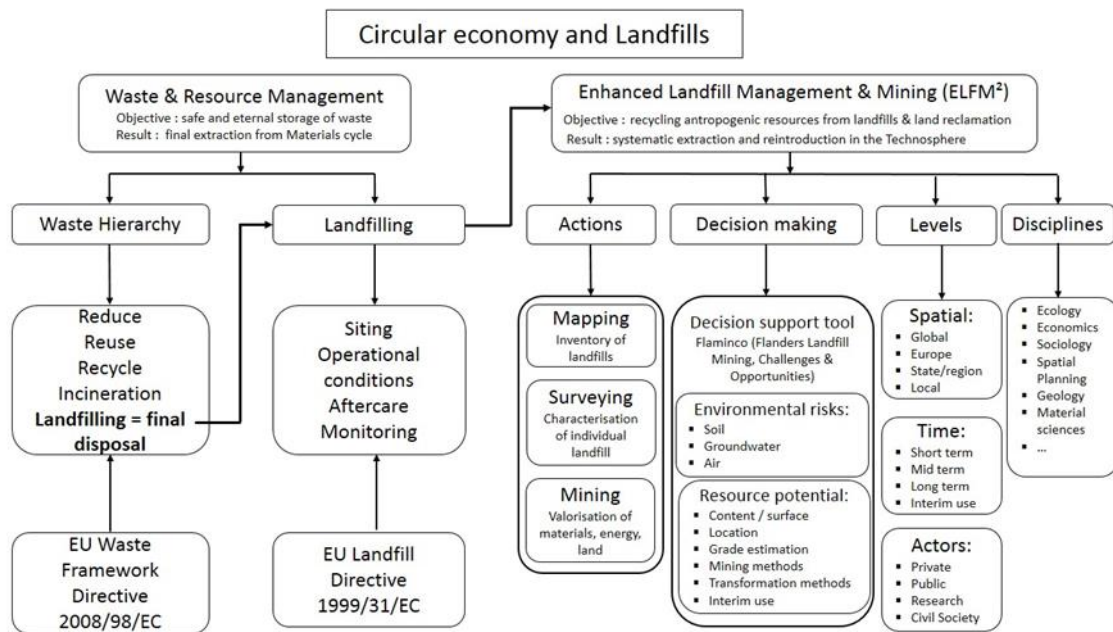


Figure 3 : Managing Landfills in a circular economy

Financial analyses have shown that the viability of landfill mining under present market conditions is limited. Since the beginning of 2015, commodity prices decreased with an average of moreover 20% and oil prices even went down to less than 30 dollar/barrel. The current incentives for mining are mainly related to the demand for additional space (still increasing real estate prices) and the obligation/need of soil remediation. In the plan period up to 2019 the contribution to the demand for raw materials is estimated to be rather limited. This does not mean that no measures need to be taken in the short term to organize the management of this reserve in anticipation of its mining. This makes the development of sustainable interim use an important issue.

When determining the time component, a long-term management spanning periods of several decades is taken into account, including an interim use to reinforce the support for ELM<sup>2</sup>. This approach also allows a better performing cost management and interim revenues which contribute to the financing.

The vision presented is based on the interaction between the individual landfill site and its surroundings. In the risk analysis, on the one hand, the risk of the source is determined and, on the other hand, the receptors that may be exposed are detected. It is studied how the location of a landfill site can affect the surroundings. This means the result of an impact approach: how can negative impacts be prevented? In this sense, the measures are mainly aimed at eliminating or mitigating the threats.

From the perspective of the inclusion of landfill sites into a circular economy, the realization of the potential is crucial. The immobilization of the waste makes the recycling of the valuable components impossible, or requires extreme processes to make it available. Isolation often hinders the use of the landfill area, so that it often remains an underused space (brownfield). Attention to the possibilities for valorization of a landfill site means a supply-based approach: how can positive effects be achieved?

The attention to the spatial dimension goes further than the content and surface area of the landfill. The landfill is seen within the context of its immediate and broader surroundings. Furthermore, in this context space must also be understood in the sense of ecological, economic and social space, in other words a multi-dimensional and complex system that is subject to numerous influences. In the development of resource management of landfills, global megatrends and system transitions will be taken into account.

