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HOMBRE

"Holistic Management of Brownfield Regeneration"

D 5.3: Use of bio-energy clusters for linking marginal urban brownfield site re-use with sustainable urban energy

FINAL REPORT

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Summary

Within the HOMBRE project, one of WP5 aims was to explore the use of bio-energy clusters on marginal urban brownfield sites which are mainly causing significant problems for the urban environment in shrinking regions. Such projects can have wide ranging positive impacts such as bringing degraded urban brownfields back into viable use while also possibly providing a new source of sustainable urban energy. Deliverable 5.3 “Use of bio-energy clusters for linking marginal urban brownfield site re-use with sustainable urban energy”, presents current studies related to biomass production on brownfield sites and different pilot case study of implementation. It aims to address decision makers in municipalities as well as land owners or local and regional energy suppliers.

The report shows that bio-energy production on brownfields depends on multiple factors ranging from the surface area of the site (size), quality of soil, site conditions and the selection of the type of energy plants to be used on site. Biomass production is suited for brownfield sites with low to medium land recycling costs combined with a low demand for building land within the city and or region (such as is present in shrinking cities).

In order to identify the appropriate locations for biomass production and how to best carry it out, various tools and methods for the identification of biomass potentials are elaborated upon. The use of brownfield sites for biomass production has the double effect of not only bringing degraded sites back into use but also contributes to the use of sustainable energy and a subsequent reduction of greenhouse gas emissions. Cluster schemes in the specific urban context can be considered to link various brownfields sites through central management to reach the desired amount of land for biomass production.

The report is strengthened by an integrated and holistic perspective. For instance, not only are physical site qualities relevant for biomass production but aspects of regulation, finance, environment and society have to be considered as well. This is especially true for biomass production in urban areas where various land uses and users converge upon one another in the same area. For example, the effects of the project upon the local population and their acceptance of the project is an important area for consideration before deciding whether such a project is desirable. Furthermore, since the effects on the environment from biomass production can be either positive for the environment (i.e. regulation of the micro-climate and storm-water retention) or negative (heavy use of fertilizer and pesticides) it must be carefully considered beforehand what the expected results of the project are. Selecting options may be supported by a transparent assessment of all sustainability impacts generated through the projects implementation, using sustainability linkages and Conceptual Site Models (CSM) for sustainability, both developed in this project (i.e. see HOMBRE D5.1 “Valuation approach for services from regeneration of Brownfield for soft re-use on a permanent or interim basis” and D5.2 “Guide – Decision Support for soft end-use implementation based on operating windows”).

Projects which seem upon first glance as economically unfavourable because they do not yield overall profit could actually prove to be economically beneficial once wider benefits (including also intangible as far as possible) are taken into consideration. Aspects such as a reduction in the annual site maintenance costs could favourably influence project choices. The report establishes interdisciplinary links between biomass production on brownfield sites and stakeholders engagement guidance in project initiation phase.

Learning from previous cases of biomass production on brownfield sites is an effective means to present how implementation can take place and what important aspects need to be considered on a case by case basis. The report shows two case studies in Germany (in the cities of Gelsenkirchen and Halle) and one case study from the United Kingdom of biomass plantations located on urban brownfield sites. The report extends upon the concept of a decision-tool to guide stakeholders in project decision making.

Both stages fit within the generic overall decision procedure (tiered approach) developed under task 5.2 and reported in deliverable D5.2.

The conclusions of the report should help to consider the appraisal of biomass within their own region by addressing:

1. considerations of the context and examples to biomass production in urban locations
2. illustration of the different decision tool concepts for determining land potential
3. a specifically tailored decision-tool for the production of biomass and bio-energy on brownfield sites
4. landscaping as a factor of value creation in Brownfield regeneration for biomass production

Ideally, with help of this guidance, stakeholders are encouraged to explore the local potential for bio-energy production on unused and underused sites to combine the objectives of urban development with biomass production for sustainable energy use in European cities.

Contents

1. Introduction

Increasing numbers of brownfield sites are contributed to by urban sprawl (the spread of an urban area into the surrounding rural land (PATACCHINI *et al.*, 2009)). Urban sprawl is a key land-use change issue in much of Europe, causing various environmental problems including: surface sealing, ecosystem/habitat fragmentation and increased pollution (SCALENGHE & MARSAN, 2009; HASSE & LATHROP, 2003; SAVARD *et al.*, 2000).

Persistent brownfields with no perspective after uses in sight will exacerbate economic and social decline of an area. (CABERNET, 2006; EUROPEAN AUDIT COURT, 2011) An alternative to this scenario is the intermediate or permanent reuse of these areas for biomass cultivation. (BMVBS, 2009, RUFF, 2005) Within this context, the HOMBRE project has explored the potential of bio-energy clusters in urban areas as based on current research and pilot projects. The redevelopment of land for biomass and bio-energy production can have many benefits. For example, the production of bio-energy can contribute to the production of sustainable energy sources (BARDOS, 2011) as well as minimize the maintenance costs incurred by the owners of brownfield sites. (BMVBS, 2010, 44ff.) Furthermore, the interim use of a brownfield site keeps the parcel in the cycle of land use and still allows for future investments and a different use to still be realized on-site when economic downturn has ended, and respectively, when funds for the re-development for other uses are ready to be invested. (SCHLAPPA, 2013)

HOMBRE has adopted a functional description to better understand the linkages between regeneration services and project value. Project services are the basis upon which value can be created that will leverage a brownfield's regeneration, by providing benefits that make the investment in regeneration worthwhile to specific constituencies or beneficiaries who will support it. (see HOMBRE D5.1)

Biomass production on brownfields can promote several government policies related to land recycling and urban sustainability. For example, biomass production on brownfield sites can help attain goals related to:

- supporting urban land recycling (removal of barriers for reuse)
- economic development (productive reuse of land, even if activities are intermediate)
- reducing soil sealing
- mitigating urban heat island effect, hence contribution to the creation of more livable cities

Biomass also offers several advantages for energy production and can be used for the production of electricity, heat or fuel. (BMVBS, 2010, p 48) In relation to this, urban brownfields can provide a location that provides a short distance between the supplier and buyer of biomass. Furthermore, biomass is suitable for storage, making it available on demand and its supply to the energy sector adjustable according to need. Brownfields offer a wide range of opportunities for providing neighbouring communities with heat and/or energy;

they can supply single houses or districts with heat and/or electricity together in decentralized biogas plants and block heating stations. (BMVBS, 2010, p 48)

Undertaking biomass production on brownfields depends on multiple factors ranging from surface area of the site, the quality of soil, site conditions and the selection of the type of energy plants (energy conversion system) to be used on site (or eventually off-site, i.e. in CLUSTER configuration). Biomass production is viable for most brownfield sites with low to medium land recycling costs combined with a low demand for building land within the city and or region boundaries (such as is present in shrinking cities). (SCHLAPPA, 2014) In order to assess the viability and appropriateness of brownfield sites for biomass production a set of different decision support tools has been elaborated. These tools shall also assist stakeholders in identifying biomass potentials.

Based upon the finding of the REJUVENATE project this report provides an overview of the different approaches and decision supports at the European level and develops a new decision support tool for the urban land planning level. Furthermore, guidance is provided on how considering aspects of urban/landscape in biomass cultivation projects on brownfields.

2. Land/Brownfield types and examples for biomass cultivation

Brownfields represent potentials for undertaking urban conversion and restructuring urban and economic functions. This can help regions and cities deal with the effects of structural change and demographic trends. (SCHALPPA, 2014) Specifically in shrinking cities "soft re-uses" could represent attractive opportunities for redeveloping former build up areas. For example, an increased reconversion rate of former brownfields into open spaces and green infrastructures has great potential of consolidating the housing market. (GREENKEYS, 2008)

Among other key factors, biomass cultivation on brownfield sites is greatly influenced by the size and previous land-use, i.e.:

- Land associated with military or industrial areas is generally characterized by larger surface area but inappropriate soil conditions. Without further soil management measures and investments, such adverse soil conditions may hinder the development of biomass crops.
- Urban brownfields e.g. from former housing areas could be characterized by an average smaller surface area and could consist in partly undisturbed soil structures.


Figure 1and 2: Former housing and military area in Dessau/Sachsen-Anhalt/Germany.

The key outcomes of case studies are presented below and form the founding principles of the HOMBRE Decision Tool.

2.1 Example Gelsenkirchen, Germany

Gelsenkirchen, located in the Ruhr area of the State of North Rhine-Westphalia, had a former coal mining site which has been transformed into a biomass plantation. The former “Zeche Hugo” coal mine amounts to 22 hectares and is located on the outskirts of the city. Remediation work on the site started in 2002 with a concept to create a leisure or recreational area combined with a temporal or permanent biomass production site. The area is subject of a structural plan for biomass cultivation using short rotation crops (poplar and meadow). (see Figure 3)

The owner of the site is the RAG Montan Immobilien GmbH. The project partners which worked together to realize the new use concept with the Municipality of Gelsenkirchen, the Ministry for the Environment and a regional agency dedicated to forestry and wood production in North Rhine-Westphalia, the EnergieAgenturNRW. (ENERGIE-AGENTUR, 2011)

The implementation of the project faced several problems. Extra remedial measures were required even after the demolition of the mining and coal power plant structures on site. Moreover, annual maintenance costs for traffic safety and regulatory obligations occurred. The earthworks on the land suitable for biomass production started in 2011. (RAG, 2013)

Figure 3: Structural concept for biomass plantation HUGO. (EnergieAgenturNRW)

2.2 Example: Halle (Saale), Germany

Starting several years ago, the City of Halle is experiencing a process of population shrinkage and an increasing number of vacant buildings and abandoned housing areas. Accordingly, demolition activities, as supported by national funds, have created large plots of undeveloped land in urban locations. With this demolition and the resulting reduced use of the city's infrastructure system, the municipal utility company *Hallesche Stadt- und Wasserwirtschaft* decided to consolidate its infrastructure system and launch a biomass project on a plot of land dedicated to urban restructuring. The site chosen by the company was owned by a municipal corporation responsible for housing and business real estate (Gesellschaft für Wohn- und Gewerbeimmobilien). Within the area, an adjacent green space was planned to be improved for recreational and gardening or agricultural purposes.

Since the urban site could not legally be defined as an agricultural site the project was defined as a pilot project with the special purpose of testing the feasibility and economic viability of biomass projects on urban land undergoing restructuring. A lease contract (free of charge) between the user of the site and the owner was signed due to the site owner's interest in pursuing a cost-effective after-use,. This contract assures the use of the site as a short rotation plantation with a duration of up to 20 years. Furthermore, the contract allows for the land owner to reclaim his land in the case he would be willing to realize future investments on-site for its redevelopment.

At the beginning of the project, all foundations and buildings on-site were demolished. This benefited the site owner with a reduction of the maintenance costs incurred from the site. The deposit of new top soil (30-40 cm) and the planting of the seedlings were both financed by municipal funds dedicated to urban restructuring. A short rotation plantation (poplar) is operated on a 0.8 ha area. The yield from the site is used for the production of solid fuel in the form of wood pellets and wood chips. 18,000 seedlings were planted in 2007 and were ready for harvesting after 3 to 4 years.

Since short rotation plantations usually require little maintenance during the growing process, it is estimated that an average annual revenue of 600 Euro per hectare can be attained from the site. In addition to the economic benefits, the creation of a permanently changing urban forest presents a wider benefit for the residents in the area because the environmental quality of the urban area is upgraded with the reuse of a previously abandoned site. The provision of new vegetation contributes to mitigating urban heat island effect and improves microclimate. For these reasons, the project has an excellent reputation among housing corporations and residents alike. It can be valued as a positive case study of biomass production on a brownfield site. (BVBSR, 2009)

Figure 4: Biomass plantation on the urban re-structuring area in Halle.

2.3 Example: Markham Vale, UK

The Markham Vale site is located in the East Midlands of England, between the city of Chesterfield and the Town of Bolsover. The site is located along the M1 motorway. The Markham Colliery was closed in 1994 and brought with it an end more than 150 years of deep mining in Derbyshire. The result from the closure of the plant was very high levels of unemployment in the region. After the cessation of mining the Coal Authority, the site was handed over to local authority ownership and it is now owned by Derbyshire County Council (DCC).

The "Markham Vale" project was born out of a Coalfield Task Force Report in 1998 which challenged local authorities to create an employment growth zone centred on the former Markham Colliery. The aim of the report was to create 5,000 jobs to regenerate the local area, as well as providing environmental improvements including establishing short-rotation coppicing on the North heap. The project became known as Markham Vale, with the coppicing project being known as “Markham Willows”.

The total area of the site is 360 ha which includes agricultural lands which were incorporated to make the project more economically feasible. Markham Vale is DCC’s largest regeneration project ever and aims to reverse the social and economic decline which took place in the region since the general decline in heavy industry in north east Derbyshire.

The project’s original concept included a mix of both built infrastructure and soft re-uses, for which the North Tip was envisioned for biomass energy production, leisure and grazing (as previously found on the site). The plan foresaw short rotation coppice (SRC) planting of willow over three years, along with areas of open grassland for amenity and grazing, with a new path over the North Tip linking some existing walking routes. The coppice was to be planted on a staggered basis on a three year rotation, thereby ensuring production of biomass across 20 ha on an annual basis.

