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Orion dashboard: Afforestation Decision Tree

Instrument on suitability assessment for the afforestation on landfills

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1. Introduction

Old landfills can offer space for nature (re)development, including afforestation. When landfill mining is not feasible, an interim use can be set up. The RAWFILL Orion Dashboard provides a number of options which link to more detailed decision support tools on several types of (interim) use. Nature development can be a sustainable solution in this case. However, some landfills will not be suitable for nature development. In order to allow the selection of suitable former landfill sites, an instrument was developed in the form of a decision tree, that allows a soil expert to screen and classify the locations of former landfills for this purpose. The decision tree can only be used with the results of a preliminary or exploratory soil investigation[1].

This decision tree was developed within the RAWFILL project, by Sertius (Accredited Soil Remediation Expert) in collaboration with OVAM and the Flemish Governmental Agency for Nature and Forest (ANB). A decision tree developed to assess the suitability of landfills for nature development and more specifically, afforestation. Furthermore, this tool enables the user to classify landfills based on their potential for afforestation.

After performing a preliminary soil investigation, a soil expert should be able to ascertain if nature (re)growth (in particular afforestation) is possible and under what conditions. For this screening, a decision tree can be followed by taking various criteria into account. Ideally, the screening can be performed on the basis of a desk study and the data that has already been included in a report of an exploratory soil investigation, without additional fieldwork or research efforts. Aspects that are important to develop such scheme, are the characteristics of the landfill itself and criteria related to forest planting and forest development in the longer term. It should be noted that this decision tree does not intend to already make choices in tree and shrub species, planting schemes, management or maintenance. However, it tries to provide as many elements as possible in order to be able to make the right choices.

2. Characteristics of landfills and criteria for afforestation

In the Netherlands, an evaluation was carried out in 2015 in the context of prioritizing landfills for urban mining and nature development (Company Milieuadvies, 2015). In this study, the emphasis was on nature development after urban mining (or remediation). Besides the characteristics of the landfill, also natural development patterns in the surroundings of the landfill were taken into account (e.g. original or desired nature target types).

[1] in Flanders, Oriënterend of Beschrijvend Bodemonderzoek.

Some of the criteria considered were based on the:

1. CONTEXT

- The current use of the surrounding lands;
- The groundwater quality[2];
- The current use of the landfill site area;

2. CONTENT

- Risk of contact with the waste material;
- The type of waste material (contaminated landfill and contamination of soil and groundwater) and the surface of the landfill[3];
- The current natural value;
- The sensitivity of the intended natural function to acidification, desiccation or eutrophication.

The stage and potential of the nature development or nature value that is already present on the site, can be taken into account as an additional element. Furthermore, the subsidence of sites, the release of landfill gases or the presence of aggressive substances and asbestos can also be limiting factors for afforestation and/or nature development. These aspects should also be taken into account if the rehabilitated sites will be opened to the public in the future. The new use of the landfill can also lead to instability/erosion of a slope or embankment (Province of Noord-Brabant, 2004).

In another study, by Talboom Environment (2021), a number of concrete scenarios were outlined which can serve as a base for the approach towards afforestation. In the document, it is emphasized that, in the end, a separate specific approach will be required for each specific landfill site. The study clarified that for successful afforestation, the growing conditions (such as soil compaction, soil structure, water management, nutrients, pollution, etc.) must be taken into account. In landfill afforestation, the main concerns are:

- The ability of the root system to penetrate the landfill cover layer;
- The possibility of the root system to dry out the landfill cover layer (clay layer) resulting in cracks;
- The absorption of contamination (heavy metals) by trees and further transport by the root system to the leaves (enrichment of the leaf litter and absorption in the food web);
- The plants/trees will die due to extreme conditions;
- The formation of a superficial root system with an increased risk of windfall;

[2] The critical threshold for the conductivity of groundwater to allow tree growth was set to 1500 µS/cm by Huvenne (1996).

[3] From this study, it appeared that for the selected landfills, no representative sampling and analysis was possible. In older landfills, the waste material is often partially mixed with soil material.

- The severe disturbance of the capping layer due to windfall and uprooting (exposing contamination and landfill material).

Hence, for landfill afforestation, the choice of the tree species is very important (matched to the site-specific conditions of the landfill).

It is often the physical soil quality that is insufficient to allow plant/tree growth, mainly due to the frequent occurrence of (brick) stone rubble, gravel, waste or other artefacts that limit the rootable space and the water storage capacity of the soils. This explains the often observed drought stress and the sensitivity to windfall (INBO, 2020). In the case of windfall, there is a need to repair the cover layer to prevent erosion channels. Furthermore, fallen and uprooted trees should be removed.