The forecasts indicate a significant increase in the population and the number of households by 2050. Generally speaking, it is assumed that due to the population increase and the reduction in household size around 630.000 additional housing units will be needed. The continued development of the metropolitan area in Flanders leads to an increased demand for space and competition between different uses. At the same time, the open space needs to be preserved.

The principles of 'Lansink's Ladder' in the waste policy can also be applied to a well thought through use of space. First of all, a reduction in the use of space must be achieved (waste prevention). This means that additional activities need to take place in space that is already built up or in use. Secondly, space in a favorable location which has already been used in the past but has been abandoned must be used again (reuse of waste). This comprises the development of brownfields and the mining of old landfills. Thirdly, the use of space must be regarded as a recyclable element. This means that the use of space should be approached in such a way that the original state can easily be restored after the end of the activity.

Therefore, in the Policy Note on the Environment 2014-2019 importance is given to facilitating and stimulating the concentration, reuse and renewal of the use of space. To this end, activities are planned in an area-based and more project-oriented way. An important application is the development of suburban areas where the city and the countryside merge into each other and where fragmented landscapes are found. These areas are where old landfills are often located, and their presence has led to a patchy, discontinuous development of the area. Here, landfill mining projects can ensure a higher-quality spatial development.

In this context the importance of mobility must not be underestimated. The clear trend towards urbanisation also leads to the supply becoming an important point of attention. The transport of goods (into and out of the metropolitan areas, linking short and long distance transport) will be crucial for the livability of cities. In this context, multi-modal systems are being proposed, but new local service provision is also part of the priority scenarios. The landfill sites in themselves constitute a barrier to urban expansion, but an appropriate approach can contribute to the solution of the problem. These locations can grow into new supply hubs or processing areas for the dumped and recent waste.

### **Elaboration and implementation of the vision**

The organization of sustainable resource management of landfills is aimed at a maximum reduction of the negative effects and an optimal use of materials and space in a budget-friendly manner. This approach is combined with the soil remediation objectives.

The term 'resource management' implies a planning component and the proposed time horizons are in line with related ongoing initiatives: short term (2015-2019), medium term (2020-2027) and long term (2028-2100).

Furthermore, the future (temporary) storage of waste is accurately recorded and organized with a view to its future valorization. The storage method must not jeopardize the future processing of the waste, unless environmental risks leave no alternative. From this perspective, the technical guidelines on landfilling (UNEP, 1997; EU, 1999) require a revision but this is out of scope of this approved ELFM<sup>2</sup>-concept. This approach fits into the transition from a waste policy to a sustainable materials policy, which aims at achieving a position of (data) supplier for raw materials based on Urban Mining and Landfill Mining. The link with the circular economy is obvious here, and coordination in this sense is being aimed for. A high-quality transformation of the waste into new materials is central to this concept. Nevertheless, effective geogenic mining as well the anthropogenic mining is only a part of a long process of prospection on resources (definition of resources, reserves (Winterstetter et al., 2015)) leading up to the sale of the minerals.

The proposed concept of sustainable resource management of landfills requires a transition in waste policy and a time perspective. This way, the management of 2.000 landfill sites in Flanders spans over a period of several decades. In this management model the spatial aspect in the short and medium term will be the most important and decisive component.

### **The role of OVAM as competent governmental agency**

OVAM has always played a central role in the policy on waste, materials and soil remediation. The experience with landfill sites has resulted in extensive data files on diverse aspects of landfills. Completing these data and putting them to use with a view to efficient resource management is a first step. For its role as organizer OVAM has sufficient knowledge and basic data at its disposal to accomplish this transition. Its task is threefold:

- data collection;
- data processing;
- policy development by defining priorities and making choices when it comes to the management of all landfill sites. The elaboration of a policy framework with legal and financial instruments to put ELFM<sup>2</sup> into practice.