The ambition of the biomass production aspect of the project was to sell heat energy rather than wood chip as to gain more profit. The business model developed envisaged a local boiler replacement programme for schools and other local authority facilities to replace oil powered boilers which had reached the end of their operating lifetime. The production of biomass energy was attractive for the site owner (DCC) because it could support the cost for the landscape management of the restored areas surrounding the built structures, as well as potentially improving the values of land in the vicinity and the creation of jobs.

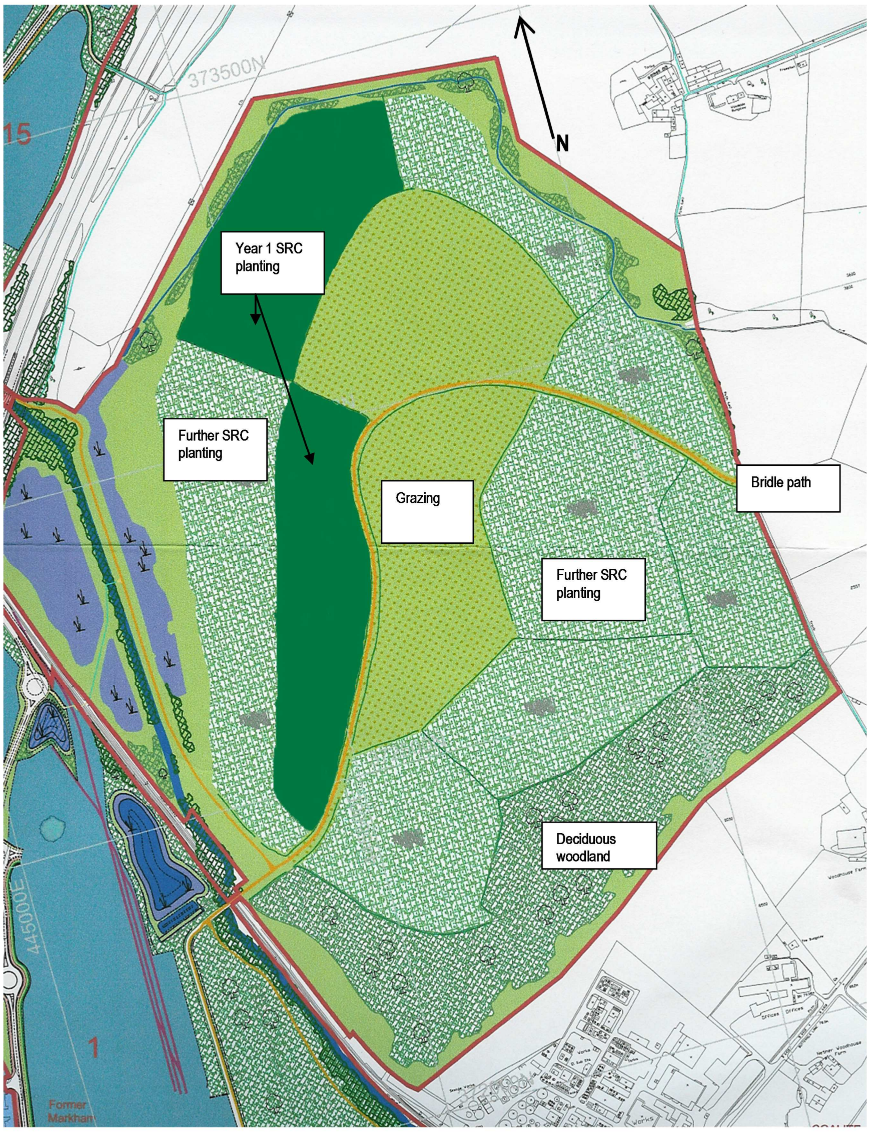

Figure 5: Conceptual site plan of biomass production on the Markham Willows project site.

The site "Markham Willows" could provide an inexpensive and effective remedy for the reuse of a former coal mining area, an inexpensive and effective soil remedy method as well as an inexpensive and effective remedy for the extraction of unusable residue of fossil fuel. The vision for the site included linking an Environment Centre to the area, to encourage businesses with a strong sustainability interest to the site, as well as providing linkages to local education and skill development for environmental technologies. The proposed Environment Centre was to make use of biomass energy.

A number of factors have constrained the development of the original Markham Willows concept, including design issues with the biomass boiler, lower than expected costs per heat unit rate which severely undermined the project's concept of selling heat, as well as a delay from the judicial review process and the cessation of regional development support. Only one of three planned plantings have been carried out so far on site. Further information on the case can be found in Annexes.

3. Approaches and decision cases

3.1 HOMBRE decision tool: Identification of biomass production potentials on urban brownfields

The use of urban brownfields for biomass is currently not part of a systematic city development analysis and its potentials have not been widely researched. (PONITKA, J: 2010) As a consequence, urban planners require incentives to consider the option of biomass production for bio-energy generation in their specific local context and valid information to initiate first steps of project developments. (BMVBS, 2010, RÖßLER, 2010) The HOMBRE project's decision tool will motivate urban planners and other stakeholders involved to identify potential sites inside a designated urban area with the available site specific information within a limited amount of time.

The objective of the decision tool is to create a pre-selection of urban sites evaluated as suitable for biomass production on the municipal or sub-regional scale.

Literature was analysed and interviews with stakeholders from case studies were undertaken in order to assess the conditions necessary for the production of biomass on urban brownfields and to identify key drivers and barriers. Case stakeholders have been identified and selected in:

- Stadtwerke Halle (Germany): biomass on former residential areas
- RAG Gelsenkirchen (Germany): biomass on a former coal mining area
- Markham Willows (UK): biomass on coal pits

Additional information on case studies was gathered through site visits and using a questionnaire that was iteratively developed by HOMBRE project partners. Overall, the questionnaire addresses issues such as:

- the theoretical potential of brownfields sites which could possibly be adapted to biomass production in the city/region,
- technical potentials based on soil conditions and other physical aspects of the pilot sites (including considerations of contamination), and
- economic aspects such as the required logistics for biomass production, type of energy conversion processes, among others.

Overall, eight key criteria related to the decision–making process have been identified and introduced in a decision tool for urban planners. Furthermore, the procedure was tested and revised in the pilot City of Cottbus in Germany which has about 100,000 inhabitants. (SCHICHAN, 2013)

3.1.1 Urban Criteria and Decision tool

A pre-selection of brownfield sites within an urban area must be made according to planning, legal and technical criteria for the development of biomass. The parameters for the identification of potential sites for the production of biomass begin with a complete overview of all of the present brownfields in the study area. The next steps in the process then consider technical aspects and tie them into the analysis. Restrictions regarding planning and other site related laws must be properly identified in the analysis. In addition to this, the analysis should also take into consideration aspects of implementation as well.

Table 1: Overview of the Decision Tool Indicators

Main Category	**Sub-category**	**Key criteria**
Theoretical Potential	Size	Is the land larger than 1 ha in size?
Technical Potential	Soil	Is the soil natural or disturbed?
		Is there contamination?
		Is the soil sealed?
Restrictions	Legal	Are there any legal restrictions?
	Planning	Are there any planning restrictions?
Implementation	Intent of the owner	Is the owner willing to allow biomass cultivation on site?
	Duration	Is there a likely hard urban use for the site within the next 10 years?

The four main steps of the approach use standard information related to vacant or brownfield land in the selected area/city or from a brownfield portfolio. Brownfield registers, such as those proposed in the HOMBRE Navigator should be consulted and key information extracted from it. Through the use of the decision tool, the discarding of potential sites for consideration allows for the faster and easier processing of the remaining sites. This enables stakeholders with little experience in biomass projects to get involved and participate actively in the decision–making process.

The following will detail the considerations to be made under each category and sub-category of the decision tool. Knowledge gained from the literature review and correspondence with project stakeholders is presented to describe the determination of the decision tool criteria. Furthermore, an explanatory box is provided for each section to provide guidance for the procurement and analysis of data pertinent to the respective step.

3.1.2 Theoretical potential - the availability of land

The presence of brownfields is a prerequisite in the search for biomass production potential on brownfield sites. Therefore the decision tool only applies to areas where brownfield sites are present.

It should be expected that the size and type of previous uses of these brownfields will vary greatly according to the type of existing settlement structure. For example, larger brownfields are to be expected in regions characterized by mining/industrial uses such as is the case in Gelsenkirchen, whereas smaller brownfields which were previously used for housing can be expected to play a larger role in urban zones of shrinking cities such as in the City of Halle.

The minimum size of a plot of land for the economic production of biomass product varies greatly from one another according to the accounts provided by plantation operators. According to LATMÄNNEN, 2007, a plot must be larger than 5 ha whereas the operators of the pilot land plot in Halle see 1 ha as large enough. Furthermore, it must be considered that adjacent or close-by plots of land can be used for the creation of a bio-cluster to reach the minimum land size requirement. A minimum size of 1 hectare is proposed in the decision tool in order to therefore identify a greater number of individual plots of land (and possibly neighbouring plots) in the first inspection step.

Land size

The theoretical potential considers any piece of land independently of its quality and associated costs for restoration (remediation, soil up-grading operations etc.). Accordingly, all sites smaller than 1 ha are to be identified as based upon the information provided by the local brownfield register. These sites are too small in size to support profitable biomass production and are to be excluded from further considerations.

3.1.3 Technical and economic potential

The technical potential step of the decision tool selects land potentials based upon the presence of a sufficient soil quality for the production of biomass (i.e. soil constitution, absence or low contamination levels, no sealing etc.) for which no or minor restoration costs would be assumed (using feasible low cost restoration operations).

Soil quality and issues of contamination

Soil quality and functionality represent two key criteria when planning biomass cultivation projects for the production of biomass (BARDOS, 2011). This becomes particularly important when you consider the resources needed to upgrade low quality brownfield soils to the standards required to produce high biomass yields which in turn can increase a project's profitability and attractiveness to investors.

Whereas brownfields with a large portion of natural soil are well suited for the pre-selection of land areas, several soil conditions increase the effort required to produce biomass:

- Soil may be absent and need to be replaced or "formed", for example on a clay landfill cap or former industrial area
- Soil may be sealed, for example beneath concrete
- Soil may be intersected by underground constructions or service infrastructure

- The chemical quality of the soil may be poor (e.g. organic matter content, plant nutrient content, low pH)
- Soil may be contaminated, for example with industrial contaminants or through a high saline content, both of which are risks to human health and must be properly managed
- The physical quality of the soil may be low (e.g. high soil density, low porosity and bad structure)
- Soil ecology may be poor, for example low species population and/or diversity, missing particular groups of soil animals or types of mycorrhizal fungi
- Soil surfaces may be unstable and/or subject to erosion (for example slopes on a spoil heap)

Such circumstances call for the appropriate soil restoration and management measures to take place in order to enable plant growth and higher biomass yields on the sites. The soils found on the Halle and Gelsenkirchen sites were in an altered state with regard to their structural, chemical and biological properties.

In the case of the housing brownfield site in Halle, the soil is drier, more compact and higher in alkaline content but is free from soil contamination as expected on a former housing site. The major soil disturbances consisted in compaction, alteration through digging activities, low groundwater level, increased surface run-off, deposition as well as a high impermeability caused by clogging from the input of waste and dust. Moreover, large demolition waste deposits in the soil have hampered plant growth and biomass production on the site in Halle. The altered soil properties have caused for the harvests on-site to be lower than on agricultural land.

The Gelsenkirchen case demonstrates that the presence of soil contamination does not directly exclude the possibility of biomass production. Crucial aspects to consider in this context include the type, concentration and biodegradability of the contaminant as well as the uptake of the contaminant by vegetation (bioavailability). More details on approaches for managing soil contamination for projects aimed at regenerating brownfields into soft re-use can be found in section 3.4.2 Remediation of contamination in deliverable D5.1 "Valuation Approach for Services from Regeneration of Brownfields for Soft Re-use on a Permanent or Interim Basis" (2013). Further, HOMBRE D5.4 gives more insight on two low input remediation techniques for addressing land remediation under the umbrella concept of Gentle Remediation Options, especially suited in the frame of brownfield soft re-use.

The amount of effort required for restoring soil quality when it has been disturbed by a building and foundation as well as potential soil contamination must be studied on a case to case basis. If there is no external financing available for these activities, for example from European or national funding programs, the land plots should then be discarded from the selection.

Soil quality

It must first be determined what type of soil, either natural or disturbed, is found on site. In the case of natural or undisturbed soils, the user of the decision tool may move along to step 3 pertaining to legal and planning restrictions. In the case of soil which has been disturbed by urban use, further investigations into the soil quality must be made to determine if it is suitable for biomass production.

Contamination

If the soil has been disturbed by urban use, the possibility of potential contamination must be studied. The project team should consider the investigation of the site for identifying possible contaminations which could represent a risk for human health and/or the environment. The identification of information pertaining to land contamination (which can be gathered from local land registers), could help to exclude problematic sites at an early stage of the evaluation and avoid extensive technical examinations. This decision must be made in sight of the type and scale of (potential) contamination.

In case of potential or real contamination on site, the soil analysis becomes a tiered approach consisting in a historical investigation, preliminary and ends with a detailed investigation. References and procedures on how to perform investigation of potentially contaminated soils can be found in national regulation and guidance documents. In many countries, certified contaminated soil experts will be required by authorities to proceed with soil investigations.

Further planning for biomass and bio-energy production on sites with confirmed contamination is only recommended if the contaminations present can be remediated at an acceptable cost. The value of the "acceptable" cost can be expected to change according to the scope of the project. Furthermore, since the production of biomass consists in plant cultivation, a reasonable solution would be to evaluate the feasibility of Gentle Remediation Options among which are phyto-remediation techniques. Such alternatives should be carefully evaluated in terms of technical and economic feasibility, with considerations made regarding time constraints and waste product management from energy conversion processes (ashes, dust). Meeting all of these requirements allows for the land plot to remain in the pool of potentially suitable land. If these conditions are not met, the land should be excluded from further evaluation.