Provided that the planting is adapted in function of the characteristics of the landfill, a forest vegetation has several advantages in comparison with other vegetation types. For examples, trees have the greatest evaporation capacity, which reduces the percolation of rainwater through the landfill (OVAM, 1996).

On dredging and sludge landfills, plants and trees can grow, but they should fit in the ecological target of an area so that a well-functioning ecosystem can be created (Nobis, 1999). Furthermore, one should keep in mind that afforestation could also be used as a nature-based solutions for soil pollution, such as phytoremediation, in which plants and their associated microorganisms are used to remove, degrade or stabilize contaminants in both soil and groundwater (OVAM, 2021). A list of plants is available in Dutch and French.

When designing an afforestation plan, special elements such as old trees, springs, pools, sunken roads, etc. are often integrated because these enhance the ecological and recreational value of a forest (VBV, 2008). This will not always be possible in forests that developed on landfills.

Besides the technical aspects of afforestation on landfills, attention should be given to (later) restrictions on the use, accessibility and maintenance of the forest, before proceeding with the afforestation works. Furthermore, also financial, organizational and communicative aspects should be considered (Noord-Brabant, 2004).

3. Afforestation Decision Tree

3.1. Assumptions

Taking into account the elements as included in section 2, the following principles were formulated in order to design the afforestation decision tree:

- The decision tree is applicable to landfill sites for which an exploratory or preliminary investigation is done.
- The flow chart takes into account that with afforestation, health and safety must be guaranteed:
  - For workers/volunteers during the planting phase;
  - For workers/volunteers during administration and maintenance (from planting to ...);
  - For recreational users when the forest is accessible.
- The outcome of the decision tree is based on the characteristics of the landfill and gives direction regarding the possibility of afforestation according to four categories:
  1. Afforestation is possible;
  2. Afforestation is possible under certain conditions;
  3. Preference for (further) spontaneous afforestation (no afforestation through planting);
  4. Afforestation is not recommended based on the characteristics of the landfill.
- The outcome of the flow chart (four categories) does not include the choice of specific trees or other plant related technical aspects that are important in the context of successful afforestation in the long-term.
- Spatial aspects or a spatial analysis are not integrated in the decision tree. The feasibility of afforestation due to spatial aspects is not part of this assessment, but must be checked case by case by the initiator of the afforestation (checking spatial and urban planning preconditions).
- In order not to burden the decision tree too much and to obtain an assessment as generic as possible, it has been decided to add (i.e. after indicating the option for afforestation according to one of the four categories) some '*landfill information*' to the assessment report. This contains information that is important for the initiator of the afforestation project for the tree species selection and the management and maintenance of the forest (such as groundwater depth, altitude of the landfill, spontaneous growth of certain plant species, conductivity, ...). Thus, it is generically indicated that afforestation is possible, but that a number of factors must be taken into account locally to make afforestation successful.
- For afforestation on landfills, it is appropriate to make sure that the formulated "conditions" on afforestation are followed over the years. Therefore, it is also advised to link the afforestation project to a nature management plan.

- The primary purpose of the flowchart is to determine the suitability of landfill sites for afforestation and to classify them on their suitability for that case. It cannot be ruled out that certain landfill sites are also eligible or have potential for DLM (Dynamic Landfill Management) or even ELFM (Enhanced Landfill Mining) (OVAM, 2021). In that case, an additional consideration can be made, case by case.

3.2. Structure

Figure 1 and Figure 2 show the afforestation flowchart, initially distinguishing between:

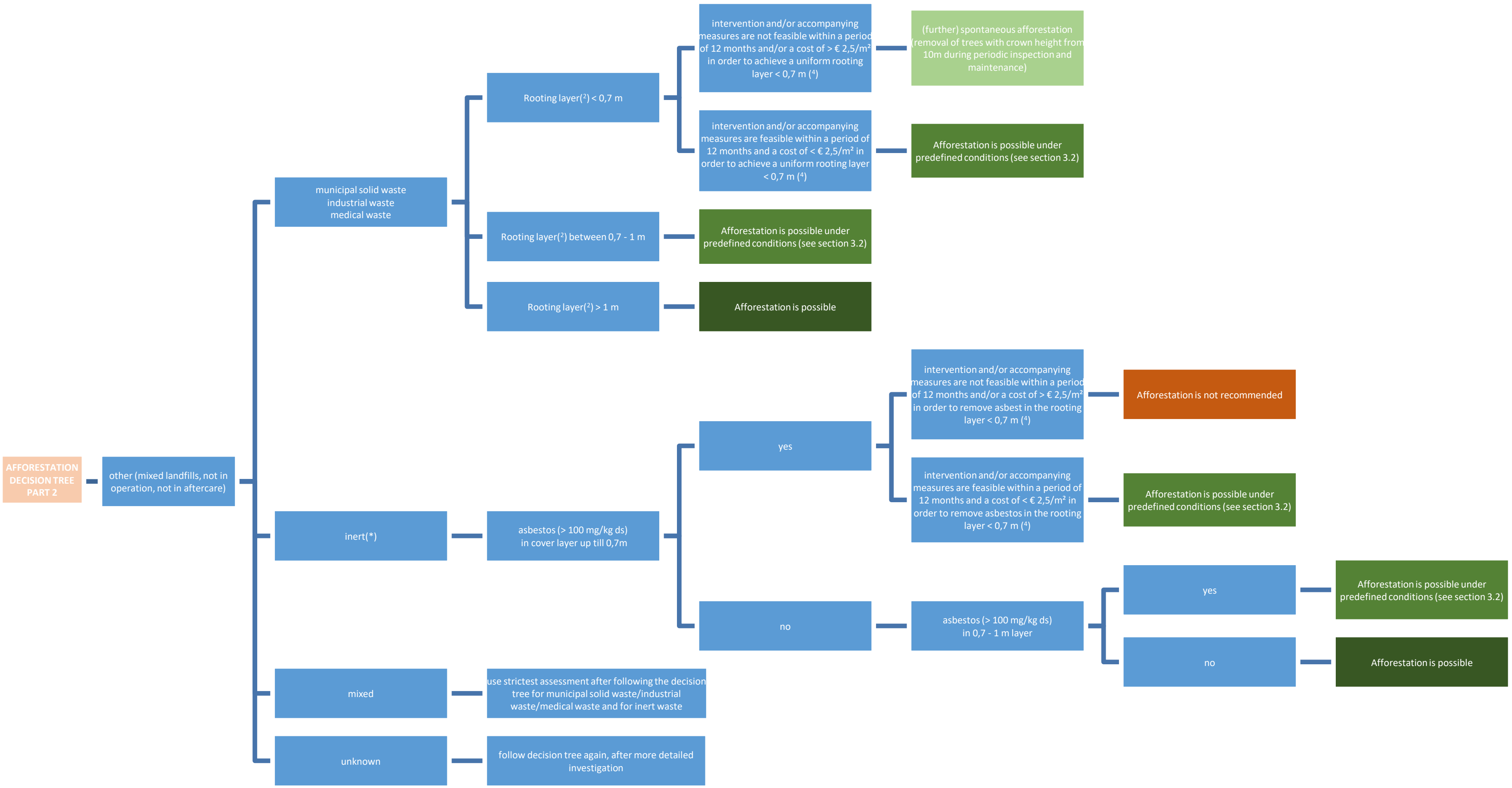
- Landfills which are currently in operation or under the aftercare (cf. the obligations after the closure of an authorized/permitted landfill, in accordance with the applicable legislation);
- Mono-landfills;
- Mixed landfills.

Going through the flowchart leads to the classification of the landfill, based on the characteristics of the landfill, in one of the four following categories:

1. Afforestation is possible;
2. Afforestation is possible under certain conditions:
    - If the depth of planting pits is limited (in relation to the thickness of the rooting layer);
    - If the planted tree species have a moderate height or if the forest is subject to a type of forest management in which the trees are regularly cut;
    - If trees are with a crown height from 10 m are removed during periodic inspection and maintenance (in order to avoid windfall and uprooting that can expose pollution and waste material) .
3. Preference for (further) spontaneous afforestation (no afforestation through planting);
4. Afforestation is not recommended based on the characteristics of the landfill.

*If debris/rubble is present in sludge or dredging materials in the rooting layer and/or if there is an indication of asbestos in the rooting layer, the decision tree should be followed from 'inert waste'. In that case, the strictest assessment will be applicable.

Figure 1 – Afforestation Decision Tree Part 1



*If debris/rubble is present in sludge or dredging materials of in the rooting layer and/or if there is an indication of asbestos in the rooting layer, the decision tree should be followed from ‘inert waste’. In that case, the strictest assessment will be applicable.

Figure 2 – Afforestation Decision Tree Part 2.