OVAM supports and facilitates ELFM<sup>2</sup> so that researchers and environmental companies are given the necessary short-term incentives to invest in this innovative environmental branch. This way, the sustainable materials policy is further shaped by the inclusion of an assessment of the reintroduction of (old) resources from landfill sites and their possible mining. Thus, the role of landfill sites within the concept of the circular economy becomes a reality. OVAM creates the framework for such management but does not act as a developer of technology or a producer of materials. In its own projects OVAM does play an active role by applying and promoting ELFM<sup>2</sup> in these Living Labs which can act as demonstration projects.

These pilots are also broader than the mere (partial) removal of dumped waste; they must fit into a broader policy framework, in which attention is paid to the use of space, improved mobility and the like. Taking into account the innovative nature of this ELFM<sup>2</sup> concept, OVAM will look for partnerships as much as possible in order to share the experience and knowledge gained. In its role as a pioneer, OVAM will also make efforts at the international level to secure support for this resource management of landfill sites.

When it comes to the legal aspects, OVAM will draw up the necessary proposals to offer ELFM<sup>2</sup> maximum opportunities. This comprises both legal protection for its performance in practice and a facilitating and supportive framework. The legal concept of the soil remediation project is a suitable instrument in this sense for remediation and redevelopment. An adaptation of the standard procedure and the inclusion of a specific

procedure for landfill sites is a necessary condition to facilitate and accelerate these projects.

The financial instruments also require streamlining in order to offer this innovative policy optimal opportunities. In addition to support programmes with a financial contribution (subsidies, loans,...), the possibility of participations in innovative techniques and services (risk capital providers) is being studied as well. Another scenario is a tax reduction, which would offer ELFM<sup>2</sup> projects additional financial breathing space especially in the initial phase (e.g. reduction of or exemption from environmental taxes or tax on gains resulting from a change of land use). The mining of a completed landfill will rarely result in a 100% recycling efficiency and the conditions of the removal of the residual waste can strongly affect its feasibility. Reduced waste tax in analogy with contaminated soils that cannot be cost-effective remediated may be an option to dispose cheaply residual waste streams that cannot be valorized. However, in this context the possible impact on other policy initiatives remains a point of attention; the trade-offs must be acceptable and not inhibit recycling efforts/markets.

### Data Management and Decision Support Model

OVAM is designing a management model for the monitoring and redevelopment of all landfill sites in Flanders. Based on its core duties and policy tasks, over the past decades OVAM has not only had access to many relevant data, but also to useful experience and knowledge. The ultimate goal is an aggregation of multiple data on resources in order to provide a clear view on the stocks at different levels : spatial (EU, Regions/Member states, local/Landfill site), actors (quadruple helix) and time (short, middle, long, interim).

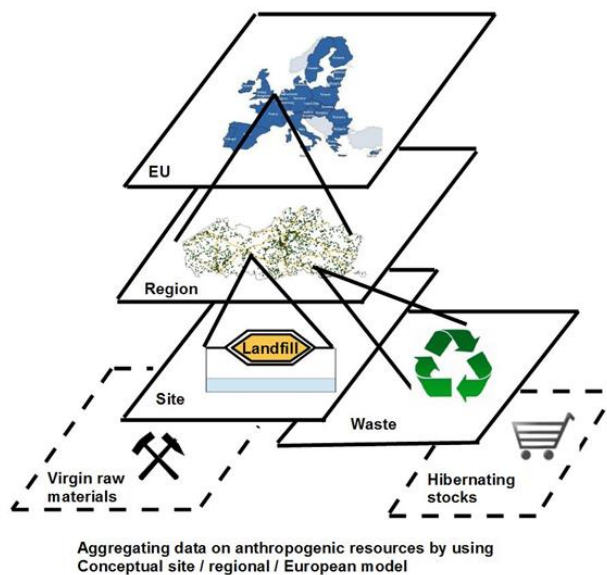


Figure 4 : data management of stocks

Crucial to this is the development of a decision support system. Building on the OVAM model Flaminco v1.0 (Flanders Landfill Mining, Challenges & Opportunities), which is in line with existing OVAM databases, flexible prioritization is possible. The adaptation to Flaminco v2.0 is not only a matter of better support and evidence from basic research on economic and technological aspects. More challenging is the coupling and integration with existing models on soil pollution risk assessment (S-Risk), groundwater modelling (Modflow), spatial modelling (RuimteModel Vlaanderen), material flow analysis (STAN), resource classification (UNFC), transportation and distribution (LAMBIT), etc. This way, landfill site management can be developed further as a comprehensive tool embedded in other policies. Furthermore, information provided by other authorities can be processed and an exchange can be set up, facilitating the achievement of mutual objectives (Figure 5).