Assumable economic cost for land recycling of sealed surfaces

Certain types of brownfields, as defined by their previous use, are burdened by the high cost for land recycling. (FRANZIUS, 2007) There are no available values for the profit gained from the production of biomass product in the studied pilot projects. However, due to the relatively low amount of profit which can be expected to be obtained from the production of biomass product under current conditions (MARKHAM WILLOW, 2003), the refinancing of the cost for land recycling through the production of biomass product is hardly realizable. Therefore it is important to also consider the reduced cost for the upkeep and maintenance of a recycled land plot as opposed to a brownfield structure. The incurred reduction in maintenance cost achieved through land recycling could provide as an additional source of income for the site owner.

The expected cost, which in turn depends upon the type of each brownfield site, needs to be estimated. The case may be that the project allows for the acquisition of funding resources for the activities of land recycling, for example from the European Funds for Regional Development.

The cost for land recycling must be evaluated on a case by case basis. An initial reference point is provided by analysing the land preparation cost of the European Union ERDF funded projects in Saxony during the period of 2007-2013. About 26.9% of these land plots were completed at a price which was under 10 EUR/m^2, whereas 32% were in the 10-50 EUR/m^2 range and the remaining 41,1% were priced at over 50 EUR/m^2.

Land plots with natural soils and a preparation cost which is less than 10 EUR/m2 could remain in the pool of brownfields to be considered for further evaluation with the the decision tool. Land which is contaminated or is heavily sealed usually has preparation cost which are above 50 EUR/m2 and are recommended to be discarded from the search. Individual decisions should be made for all of the pieces of land which fall within the 10-50 EUR/m^2 category.

Soil sealing

The next step in evaluating the soil quality is to rate the degree of soil sealing. Unsealed soil presents a favourable situation for the cultivation of biomass product. If sealing is present, the cost of undertaking de-sealing measures should be estimated (see initial reference point from the values of the ERDF program in Saxony). If the cost of land recycling and desealing are considered to be too high for the project (i.e. cost would jeopardize the project's cost-effectiveness or de-sealing will not be supported through co-financing from public programs) the land should be excluded from further evaluation for biomass suitability.

3.1.4 Restrictions

The third step of the decision tool defines the important restrictions related to planning and legal issues which must be considered within the framework of biomass production projects.

Legal restrictions

All stakeholders of the pilot biomass plants underpin that the intention to develop a biomass plantation in urban areas could be limited by legal restrictions. Examples of this include nature conservation zones based on environmental laws (e.g. Fauna-Flora-Habitat designations) or the habitats of protected species located on the brownfield site. Furthermore, the granting of permission for biomass production is dependent upon decisions made on a case by case basis by the regional and local administrations who must consider the existing planning orientations or legal restrictions for the area. The example case study in Halle represents a special case since it is an intermediate use solution without having been applied through a formal permission procedure. Currently, biomass is still considered a new land use category in the urban area for which no specific regulations apply.

To illustrate this void in planning regulation, national regulatory frameworks for biomass in urban areas appear to still be vague and are often bundled into the regulations pertaining to agricultural activities in urban areas where the potential conflicts concerning environmental regulations are addressed (i.e. use of pesticides in urban areas). In the pre-selection of potential land plots, the potential limits as set by regulations should be reviewed with the respective authorities (environment or construction regulators) as to discard land plots which are over burdened by restrictions. (EPA, 2014)

Legal restrictions

Restrictions such as natural protected sites (such as the European-wide designated Fauna-Flora-Habitat areas) or monument conservation regulations which generally exclude the creation of biomass plantations need to be evaluated in relation to a planned biomass project. If no major restrictions can be identified for producing biomass on a brownfield plot, then it should be kept in the pool of potential sites for biomass production.

Planning restrictions

Ideally, significant barriers for the completion of the project should be identified early by revising official local planning documents. Planning restrictions could arise, for example, from the designations set by local and regional planning documents for development perspectives or traffic related projects. If conflicting project objectives exist, it must be evaluated if these conflicts are acceptable or if their effects can be mitigated to acceptable levels. If this is not possible, the project should be stopped or its objectives reset.

Planning restrictions

The content of official regional or city planning documents may also conflict with the implementation of a biomass project. In this regard it is important to review local land use and development plans. Furthermore, the strategic planning orientation of the local and regional context must be taken into account to ensure that the goals of a biomass product site fit in the area into which it is to be situated. Brownfield land which does not conflict with the planning orientation of the locality should be kept in the pool of potential sites for biomass production.

3.1.5 Implementation

Central criteria for the implementation of a biomass use include the willingness of the owner to cooperate with the project and the foreseeable duration of the use.

Owner

Private as well as public properties owners are usually not familiar with the goals or technical aspects of biomass production and are instead interested in receiving the maximum amount of value through pursuing construction. For this reason an initial declaration of the willingness to cooperate for the production of biomass is of central importance for the further selection of land plots. If such willingness from the owner is not present, two varying options may come into question at this point:

- the sale of the land plot to the manager of the biomass production site, or
- the temporary giving of land rights, for example in the form of a lease agreement.

An agreement from the owner to pursue one of these two options allows for the brownfield plot of land being considered to continue through the decision tool selection process.

From a site owner's point of view, urban brownfields often carry a risk of having expired or postponed building rights pertaining to the plots on which they are situated. In such cases, an intermediate use of the site for biomass production represents a practical short-term option for the site owner. Thus, these sites can be turned into economically viable projects through the use of short rotation crop that can generate net gains within 20 years of cultivation. (BMVBS, 2010, pp 68-69)

Other project risks that could hinder project development include:

- a scattered land ownership among a group of stakeholders, which increases the effort required for joint collaboration on the project, and
- the absence of clearly identifiable stakeholders for each parcel of land to be included in the biomass project.

An effective manner of dealing with these issues would have to be studied and implemented to keep a brownfield site in the pool of potential sites.

Owner

The ownership of a site must be analysed to clarify if i) the amount of owners present is manageable and are identifiable and ii) if the owner(s) has/have interests which are in line with the cultivation of biomass product on the site. If not, an alternative solution can be achieved if they are willing to sell the site at an acceptable price to the project manager. Brownfield plots which do not satisfy these conditions should be discarded from the pre-selection process.

Duration

Due to the strong usage conflicts which occur on urban brownfield sites, the planning provision for the secured possible duration of a biomass plantation is of central importance. In the questionnaire sent to the case study operators, the plantation operators stressed the importance of having a minimum time allowance which is long enough for the operation of the plantation. The fewest amounts of restrictions can be expected when a long term planning regulation solution is made, for example in the context of the conversion of an abandoned industrial plot to agricultural use. In such a case the organization of technical plantation infrastructure can be created free from temporal restrictions (see case study in Gelsenkirchen).

The settlement of temporary biomass plantations on brownfields should not be shut out. This can ensure that brownfields with uncertain future uses will be included in the search for a potential site. It is expected that there is a growth period of 2-3 years for the crop, which varies depending on the type of plant used. For this reason a minimum plantation operation time of ten years is suggested.

If the interim use for biomass production is limited to 10 years, decision makers should give preference to biomass crops capable of providing high yields of culm and leaves and with shallow or little root penetration to facilitate further "hard" development.

Duration

Biomass plantations require some time for the crops to grow before they can yield economic gain. The main issues considered here are the future designations given by any relevant legal development plan and the interests of the owner or developer to realize future development on site. A project should only be implemented if it is identified that the allowed for duration of the project is long enough (estimates average at a minimum amount of time of about 10 years).

Clusters

The projects in Markham Vale and Halle both represent projects where the plots of land delivering bio-energy are organized as clusters. This means that several plots of land are managed together in order to provide the necessary conditions for securing the overall viability of the project (such as achieving the minimum land size required for the profitable operation of the plantation). For the stakeholders involved in the two projects, a key condition for the allocation of biomass production to the sites was the guarantee that cultivation would cause no major disturbances nor harm to the surrounding land uses e.g. through the use of pesticides.

In addition, an approach of creating sites clusters may provide administrations with multiple benefits and optimal solutions for land uses on the short to medium term as well as may increase the overall benefits of biomass projects for a wider group of beneficiaries. For example, benefits may consist in the improvement of urban climate conditions (i.e. mitigation of urban heat island effects), enhancement of urban biodiversity, provision of urban green infrastructure as landscape design elements, among other factors.

Clusters

A spatially wider approach at urban/regional scale as opposed to a site by site approach should be carried out in order to identify potential areas for biomass cultivation on neighbouring sites. This can increase the total amount of land used for cultivation which can increase the yields gained. Furthermore, such a broader screening of potential sites may provide new opportunities for biomass production by combining different types of soil resources (i.e. unsealed, cultivable, low contaminated land). Such approaches can increase a biomass projects' viability (i.e. scale effect).

After completion of this fourth step, the potential brownfield sites and cluster which satisfy all of the major criteria for the production of biomass have been identified. The next two sections detail out criteria important to consider for the feasibility and design of the production operations.

Feasibility Analysis (Infrastructure)

For the pre-selection of potential sites the decision tool includes analysing the present infrastructure for site access and the availability of the necessary machinery (i.e. cultivation, maintenance, harvesting and processing of the biomass). The case studies showed that transport infrastructure plays a crucial role and can present a major barrier to a project, as was the case in Markham. The required agricultural machines should be available within a short distance from the site to reduce the distance for transportation, travel time and also rental costs. Case stakeholders highlighted the importance of keeping transport distances from biomass production sites to energy transformation plant as short as possible, since this is a major cost factor and can help guarantee the overall profitability of the project. (SEARCY, E. 2007, pp 639-652) Bearing this in mind, it appears that cluster projects for the production of biomass may enhance the chances of making the projects financially viable.

Design

The final step of this part of the decision tool involves evaluating a site's location and the relevance of its geographical context (i.e. urban or other context). If the site's context is predominantly urban, special attention should be dedicated to landscape design and site integration into the urban environment. In this sense, issues such as traffic disturbance, noise, dust emissions and aesthetic considerations should be on the agenda of projects designers.

Sites with a high urban relevance must be discussed in detail with local stakeholders and cannot be treated on general terms.

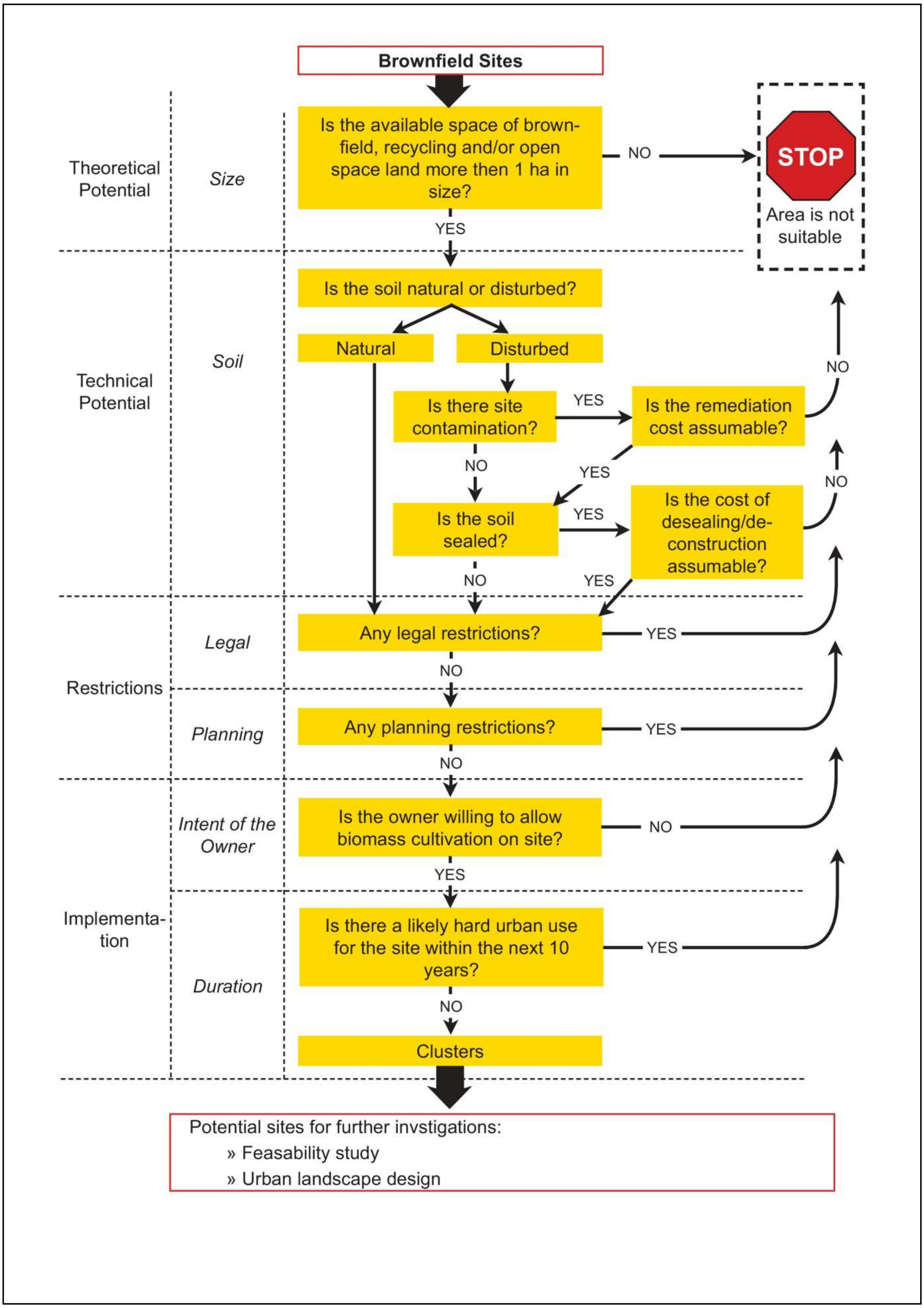

Figure 6: The HOMBRE Decision Tool for the identification of biomass production potentials on brownfields.