Further explanations for some elements in the decision tree:

(1) Radioactivity

> *Measurements of radioactivity are carried out at the top of gypsum or gypsum-containing material and a maximum of 1 m-mv if the top of gypsum or gypsum-containing material is deeper.*
>
> *For the threshold value, reference is made to the activity concentration level in accordance with Annex VIII, table A of the Royal Decree of 20/07/2020 (BS 19/08/2020), (as stated in the Belgian law). These values depend on the type of radionuclide and there are specific values determined for mono-landfills. If you live in another region, please consult the threshold values determined in your country.*

(2) Rooting layer

> *Soil layer that does not contain bulk material and is visually clearly distinguishable from the underlying bulk material. The rooting layer may also be a contaminated soil layer that may or may not contain inert materials.*

(3) Additional evaluation regarding maturation, dewatering and soil compaction

> *Afforestation is possible, but with recently (< 30 years) applied silt or dredged material, the soil is still little or not developed; this must be taken into account in the case of afforestation.*

(4) Interventions and/or accompanying measures cannot be carried out within a period of 12 months and/or costs > € 2.5/m²

> *At some sites, it will be possible to still meet the conditions for (spontaneous) afforestation by means of limited interventions or measures. The accredited soil expert evaluates its feasibility in terms of timing (timing based on permits obtained, whether or not within the BSP procedure) and cost. The final decision to implement this lies with the initiator of the afforestation.*

(general)

> *If rubble-containing material is present in silt/dredging or in the rooting layer and/or if the rooting layer is suspected of asbestos or contains asbestos, the schedule must also be run from 'inert'; the strictest assessment after going through the schemes applies.*

3.3. Landfill information

After the classification of the landfill site in one of the four categories, some more information should be gathered for the initiator of the afforestation project. This information:

- can be (simply) collected or derived based on the results of a preliminary soil investigation;
- can be important for the choice of trees and shrubs, planting schedules and the type of management and maintenance.

Table 1 includes an overview of the landfill information to be linked to the landfill and the output of the Afforestation Decision Tree. The landfill information should only relate to the 'zone with landfilled material' (so no evaluation is made for zones without landfill material). The applicable categories of the different parameters should be indicated.

Table 1 - Explanation of landfill information.

Parameter	Explanation	Category
Groundwater depth (m-mv) - highest	Highest groundwater level (GWL) based on measurements. (It is not required to measure periodically on the ground water level. If time series are available, these can be used. If no time series are available, then this concerns the highest groundwater level as determined at the height of the landfill.)	- GWL 0 - < 1 m-mv - GWL 1 - 2 m-mv - GWL 2 - 3 m-mv - GWL 3 - 5 m-mv - GWL > 5 m-mv
Groundwater depth (m-mv) - lowest	Lowest groundwater level (GWL) based on measurements. (It is not required to measure periodically on the ground water level. If time series are available, these can be used. If no time series are available, then this concerns the lowest groundwater level as determined at the height of the landfill.)	- GWL 0 - < 1 m-mv - GWL 1 - 2 m-mv - GWL 2 - 3 m-mv - GWL 3 - 5 m-mv - GWL > 5 m-mv
Groundwater conductivity (µS/cm) – lowest	Lowest conductivity (EC) of the groundwater the monitoring wells.	- EC < 750 µS/cm - EC 750-1500 µS/cm - EC 1500-225 0 µS/cm - EC > 225 0 µS/cm
Groundwater conductivity (µS/cm) - highest	Highest conductivity (EC) groundwater at the monitoring wells.	- EC < 750 µS/cm - EC 750-1500 µS/cm - EC 1500-225 0 µS/cm - EC > 225 0 µS/cm

Current use and/or nature development	Observations during site visit – Photo report.	- Cropland/arable land - Grassland (pasture and/or mowing land) - Fallow land - Forest development (> 50%) with herb layer[4] - Forest development (> 50%) with shrub layer[5] - Forest development (> 50%) with tree layer[6] - Other (specify)
Altitude	Zone with landfill material compared to surrounding plots.	- Higher location > 3 m - Higher situated 1 -3 m - Connecting to surroundings (max. 1 m higher and max. 1 m lower) - Lower location > 1m
Chemical aspects	Based on measurements or field observations.	- Evaporation gases – methane - Evaporation gases – BTEXS - Evaporation gases – VOCl - Evaporation gases – other (please specify) - Evaporation gases – unknown – no data available - Evaporation gases – not applicable
Physical aspects	Observations during site visit – Photo report to be added.	- subsidence / subsidence (> 1m) - Uneven ground level (pits/heaps > 1 m) (terrain to be levelled) - Erosion / run-off verges / slopes - Buildings, constructions or paved areas present - Not of application

[4] The herb layer is the vegetation layer of 10 to 135 cm high with mainly herbaceous plants and young plants that can grow to higher layers.
[5] The shrub layer is the layer from 1.35 m to 8 m heights with vegetation in which shrubs and small trees predominate.
[6] The tree layer is the layer higher than 8 m, above the shrub layer with especially the crowns of the trees.

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