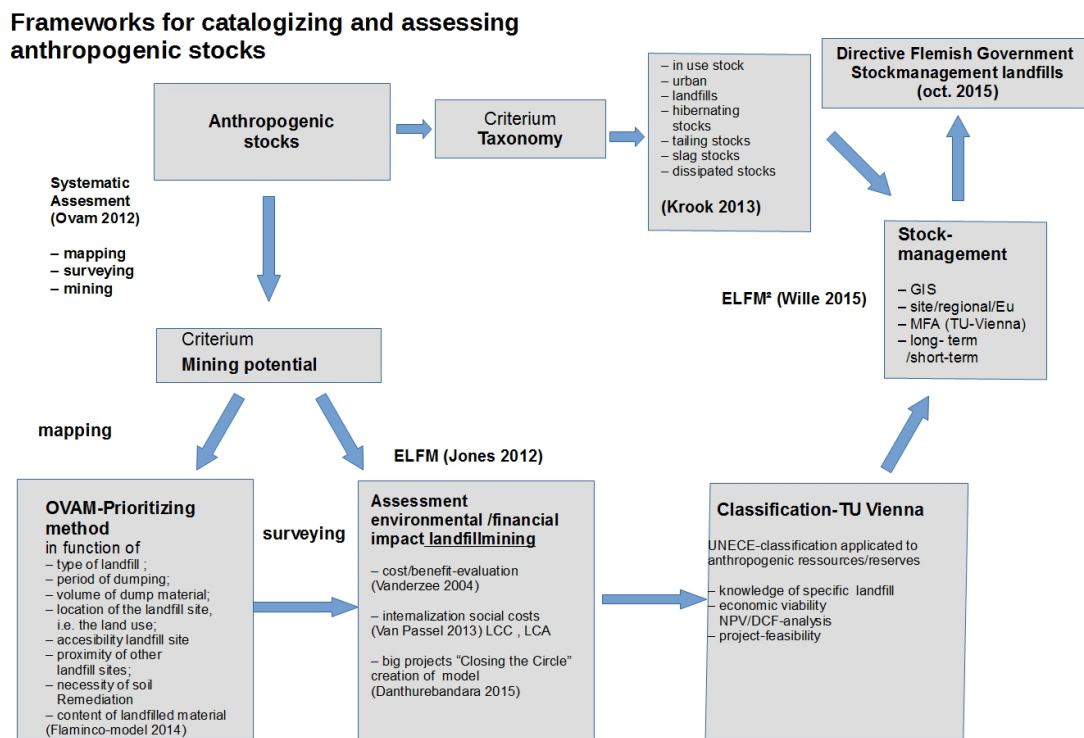


Figure 5 : Framework of anthropogenic stock management

## Monitoring and interim use

OVAM will draw up a monitoring plan which, on the one hand, offers guarantees when it comes to the burden on the environment and, on the other hand, reports on the available resources in the framework of a circular economy. This way, the objective of providing information about the impact and the availability of resources is met. This monitoring gets its basic information from the OVAM databases and archives and is in

line with the current guarantee regulation for operational landfill sites, which has been managed by OVAM since 1984.

In anticipation of development, sustainable interim use is provided for and the impact on the surroundings is limited as much as possible. To this end, solutions will be worked out in collaboration with other authorities for rural landfill sites (land and nature management) and urban landfill sites (brownfields). Through the collaboration in VITO's spatial model RuimteModel Vlaanderen (Engelen et al., 2011), the spatial offers and demands are mapped more accurately and it is studied how landfill sites can make a contribution in this respect. In this framework it is important to maximise the interim use of landfill sites. Moreover, this generates interim revenues with which management measures can be financed.