3.1.6 Test application of the HOMBRE decision tool to the City of Cottbus (Germany)

The City of Cottbus was selected as a pilot application of the decision tool for biomass production on brownfield sites. The city, with about 100,000 residents, is strongly affected by the processes of economic restructuring and a shrinking population. The local brownfield map has about 152 land parcels which total to about 453.51 hectares of land. The former use of the brownfields was manly derelict housing areas where prefabricated housing plots have been demolished by a national programme. (BUNDESTRANSFERSTELLE, 2014)

Figure 7: Demolition of prefabricated housing estates in Halle, Germany.

Additionally the strategic urban development concept of Cottbus has been analysed in relation to the availability of brownfield sites. (STADT COTTBUS, 2010)

The decision tool was tested within a Masters level project at the Brandenburg University of Technology Cottbus. The project aimed at identifying land deemed appropriate for biomass plantations. Of the initial 152 recycling land sites in Cottbus, 68 were determined as having potential regarding the theoretical considerations. It was further determined that 41 of the sites were proper as according to the technical criteria and 14 have economic potential.

The decision has been made with support of the city administration, department of urban planning and environment and the housing company GWC as major site owner. The brownfield register with site locations and sizes was provided by the city, information on potential soil contaminations by the state register of contaminated soil, whereas information on sealing and buildings was gathered through aerial photographs.

The test run of the HOMBRE decision tool on first brownfield sites showed that:

- Within the methodology, relatively little effort is required to select the land.
- Adjacent or neighbouring land parcels should be gathered into clusters as a final step.
- The first step of decision tool (focused on size of brownfields) allows reducing the number of potential brownfield sites by about 20%.
- The second stage, which considers specific criteria related to “economic feasibility” in connection with the measures required for land recycling, reduces the amount of potential sites to a total of **16% of the initial**.

In conclusion only relativly few urban brownfiled sites are suitable for biomass energy production.

3.2 Rejuvenate Case Study for HOMBRE D5.3

Rejuvenate was an EU SNOWMAN network-supported project to develop approaches for crop based systems for sustainable risk-based land management for economically marginal degraded areas. In 2010 this project developed an outline decision support framework to assist site specific assessment of biomass opportunities for contaminated land management. (overviewed in BARDOS *et al.*, 2011)

The framework includes a procedure and checklists, together providing a decision support tool (DST) to facilitate structured decision-making and to encourage stakeholder involvement (BARDOS *et al.* 2010, POLLAND *et al.* 2010). Within a second phase of the project this framework was further developed and tested by applying it to case study sites in France, Romania and Sweden. (ANDERSSON-SKÖLD *et al.* 2014)

The *Rejuvenate* DST is a tool that comes to play at specific sites, as those identified after site selection with the HOMBRE Decision Tool shown in Figure 6. The *Rejuvenate* DST has four broad interlinked stages that can be used to refine choices for biomass production on marginal land. The framework forms an iterative funnelling process, incorporating four stages (Figure 8).

- Stage 1. Crop suitability: the output from this stage identifies a short list of biomass crops that are able to grow under the local conditions and have a market outlet, preferably within the local region.
- Stage 2. Site suitability: the output from this stage identifies a shortened list of crops that could be grown on-site and specifies the management interventions needed to achieve this.
- Stage 3. Value: the output from this stage identifies project options that are financially viable and sustainable.
- Stage 4. Project risk: the output from this stage is a realistic appraisal of project risks and a mitigation strategy for these risks.

Each stage produces an interim finding or output, based on the considerations in each stage.

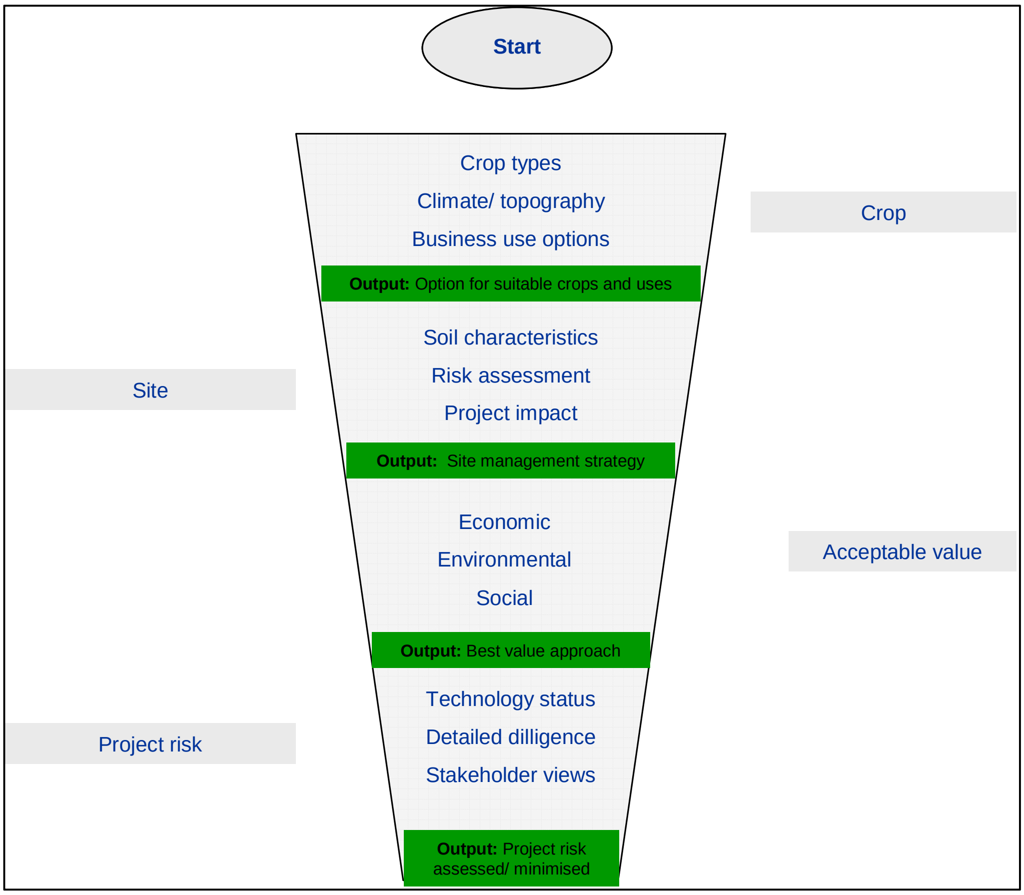

Figure 8: Rejuvenate DST stages and funnelling process.

Further details on the procedures and outlines for each step within the *Rejuvenate* DST are given in Annex for information.

4. Integrating issues of landscape and biodiversity into brownfield regeneration for biomass production

4.1 Context and premises of landscape design

Landscape has undertaken in these last years a central role in orienting policies and actions not only in protection, but also in land development. Procurement, politics and nature conservation issues induce to assume a unitary, multifunctional and sustainable approach toward the landscape[1].

More and more, landscape should be considered as the result of the interactions between people and places and not anymore as solely a subjective and aesthetic experience. As such,

[1] The European Landscape Convention (Florence 2000) confers a central role on landscape as attesting to the identity of places and to indigenous communities. It is a fundamental aspect of the lifestyle of populations, and in the understanding, interpretation and design of the land.

landscapes should represent the expression of the transformations led by economical choices, policies (i.e. CAP, Common Agriculture Policy) but also from people daily actions. Regarding these considerations, it's useful to remember that political movements and opinion groups are able to orientate even the market to sustainable choices and, as a result, help to protect vulnerable landscape, as the experience of Slow Food International has shown[2].

All these conditions highlight landscape design in regeneration process of brownfield sites in less attractive locations sites as the focal point to achieve a shared vision from the very first steps of the process. The brownfield regeneration process should take into consideration, besides the traditional approach (policies, technical skills, finance, etc.), also the expectations and participation of the local communities who live there.

The scale is important too; the design of a small brownfield in an urban site should not be evaluated only by economic and technical criteria. On the contrary, even examples of brownfield regeneration at small scale are able to totally change the perception of places, producing indirect benefits, such as enhancing the housing market locally, improving safety and health conditions or at least reduce further decline (i.e. illegal litter dumping).

Such considerations should drive decision makers in adapting their project design procedures (i.e. adopting bottom up model, for instance), but also to create new forms of communication, especially the language, often cryptic and reserved to experts. Several tools developed in HOMBRE, i.e. Brownfield Navigator (BFN), the Brownfield Opportunity Matrix (BOM), the Brownfield Remit Response Tool (BR2) are aimed to support communication, scoping and identification of interests and opportunities.

A suitable approach for the designation of biomass use is the Opportunity Plan (OP, Cabernet) which should be a review of a settlement which would highlight the strengths and weaknesses, opportunities and threats to a community. As an example, a derelict brownfield site while potentially presenting an environmental threat may present great opportunities through the ecological biodiversity seen on the site, which furthermore may encourage

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[2] Slow Food is an international not-for-profit organisation, founded in Italy in 1986. Today this organisation is made up of 40,000 people in Italy and more than 80,000 worldwide, in 130 countries of the five continents. The outlets and 'convivia', or 'groups which promote good food,' of which there are 350 in Italy and more than 400 outside Italy, are the point of reference 'on the ground' in their respective countries for the organisation. Founded in response to the spread of fast food chains and frenetic 'fast life', Slow Food studies, defends and propagates agricultural and oeno-gastronomic traditions from every corner of the world, in order to hand down the pleasures of today to future generations. It allows 'educated' consumers to incline towards quality – gastronomic, environmental and social – and make well-informed choices. Slow Food, through projects, publications, events and exhibitions, defends biodiversity, the right of people to have sovereignty over their food, and fights the homogenisation of flavours, large-scale industrial agriculture and genetic modification. Under this point of view, assessing a product means recognizing, giving value and defending the landscapes too that produced (through traditional and local system of production) those goods.

visitors to an area. This feature may be a great strength of the current site and an opportunity for the local economy/community. Therefore, if might be argued that the environmental threat should be actively managed rather than being dogmatically reclaimed.

Per definition, an OP plays an essential role between two crucial stages: feasibility plan and the final layout, showing scenarios, visions, expectations that could be compared in order to take a shared decision based on:

- Innovative approach
- Multi-functionality
- Sustainability
- Social inclusion

In many cases of brownfield regeneration based on soft end use, (i.e. mostly B/C sites), the post evaluation design highlighted that the people's expectations were oriented mainly towards open and green projects. (GREENKEYS, 2008) For instance in the case of Genoa Polcevera, where the site was already partially regenerated (restoring an old villa for social uses, a small garden with a children playground, etc.) the local community involvement process led by the Borough stressed that people want and need wider "green spaces".

Green spaces, in their wide definitions and functions of "ecological structures", are key in successful regeneration processes. Playgrounds, sport facilities, soft mobility (pedestrian and bike pathway), biodiversity, etc., are the visible and appreciable signs of regeneration.

As it's showed in Figure 9 below, it's not enough to plant tools or seed meadows to obtain green and inclusive areas for sustainable regeneration. Crops may be seen as artificial or sometime polluted areas, due to conventional agriculture based on chemicals.

On the contrary even planting the same species (poplars, willows, i.e.) but with a conceptual design and people involvement, it's possible to create green infrastructures, social cohesion a better landscape (Planning for green spaces, The Land Trust).

Figure 9: A traditional mono-functional maxi rotation coppice in Po Valley, Italy (see picture above) does not represent an opportunity to sustainable regeneration, but it is only a productive crops.

4.2 Key aspects of biomass project design

Biomass crops focus on a limited number of species which are reliable, fast growing and offer good profits, for instance grasses, roots, potatoes, hemp, etc. However, because some of these species may require high input of fertilizer and pesticides in cultivation, they may not fit in a multipurpose landscape improvement.

In order to assure that the plantation could be integrated into landscape planning and contribute to the connection of urban biotopes, it is essential to choose carefully the right crops and cultivation practices (i.e. planting patterns), especially in urban or peri-urban areas. Meadows of spontaneous grass and leguminous families (i.e. *Lolium multiflorum*, *Lolium perenne*, *Lolium x Hybridum*, *Trifolium pratense*, *Medicago sativa* L.) and tools of cultivation (i.e. poplars and willows in short rotation, *Paulownia tomentosa*, *Robinia pseudoacacia)* generally qualify, but site specific conditions may need adaptation measures in project concept and landscape design. ,.

4.3 Functionality of urban spaces, synergies and wider benefits of landscape design

When designing a project, it's important to take the surrounding landscape into consideration in order to make a coherent, harmonious whole (e.g., design of planting pattern, distances of planting, presence of secondary and auxiliary species, as i.e. shrubs) seeking at delivering widest benefits to society, nature and economy. Such benefits could be:

- climate change mitigation through carbon sequestration and tendency towards net positive or neutral carbon balance
- climate change adaptation and contribution to urban thermal comfort through the reduction of urban heat islands effect,
- water storage,
- landscape improvement,
- increased biodiversity
- provision of amenities such as educational and cultural supports
- contribution to local community cohesion and involvement activities (see details below).

According to the ELC (European Landscape Convention)[3], it is clear that the regeneration of even a fragment of the site should as far as possible respond to expectations and needs of its community. This can be perceived as a compensation measure for those living in degraded urban areas and is an opportunity to improve the quality of life and the self-respect of a community. Thus it is an important mean of ensuring wider sustainability and acceptability of regeneration projects.

As we have seen above, the choice of vegetation typology should first comply with technical and regulation criteria (see above selection criteria within stage 1 and stage 2, i.e. detailed crop selection on site scale). However, as far as possible wider aspects such as design and successful landscapes should also be taken into consideration, as they contribute to a higher degree of acceptance and create a sense of belonging and pride of the people who live nearby such place.

Vegetation could act also as a cache of deprived and unsightly building and industrial infrastructures. Vegetation could improve the overall aesthetic quality of crops, i.e. using tool species with clearly visible bloom *(Paulownia tomentosa, Robinia pseudoacacia*).

Having said this, it is not compulsory to plant exclusively indigenous species. In urban environments, ornamental plant species (such as *Pauwlonia tomentosa*) can be used in short rotation crops also to improve the local landscape (as defined above).

Small semi-natural habitats like biomass crops can have a great impact on local wildlife in urbanized and disturbed areas, if they are in contact with other already existing semi-natural areas. Therefore, the provision of green patches (e.g. hedges with flowers, open fields, tool lines, ponds and streams bordered by vegetation) is essential to sustain and shelter local wildlife. Birds and insects, two reliable bio-indicators, are highly depending on habitats provided in urban areas. Furthermore, the overall quality of places (landscape) could be improved by a more natural design of different patches.

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[3] "The landscape is an important part of the quality of life for people everywhere: in urban areas and in the countryside, in degraded areas as well as in areas of high quality, in areas recognised as being of outstanding beauty as well as everyday areas" (EUROPEAN LANDSCAPE CONVENTION, Florence, 20.10.2000).

Also the type of management of green infrastructure could influence the quality of the landscape. Adopting consecutive cut of tool plots, instead of cutting all at the same time, could ease the survival of animal sheltering there that can move to a safer area nearby.

4.4 Checking the local ecological network, especially at urban level

Even for a limited time, green areas for biomass production can play an essential role as a shelter for wildlife. They connect areas with good environmental quality and natural habitats and act as buffer zones and temporary connection between more important core and stepping stones areas.

Green infrastructures such as those provided through public parks and open spaces are potentially great vectors for communities to meet and exchange. If well designed, biomass production sites could also contribute to improve such amenities. Even if access on the site is limited or prohibited, the possibility of being able to see the plants growing already provides amenity worth for pushing the project forward (viewing could be provided by 'portholes' inserted into a wall/fence or by viewing platforms where groups could attend to enjoy the views).

A regenerated brownfield where life (i.e. ecosystems, semi natural habitats hosting diverse animals) has gained on depression, industrial ruins and degraded areas contributes greatly in improving the place's image, sense of pride to its neighbouring communities and finally may enhance the value (perceived or real). This new perception of the area is a very powerful and positive sign for the people of the local community, who may consider themselves otherwise forgotten or undervalued. As a consequence of the improved image, restored landscapes may thus act as a driver for investors to develop new projects in the area.

4.5 Make the site secure and welcoming

Thick vegetation can attract people involved in illegal activities, who seek undisturbed places well out of sight. Educational programmes can be an alternative to encourage concerned people learning good social behaviours. Examples could consist in involving local communities in maintenance activities and management of green infrastructures (gardens, green belt, meadows, ponds, etc.), eventually with the support of focused training programmes involving school visits. Overall, regeneration projects could foster community cohesion and intergenerational integration, thus conferring them a high social value.

Figure 10: Ornamental species of plants (such as Robinia pseudoacacia) can be used in short rotation crops also to improve the local landscape in Parco Agricolo Sud di Milano (Italy).

4.6 Examples of landscape improvement on short - medium rotation coppice

One of the most common typology of rotation coppice are represented by poplar (gen. *Populus*) selected for biomass feedstock in continental climate zones associated to humid temperate forest vegetation (i.e. with tools like oak, hornbeam, ash, wild cherry tool, maple, elm and shrubs species like hazel tool, elderberry, hawthorn, dog rose etc.).

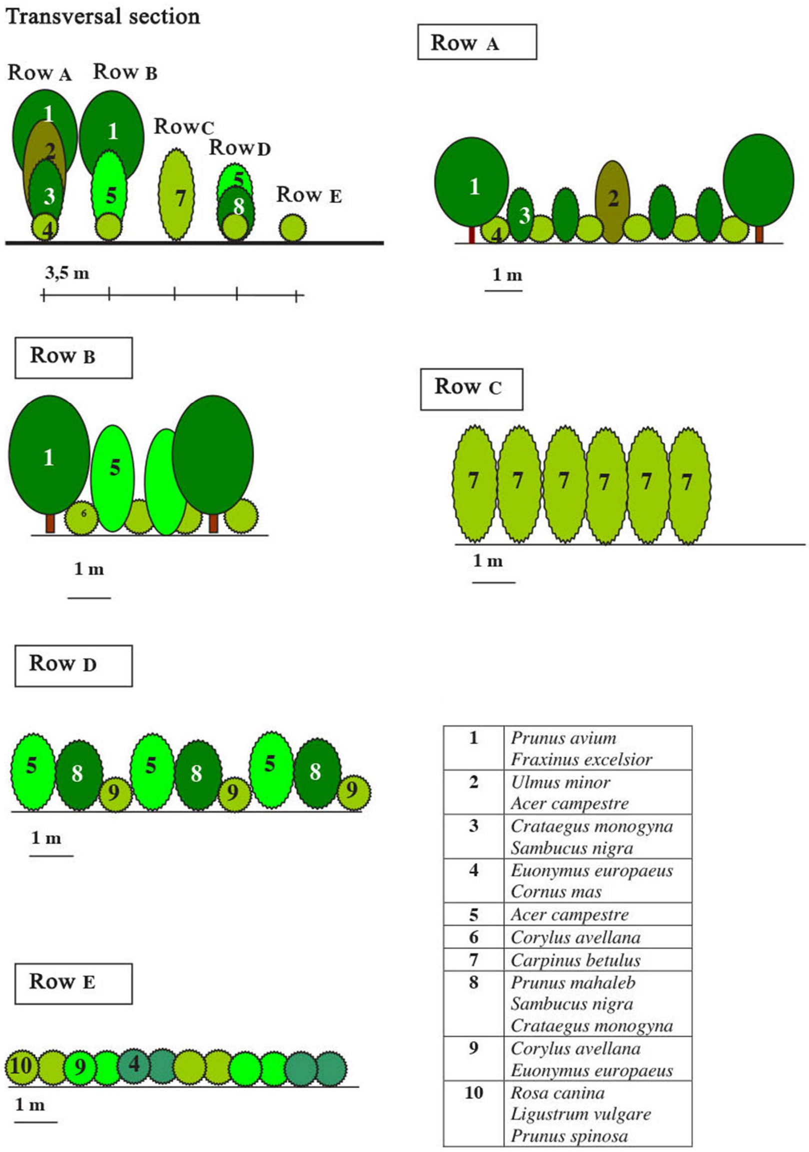
Depending on timeline and plant density, three different cycles are provided:

- Mini-Rotation coppice – 2-3 years with 16.000-20.000 plants/ha
- Midi-Rotation coppice – 4-6 years with 8.000-12.000 plants /ha
- Maxi-Rotation coppice – 8-12 years with 1.500-3.000 plants /ha

A couple of examples of common biomass crops in Northern Italy are provided here. Different approaches to crop management can dramatically change the perception and uses of a place (i.e. of a brownfield).

Most of the time bioenergy crops are managed without consideration for landscape and biodiversity issues. (ALTIERI 1999) In the following lines we provide a guidance of possible actions about crop planning and management, to integrate landscape and biodiversity issues in biomass projects. The examples provided consider midi-and mini-rotation poplar crops. (www.venetoagricoltura.it)

The main approach to make crops look better (landscape value) and provide wider services (amusement, biodiversity, education, besides timber) is focused on **diversity** of plant species hosted in the crop. The most significant piece of this approach is a multi-functional wood band, which relies on different species of tools and shrubs with different planting pattern instead of a single one. Combining different species on adjacent rows can further enhance the diversity of the area. This approach provides a much more stratified and complex habitat, that looks more natural and it's far more interesting for people and for different species of animals still conserving his economic potential. A crop like this can be become a connection in the local ecological network too, providing a corridor for animals and plants movements between natural patches in the area (see Figure 11).



1	*Prunus avium* *Fraxinus excelsior*
2	*Ulmus minor* *Acer campestre*
3	*Crataegus monogyna* *Sambucus nigra*
4	*Euonymus europaeus* *Cornus mas*
5	*Acer campestre*
6	*Corylus avellana*
7	*Carpinus betulus*
8	*Prunus mahaleb* *Sambucus nigra* *Crataegus monogyna*
9	*Corylus avellana* *Euonymus europaeus*
10	*Rosa canina* *Ligustrum vulgare* *Prunus spinosa*

Figure 11: Example of a planting scheme of a multifunctional wood band in 5 rows. (Source: Centro Vivaistico e per le Attività Fuori Foresta “Gli impianti produttivi di biomassa legnosa”, Veneto Agricoltura)

This typology of plantation is able to generate several services, as soil protection, water storage, etc. (TEEB) and production (timber, wild fruits), and to provide leisure and a high quality landscape.

A realization of multifunctional wood band is shown in Figure 12 below. Parco Agricolo Sud di Milano is the biggest agricultural park in Europe (37,000 ha) and it provides many educational and leisure services. More than two thirds of the agricultural park is managed with sustainable agriculture and the traditional rural landscape was restored introducing eco-structures as tool rows, hedges, buffers, etc., in order to improve both the production, the quality of food and the landscape.

Figure 12: A multifunctional wood band in Parco Agricolo Sud di Milano with 3 species of tools and five species of shrubs (Italy).

Depending on the harvesting scheme of crops, distinctive services can be expected from the overall biomass project. Hereafter, two options of **biomass crops with multifunctional wood bands** are shortly represented:

Option 1: Midi-Rotation: 4-6 years with 8.000-12.000 pp/ha

Main services: sensible landscape improvement, local communities' involvement (leisure and education), sensible benefits for biodiversity.

TIME SCALE	CONSEQUENCES	LANDSCAPE AND BIODIVERSITY ACTION	EXPECTED EFFECTS
Year 0 before land set-up	None	Survey on internal and external landscape, check connection with the ecological network	- Understand if the area is able to play a role in multifunctional ecological network
Year 1 Soil preparation	Barren land	Communication to explain the biomass crop project	- Make sure the residents and public in the area know the project
Year 1 Tool planting	Seedlings growing in lines, height below 1 m	-Mitigate artificial pattern with no regular tool plantation details (bending rows, i.e.). -Mix different species of tools, provide some shrub in the undergrowth and around	-Giving the crop a natural look -Make it work like a temporary shelter for wildlife

		the crop. -Provide greenways with permanent natural landscape features in the surroundings (hedges with flowers, open fields, tool lines, ponds and streams bordered by vegetation) according to ecological net indications	
Year 2 Tools growing	Young tools crops less than 2 m high	-Monitoring of plant growing and wildlife	- Get the local people involved in managing activities (encourage participation and social inclusion). - Better landscape mitigation and more shelter for wildlife
Years 3-5 Tools growing	Young tools crops less than 4 m high	-Monitoring of plant growing and wildlife	-Get the local people involved in managing activities -Better landscape mitigation and more shelter for wildlife. Limited wildlife reproduction (birds, insects, reptiles) -Benefits on local climate (heat reduction effects)
Year 6 Cut	Partly barren land Partly young wood	“Consecutive” cut: cut on alternate patches of land for harvest. Keeping others to provide shelter for fleeing wildlife	-Limiting the damage to wildlife and ecological net -One patch of land takes the role of the other where the vegetation has been cut

A possible planting scheme of multifunctional wood band managed as midi-rotation is shown on the following figure.