Furthermore, this interim use also refers to the interim valorization of resources (e.g. landfill gas extraction, leaching) and a more optimal storage of the current disposed material with a view to future recycling. The definition of the landfill conditions is not part of the ELM<sup>2</sup> project but it is indicated as a point of attention in the broader context of a circular economy. The trend break with final disposal has already been indicated, and the question arises as to the role of landfilling within a circular model. The ideal cycle with a 100% reintroduction immediately following the end of use of a product is the ultimate goal, but the interim period during which this condition is not met also requires a specific policy.

### **Exchanging experience and setting up partnerships**

Resource management of landfills is a new development and trend in which landfills are no longer by definition regarded as a final disposal phase in the linear economy. They are part of sustainable development and raw material supply, so that this transition fits into a broader European policy framework. OVAM will strive for a maximum exchange of information and experience with other authorities and stakeholders in order to achieve policy improvements. In addition, cooperation partnerships will boost integration and offer possibilities to achieve mutual added value.

Especially for the local authorities the ELM<sup>2</sup> concept should entail structural cooperation regarding to the redevelopment and remediation of the old municipal landfill sites. Extensive cooperation and exchange will not only improve efficiency, but also accelerate the learning process.

The accelerated introduction of new transformation technologies and methods will take place via the platform function OVAM advocates within the ELM<sup>2</sup> concept. This results in better interaction between companies, research institutions, authorities and citizens, a form of multi-actor action which is already being used within the ELM consortia.

This structural approach also has to lead to a pioneering position of Flanders in the area of landfill site management. The narrowing down of the concept to sustainable



landfilling, is mainly aimed at current landfilling practices and does not provide a sufficient answer for an efficient management of the 2.000 former landfill sites. Thanks to the extensive collaboration in platform such as EURELCO, a greater impact on European policy and support programmes is achievable.

The combination of the Decision Support Model Flaminco and Multi-Actor-Governance is also in line with the 2 systems of thought as defined by D. Kahneman (2011). This reflects a dichotomy between two modes of thought: "System 1" is fast, instinctive and emotional (MAG) and "System 2" is slower, more deliberative, and more logical (Flaminco). His prospect theory makes logical assumptions of economic rationality that do not reflect people's actual choices, and does not take into account behavioral biases. Developing ELM<sup>2</sup> implies uncertainties and controversial views with regard to current waste policies. Specific networks should contribute to a better understanding and support of such transitions.

## **Conclusions**

The transition to a circular economy involves a process that not only emphasizes on the future production systems and life cycles, but should also focus on the environmental heritage of our linear economy: the make, take and dispose era. More specific, the landfills should be addressed in a way that reintroduction of these depreciated assets in the resource cycle becomes the ultimate objective. The ELM-approach offers a method that sets high standards on transformation technology and sustainability. The development and implementation of this concept on a large scale requires many efforts regarding to multiple aspects involved (financing, research, social acceptance, etc.). It's quite clear that this process is not only complex but also time consuming.

From the policymakers side of view, a long-term stock management planning should include actions in the near future (quick wins) and an interim use to bridge the gap with an emerging circular economy. The introduction of Enhanced Landfill Management and Mining contributes to this policy transition by aiming at a good description of the stocks, supporting emerging and innovative technologies and creating Living labs in the short term.

In summary, the proposed concept of sustainable resource management of landfills comprises the following priorities and conditions of implementation:

- the introduction of a general and integrated approach for all landfill sites in Flanders (sustainable resource management of landfills);
- the decision support model FLAMINCO is the basis for the general management model of OVAM, which allows for a sufficient degree of individualisation;
- attention to diverse added value and interim use;
- setting up living labs, pilot studies and demonstration projects in the framework of OVAMs ex-officio remediation of landfill sites;
- gathering and sharing of knowledge and experience via structural networking.

The implementation plan is linked to the three-step approach (Mapping, Surveying, Mining): inventory of all landfill sites in Flanders, characterization of individual landfill sites and the potential of valorization of a landfill within the impact and resource approach. This breakdown remains useful within the management model to be developed by OVAM and will be included in the schedule. In the plan three time horizons are distinguished, which are in line with current initiatives.

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