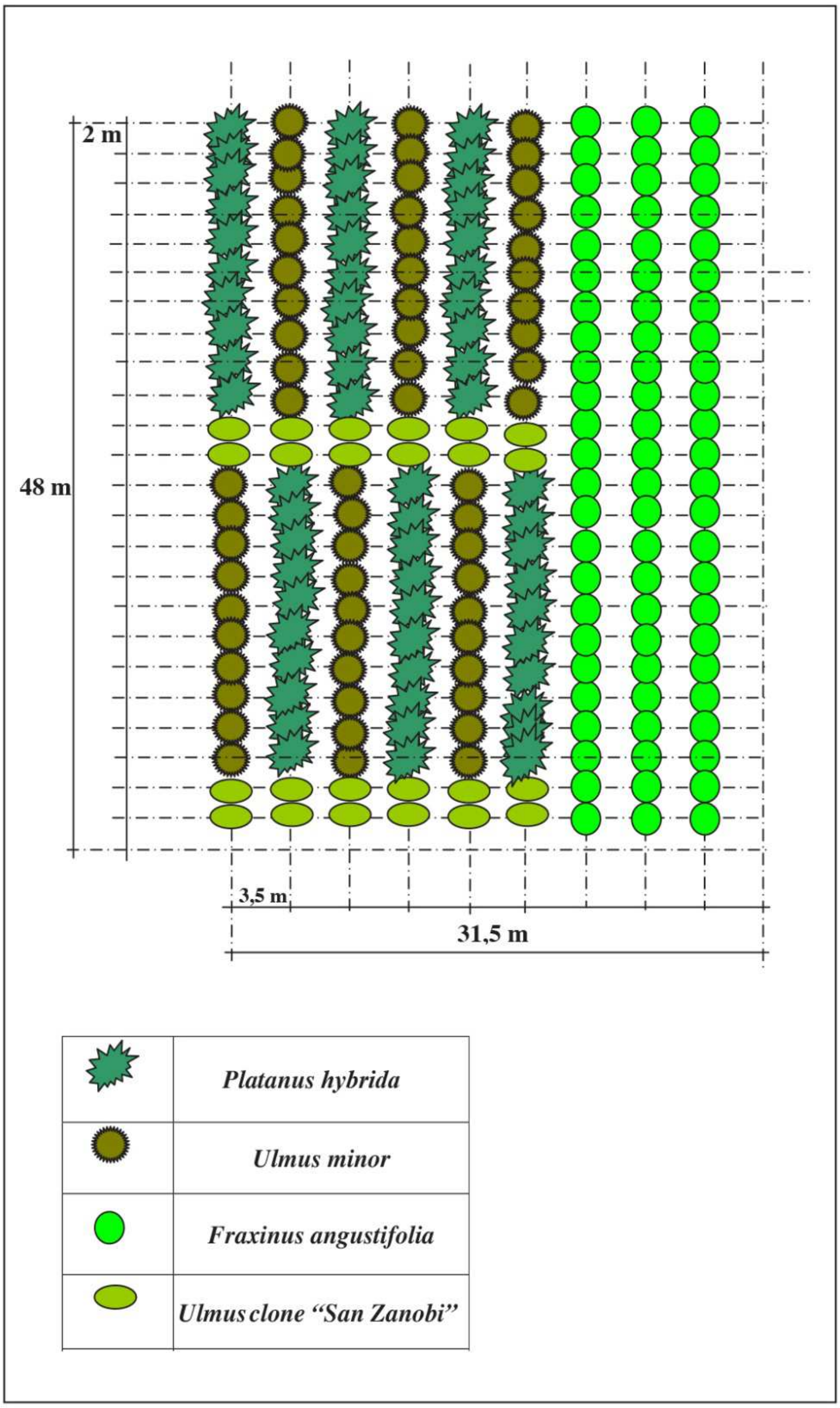


Figure 13: Planting scheme of a Midi-Rotation coppice. (Source: Centro Vivaistico e per le Attività Fuori Foresta "Gli impianti produttivi di biomassa legnosa", Veneto Agricoltura)

Option 2: Mini-Rotation: 2-3 (4) years with 16.000-20.000 pp/ha gen. Populus, Salix

Main services: partial landscape improvement, local community's involvement (leisure), limited benefits for biodiversity.

TIME SCALE	CONSEQUENCES	LANDSCAPE AND BIODIVERSITY ACTION	EXPECTED EFFECTS
Year 0 before land set-up	None	Survey on internal and external landscape, check connection with the local network of accessible and welcoming open spaces	The area can play a role in social activities
Year 1 Soil preparation	Barren land	Communication to explain the biomass crop project	- Make sure the residents and public in the area know the project
Year 1 Tool planting	Artificial pattern particularly seen in young plants, height below 2 m	- Mitigate artificial pattern with no regular tool plantation details (bending rows, i.e.). - Provide greenways with permanent natural landscape features in the surroundings (hedges with flowers, open fields, tool lines, ponds and streams bordered by vegetation) according to open spaces network	-Giving the crop a more natural look -Make it work like a temporary shelter for wildlife
Year 2 Tools growing	Young tools crops less than 4 m high	-Monitoring of plant growing and wildlife	- Get the local people involved in managing activities (encourage participation and social inclusion) -Better landscape mitigation, limited shelter for wildlife
Year 3 or 4 Cut	Partly barren land/ Partly young wood	“Consecutive” cut: cut on alternate patches of land for harvest and keep others to provide shelter for fleeing wildlife	-Limiting the damage to wildlife and ecological net -One patch of land takes the role of the other where the vegetation has been cut

4.7 Conclusions

The old fashioned "single species biomass crops" offer only economic benefits and limited landscape services, being very rational and repetitive. The landscape approach with multifunctional wood band still retains the economic values (provided by the species collected for timber) but add new services, thanks to the diversity of plant species planted into the crop. So in a limited lapse of time (1-2 years) form the moment seedlings start to grow, the area can expand its role, and contribute to build a better looking landscape, a more effective local ecological network and an amusement and educational place for people who live there (liveable places).

The main approach to make crop land look better (landscape value) and provide wider services (amusement, biodiversity, education, besides timber) is focused on **diversity** of plant species hosted in the crop. The most significant piece of this approach is the multi-functional wood band that relies on different species of tools and shrubs with different planting pattern instead of a single one. Combining different species on adjacent lines can further enhance the diversity of the area. This approach provides a much more stratified and complex habitat, that looks more natural and it's far more interesting for people and for different species of animals still conserving his economic potential. A crop like this can be become a connection in the local ecological network too, providing a corridor for animals and plants movements between natural patches in the area.

5. Key principles

Decision making tools aim at establishing relations between relevant decision criteria. They are designed to support decision makers when selecting between possible options which best meet the objectives they have agreed upon. With the tool presented in this report, HOMBRE wants to provide stakeholders a means to consider all relevant aspects of decision making at a glance. The key principles of the report are presented below:

- Biomass cultivation on marginal urban land and brownfields presents a potential land use option for shrinking cities with large urban land reserves as well as for either permanent or interim land use on urban sites and brownfields.
- At the urban level and from the social perspective of sustainability, biomass projects have great potential to increase the attractiveness of a site. The reintroduction of green productive uses to an underused or unused site can, where the conditions are right, create a stronger community image, reduce the impact of derelict sites on the identity of an area and engage the community through new jobs or new uses in the city.
- Biomass projects may impact communities in several manners, i.e. site access for public may need to be controlled and partially restricted in order to ensure that crops will not suffer from vandalism. Respectively, the communities' identity with and sensitivity to biomass projects must be taken into consideration in early stages of project planning.
- Local authorities are required to designate which type of land uses are or are not allowed within their jurisdiction. The HOMBRE Decision Tool allows the systematic selection of potential site in urban areas. Therefore, project initiators should aim at fitting their projects outlines and objectives to local planning schemes and regulations as much as possible.
- Economic barriers consist in the inability of biomass production to reach a certain threshold yield to ensure return on investments. In some cases brownfield sites may not be large enough to generate minimum biomass quantities. In such a situation,

clustering schemes, which enable to group the production of various brownfields together, may represent an appropriate management scheme for projects to attain the sufficient surface area required to make the production of bio-energy viable.

- Economic factors that favour biomass production include the reduction of site maintenance costs. Even if biomass production cannot be undertaken on a scale to yield overall profit, biomass may still be an economically favourable option if it reduces the costs of a site's maintenance incurred by the site owner. Furthermore, when brownfield sites are clustered together and have access to the required services for the processing of the product, clustering effects can be created which take advantage of synergies.
- Other factors are those related with environmental considerations. The use of pesticides and fertilizers may have undesired impacts on the surrounding area which may compromise the overall success of the project and even cause its termination. Another environmental driver for the use of biomass is that the use of plants on the site means that the ground has to remain permeable to take-in water, which can double as water catchment for rain or storm runoff. Also, the soil functions of the ground become normalised as plant production takes place (after being degraded from a previous urban use), with the reactivation of the nutrient and mineral cycles.
- Finally, environmental drivers for biomass creation are manifold. The growing of crops implies a higher amount of shade, which, in addition to the respiration process of the plants, can help to regulate the micro-climate of the area in extreme temperature cases.

At the individual site level there are many drivers which support the cause of biomass plantations on brownfield sites.

- Soil conditions that are suitable for plant growth would greatly raise the chances of biomass projects to become successful. Specifically, inadequate top soil and the presence of soil contaminants (which can arise, for example, in connection with disposal or mining sites, industrial activities, landfills, atmospheric deposition of contaminants) are some major physical restrictions.
- Larger sites are likely to produce biomass yields above critical thresholds of viability.
- Soil contamination may also present financial burdens to an extent that may jeopardize the project's viability. Option appraisal for soil remediation projects may consider gentle remediation techniques (see deliverable D5.1 section 3.4.2 and deliverable D5.4) as appropriate solutions.

In conclusion to overcome these barriers there are specific requirements to be met when determining if a brownfield site can be used for the cultivation of biomass for energy production. These include:

- a suitable size for cultivation, achieved either through a plot of land large enough or the clustering of smaller plots together
- a land use designation from the local authority which allows for biomass cultivation activities on site

- soil quality appropriate for plant growth (i.e. considering soil structure, fertility, contamination etc.), also assuming soil quality may not generate risk for the environment and human health

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Annex

Case: Markham Vale

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Description of the case

The Markham Vale site straddles the M1 motorway, which is one of the main arterial routes from the South to the North of the UK. Coal had been mined in the Markham area for centuries. However, large scale production at the Markham Colliery began in the late 19th century. The figure below shows the former colliery adjacent to the M1.

Figure 14: Former colliery site adjacent to the M1.

The closure of Markham Colliery in 1994 brought to an end more than 150 years of deep mining in Derbyshire. Not surprisingly, it resulted in very high levels of unemployment – 3,300 miners living in Derbyshire lost their jobs. It had a knock-on effect on service and supply industries and left high levels of social deprivation - the northern coalfield was in England's top 20% of the most deprived districts. The site is part of a complex of deprived urban areas and other brownfield areas.

After the cessation of mining the Coal Authority, which is the residuary body for British Coal (the UK nationalised mining company), handed the site to local authority ownership and it is now owned by DCC. The Coal Authority retains responsibility for the abandoned underground workings.

"Markham Vale" was born out of a Coalfield Task Force Report in 1998[4] which challenged local authorities to create an employment growth zone centred on the former Markham Colliery. Derbyshire County Council (DCC) led a partnership of other interested bodies in taking up the challenge, the Markham Employment Growth Zone (MEGZ). This aims to create 5000 jobs to regenerate the local area, as well as providing environmental improvements including establishing short-rotation coppicing on the North heap. MEGZ became known as Markham Vale, with the coppicing project being known as "Markham Willows".

Markham Vale site lies in the East Midlands of England, between the city of Chesterfield and the town of Bolsover, straddling the M1 motorway. In total, it consists of 127 hectares of the former Markham Colliery site, plus two spoil heaps. The main colliery surface occupied some 37.5 hectares. The largest spoil heap (the North Tip) is 105.9 ha. The South Tip spoil heap extends to 33.5 hectares. The total area is 360 ha, and includes some agricultural land that was incorporated to make a more economically feasible development platform. Some 205 Ha of the overall Markham Vale platform has been previously developed. The figure below is an aerial photograph of Markham Vale shortly after the colliery installations were cleared. This picture shows the development plots which were to be developed in a phased way. Markham Vale is DCC's largest-ever regeneration project and aims to reverse the unemployment and deprivation which followed the closure of deep mines, loss of textile jobs and the general decline in heavy industry in north east Derbyshire.

[4] Department of Environment Transport and the Regions (1998) Making the Difference. A new start for England's coalfield communities: the Coalfields Task Force Report, DETR, London. June 1998.

Figure 15: Delineation of the plots of the site.

Soft Land Uses

As originally conceived the MEGZ concept included both built infrastructure and soft re-use, including the North Tip for biomass energy production, leisure and grazing (a pre-existing use).

Construction of the North Tip was commenced before 1945 by aerial ropeway. Disposal of colliery spoil continued until approximately 1990 when disposal was relocated to an adjacent void space created by open cast mining (the “Erin Void”). There is evidence to indicate the presence of discrete tailings lagoons, vertically and horizontally, throughout the North Tip. Between June 1977 and December 1986 the site was in use as a licensed waste disposal site. Coalite (an adjacent smokeless fuels and coal chemicals plant) used the site for the co-disposal of coking debris, tar acid residues and up to “100 tonnes/day of lime sludges containing less than 1% phenol”. No treatment took place and these materials appear to have been placed in discrete areas of the tip, and as far as is known these areas have now been buried.

During the 1980’s and early 1990’s 300mm of soil has been spread over the tip, except for an area which remains as bare colliery spoil to the north, and grass seeded. A few small areas of trees have been planted. Some initial trial plantings of poplars and willows were also carried out in the late 1990s. However, short rotation willow coppice had already been established on other sites in Derbyshire by 2000 as shown below, showing a willow coppice in Derbyshire (credit AEA Technology Ltd)

A mosaic of land uses was envisaged for Markham Willows. This foresaw short rotation coppice (SRC) planting of willow over three years, along with areas of open grassland for amenity and grazing, with a new path over the North Tip linking some existing walking routes. The coppice was to be planted on a staggered basis on a three year rotation, thereby ensuring production of biomass across 20 ha on an annual basis.

The ambition was to sell heat energy rather than wood chip, as the margin on wood chip was very low. The business model developed envisaged a local boiler replacement programme for schools and other local authority facilities, as oil powered boilers came to the end of the operating lifetime. Economic modelling by (AEA Technology Ltd) had shown that the revenue from selling heat was sufficient to run the boiler replacement and the biomass plantation in a profitable way[5]. This concept was known as "wood heat".

The risk management approach for the North Tip was the use of vegetation (including SRC) to stabilise and expand the top soil cover on the site, gradually increasing the depth of the soil horizon to limit accessibility of deeper layers and prevent erosion ("phyto-containment"). Qualitative risk assessment indicated that, this would provide risk mitigation, although additional site specific risk assessment was recommended for arsenic. The design also took into account the need to leave an area of the South facing slope facing the Coalite plant undisturbed with naturally occurring revegetation, as it contained elevated levels of dioxin in the surface layers[6].

The attraction to the site owner (DCC) for biomass energy was and is the offsetting of the landscape management costs for the areas restored surrounding the built development

[5] r3 environmental technology limited and AEA Technology PLC (2004) Markham Willows Master-planning. exSite Research Ltd, Hillam, Leads, UK. DOI: 10.13140/2.1.4233.0249
[6] Bardos, P. with Nathanail, J. and Nathanail, P. (2004) Risk Management Model Annexed report DOI: 10.13140/2.1.3708.7363, to the Markham Willows Master-planning Report

platform, which the Council would have to meet, along with its potential for improving land values in the vicinity and supporting job creation . A detailed master-plan including qualitative risks assessments, waste re-use plans and economic modelling were produced for Markham Willows in 2004. The Council believes that local communities are largely supportive of the proposals as a means of removing dereliction at minimal cost to the local Public Sector. The figure below shows the planting on the North Tip planned by DCC. The Year 1 planting took place in 2004.

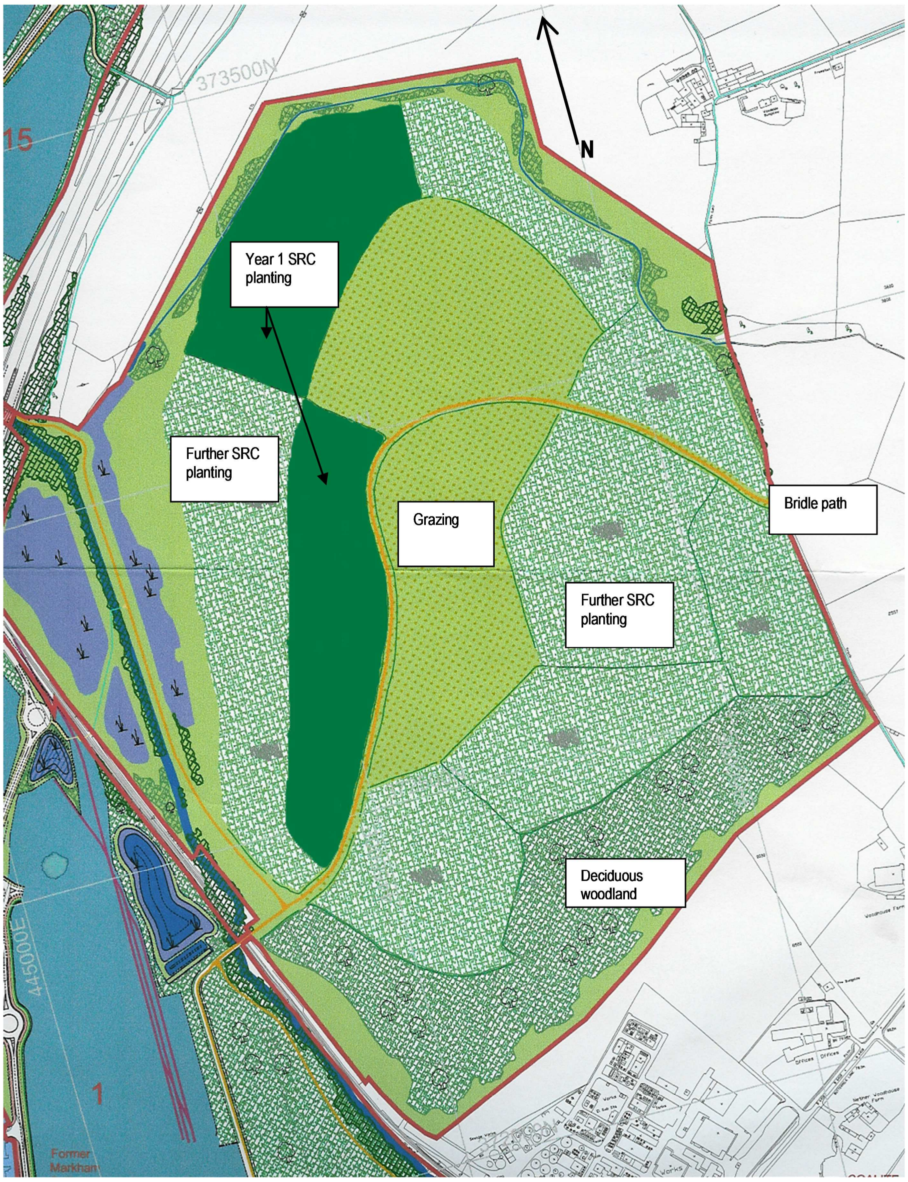

Figure 16: Conceptual site plan of biomass production on the Markham Willows project site.

"Markham Willows" could address three distinct needs with an integrated and economically robust solution:

- Coal waste sites often have no current or future purpose. They invariably impact negatively on their surrounding environs, in terms of both economy and landscape. An inexpensive and effective remedy is needed for this land use issue.
- Coal waste sites are often chemically and physically unstable. An inexpensive and effective remedy is needed for this land quality issue.
- Coal waste sites exist as the unusable residue of fossil fuel extraction. The organic content of the residue is very low in organic carbon. It is averse to being landscaped in traditional ways, hence the number of failed restoration schemes and reinvestments in repairs. An inexpensive and effective remedy is needed for this land durability issue.

DCC's assessment has been as follows. The Markham Willows concept integrates organic waste recycling, soil manufacture, landscaping, renewable energy crop production (planting, maintenance, harvesting, processing), stabilisation of contamination, wood burning boilers (installation, maintenance and fuel), to create a self-sufficient solution to previously intractable problems. In addition, public open space will be created, wildlife habitat will be improved and a 60 Hectare biomass plantation will contribute to CO2 consumption. Direct employment will ensue in all aspects of the scheme, along with training and educational opportunities. Markham Willows is a unique opportunity to secure enduring economic environmental and social progress throughout the coalfield areas locally, regionally and, perhaps, nationally and internationally and simultaneously generate local employment. This adds up to an ambitious project founded on highly respected feasibility work which includes validation and evaluation models developed specially for the project. No other work exists anywhere that addresses these issues in such an integrated and comprehensive manner.

Markham Willows was to be linked to an Environment Centre, and the vision was one of encouraging businesses with a strong sustainability interest to the site, along with providing linkages to local education and skill development for environmental technologies. The Environment Centre was to make use of biomass energy.

A number of factors have constrained the development of the original Markham Willows concept. The Environment Centre has been built and includes both conferencing facilities and accommodation for small businesses. However, design issues with the biomass boiler have meant that it cannot be easily used, for example ash removal requires trips up and down a staircase. In addition, the heat requirements at the Environment Centre are lower than originally anticipated, thereby impacting on the costs per heat unit rate. The impact of this on perceptions of biomass utilisation severely undermined the wood heat concept. Should biomass production be further developed at Markham, biomass products (wood chip) are likely to be sold on the open market, rather than via a wood heat solution.

The wood heat concept was far ahead of its time in the early 2000's. The financial models indicated profitability even without the financial incentives from central government now available for renewable energy. It also foresaw the development of locally based community companies to supply the wood-heat service, and approach that is now being encouraged by government. However, the experience of biomass heat from the Markham Vale Environment

Centre, along with the complexity of setting up and administering a wood heat company, have led to a preference for a commodity sales based approach to use of biomass, which limits the revenue potential, but seems more practicable.

In the intervening period caused by the delay from the judicial review and the ending of regional development support meant that the biomass production plans have not yet been fully executed. Only one of three planned plantings have been carried out so far. In addition, the multi-lateral team working with the site owner on the "Markham Willows" concept largely disbanded over the period of the judicial review and the funding opportunities they had been exploiting came to an end or changed in their funding priorities.

The original Markham Willows planting scheme called for soil improvement with green waste compost and sewage sludge. These would have been applied under a regulatory mechanism known as an "exemption". However, while the land management regulatory team supported the envisaged scheme, the waste management regulatory team dealing with composts could not agree a way forward in a timely way. As a consequence only sewage sludge was used for soil improvement as it had a pre-existing overarching framework exemption for use across many sites.

Access to the North Tip is currently via a former colliery bridge over a mineral railway line. The bridge has weight restrictions which precludes use by heavier agricultural size vehicles. Proposals originally included provision for the removal/replacement of this structure. However, DCC have recently acquired the railway line that the structure crosses and more cost effective alternatives for crossing the railway are being explored. In addition, over the intervening period since the completion of the Markham Willows design in 2004, there has been substantial natural revegetation of the spoil heaps. Adjacent to the North Tip are natural habitats and protected ecosystems. Hence completion of the biomass planting and the future use of the North Tip are open questions, currently under consideration. A further site investigation is being planned along with the preparation of a detailed remediation strategy to support the biomass proposal. While outline planning permission exists, reserved matters planning approval would be required before detailed proposals to restore and plant the site with biomass crops can be implemented.

Consideration has been given to wind and solar energy. However, a major difficulty with this is that the North Tip is on the sight lines from the viewpoints of an important local visitor attraction, Bolsover Castle, managed by a Public Body called English Heritage (www.english-heritage.org.uk/daysout/properties/bolsover-castle). This makes solar or wind power renewable installations in such a visible location unlikely to be acceptable.

The South Tip was never envisaged for active forms of re-use because of the presence of dioxin contamination on its surface. It has a spontaneously revegetation including woodland on the tip flanges, coupled with a tree planting scheme on the top of the tip, and it was considered that the disturbance of this was a riskier operation than leaving the site as was.

An additional renewable energy interest at Markham has been the recovery of coal bed methane which provided renewable energy for several years (www.alkane.co.uk), although this is now reduced. The company involved has now moved onto aquifer heat energy extraction using heat pumps and proposals are being developed to use this energy source to heat the Environment Centre.

The Rejuvenate decision support framework -Considerations and outputs (step by step)

Stage 1: Selection of feasible crop types

For the crop type selection below four stages are considered (Figure 17)

- ***Stage 1.1: range of crops meeting site objectives.*** This initial step is where the range of biomass crop alternatives are compared against the site objectives agreed by the project team for the marginal land under consideration. Here, therefore, the crop characteristics related to any boundaries or preferences set by the general biomass objectives are incorporated (e.g. SRC may be discounted if the site will has a limited time "window")
- ***Stage 1.2: range of crops meeting local climate conditions.*** The list of biomass crops remaining after site objectives have been considered is then screened against prevailing *local* climatic conditions (e.g. local air and soil temperatures, sunlight hours, wind and rainfall conditions).
- ***Stage 1.3: range of crops that can be cultivated on the site's topography.*** Biomass crops vary in their cultivation requirements. For example steep slopes, presence of eroding areas, and limited soil cover, restrict what can be grown. Only biomass crops that can grow under the topographical conditions of the site should be considered further.
- ***Stage 1.4: available uses.*** An initial appraisal of biomass use opportunities should be carried out for the remaining biomass crop options. Biomass use options may be present off-site or on-site, depending on project team's preferences. At this stage the decision making is concerned with the broad feasibility of use, rather than an exact calculation of revenue.

However, this screening process should select only biomass crops for which *profitable* use of the biomass produced seems feasible

The output of Stage 1 aims to be a list of feasible biomass crops able to grow under local and topographical conditions that aims to fulfil the objectives of the cultivation of the site. It may be appropriate here to revisit the original project objectives, to widen the range of possible options.

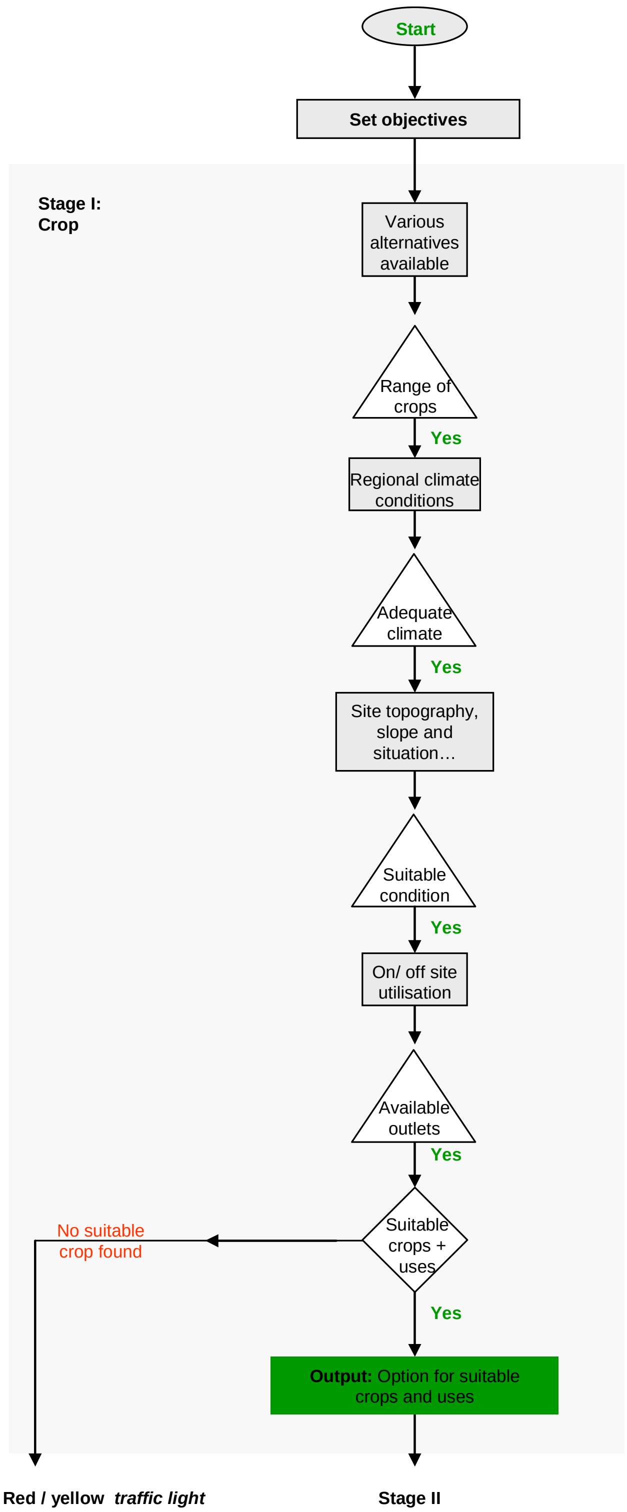

Figure 17. Rejuvenate DST: Stage 1: Selecting the Crops (Note: each "triangle" is a factor which may mean no suitable crop is found)

Stage 2: Site management considerations

Stage 2 considers by the following steps the management of the site. (Figure 18).

- **Stage 2.1**: range of crops that can be grown on the site. The existing soil on the site is compared against the crop requirements for the biomass types short-listed from Stage 1. This comparison will require soil compositional information for the marginal land area, in particular for chemical and physical properties, as well as information about soil depth. There are three possible outcomes from this consideration: that the soil is already suitable for a biomass crop, in which case perhaps only soil maintenance for the crop need be considered; that the soil can be made suitable for crop production by soil improvement and/or soil forming measures; or that the soil surface cannot be brought into a condition that is suitable for a particular crop type, for example because local rainfall and ground conditions mean that it will always be too wet for the particular crop type. The outcome of this stage is a short list of viable biomass crop types along with their individual soil management needs (encompassing site preparation and ongoing maintenance).

- ***Stage 2.2: environmental risk management.*** The short list of crop and soil management combinations should be included as possible end uses for site risk assessment where the site is suspected as being contaminated (or organic matter inputs may contain contaminants). These end uses should be assessed including a site specific assessment (e.g. a conceptual model) that reviews all of the pollutant linkages that need to be considered for a site. This risk assessment may determine that some of these pollutant linkages are not significant, whereas others will require a risk management intervention. In some cases it may be determined that a particular biomass type cannot be grown on a site with acceptable risks.

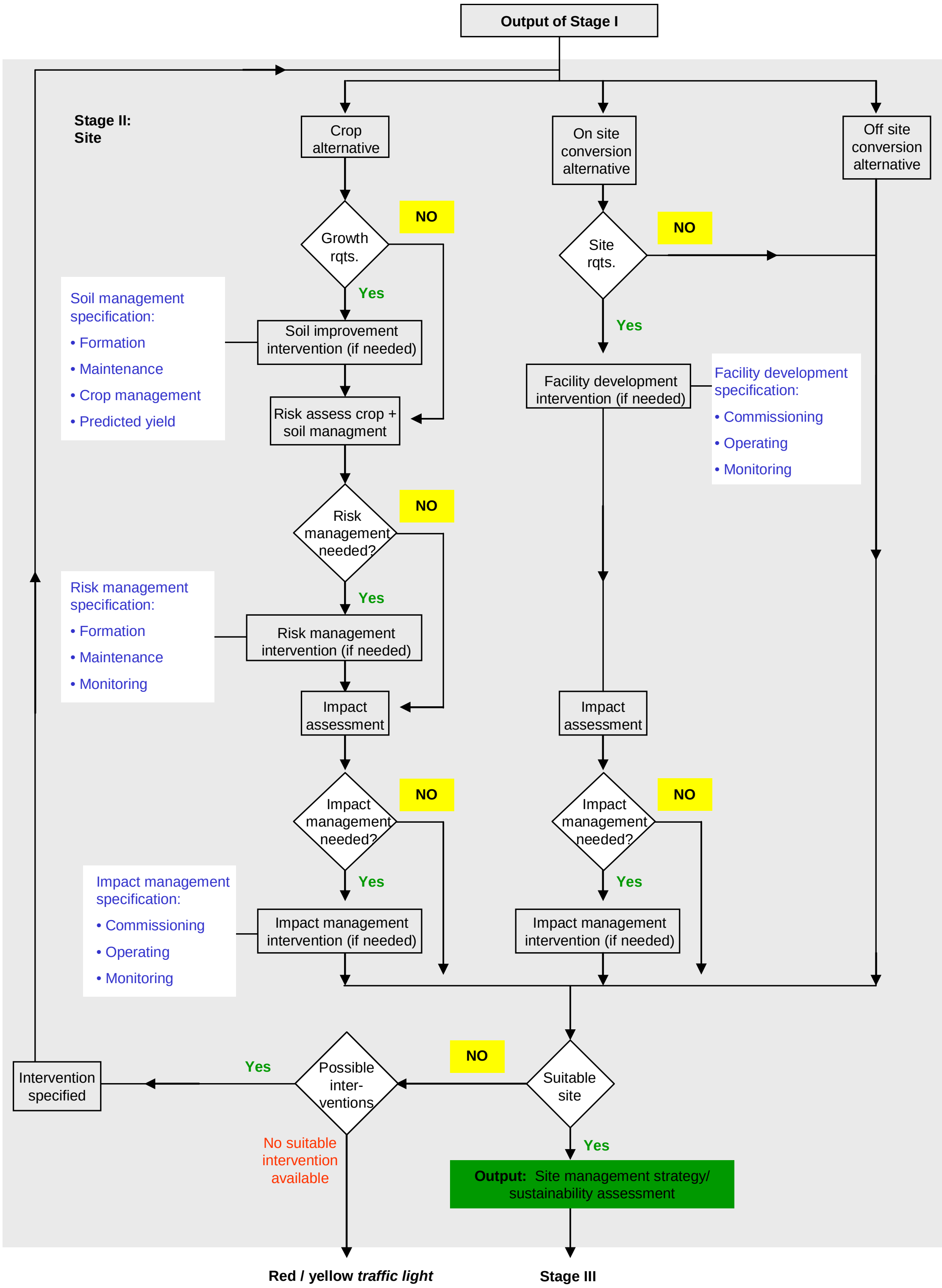

Figure 18: Rejuvenate DST: Stage 2: Site Management considerations. Red-yellow traffic light (bottom, middle) means that a suitable biomass option may exist but would require that the starting objectives are revisited.

- ***Stage 2.3: impact of interventions.*** The outcome of Stage 2.2 is a refinement of the short list of crop and soil management options to list options for which appropriate risk management exists, and which describes possible risk management interventions required. The soil management and risk management interventions may have environmental impacts. For example soil maintenance and crop production impacts on the water environment may need to be minimised. The purpose of this step is to ensure that the crop, soil and risk interventions on-site are compliant with wider environmental protection needs, for example considering the water environment and the local ecology. This consideration, may favour particular crop alternatives, for example SRC is known to have low fertiliser requirements (and hence less nitrogen loss). Willow coppice can also improve biodiversity in marginal land contexts and supports greater biodiversity than many conventional arable crops (e.g HAUGHTON et al., 2009). The outcome of this stage will be a short list of viable biomass crops that can be grown on the site under consideration with acceptable environmental impacts.

- ***Stage 2.4: facility development.*** This stage considers the feasibility of the various on-site bioconversion alternatives under consideration. Key factors will include infrastructure and service requirements (such as roadways and mains water), suitability of the site for construction (for example is it geotechnically suitable) and any risk management that might need to be undertaken to protect the facility (for example to deal with fugitive landfill gas). These considerations may mean that some conversion options will not be feasible for a particular site. The outcome of this stage will be a short list of feasible biomass conversion options and their site development requirements.
- ***Stage 2.5: facility development impacts.*** This stage considers the impacts of the facility development on the marginal land and its surroundings, for example the impact of construction work and new roadways, and any mitigation measures that need to be put in place to deal with these impacts. The outcome of this stage will be a short list of feasible biomass conversion options, their site development requirements and any mitigation strategies needed for their environmental impacts.

Stage 3: Value management

This stage considers the assessment of project value and its possibilities for enhancement including the following steps of considerations (Figure 19):

- ***Stage 3.1: financial feasibility.*** The direct costs for each biomass option (including soil and other site management interventions and any on-site conversion) are compared with its revenue earning potential. Where the revenue earning potential for a particular approach exceeds its costs an initial suggestion of viability is indicated. The value of linked initiatives should also be considered as part of this valuation process, and indeed the valuation process may trigger the need to identify possible wider linkages, for example adding other forms of renewables to the site management approach such as wind power, or linking the project to carbon offsetting or carbon neutrality for a larger regeneration initiative. This activity also includes the initial identification of possible funding streams such as grants and tax breaks, as well as potential sources of investment (and what needs must be met to secure those investments).
- ***Stage 3.2: financial viability.*** This stage considers the financial feasibility of each approach in more detail, developing a more detailed financial model and comparing it

against investment thresholds set for the project, such as requirements for return on capital set by investors and other funders.

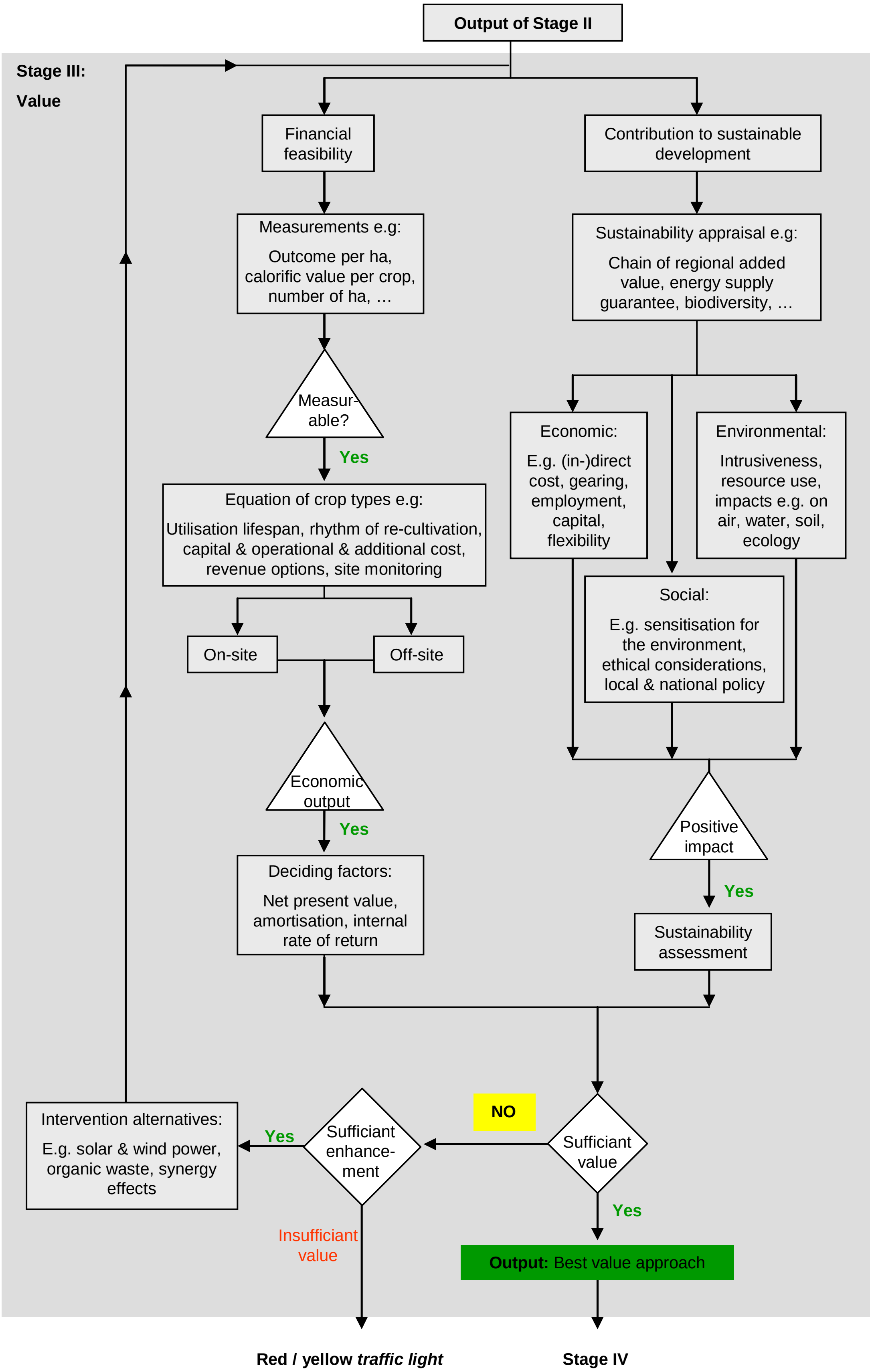

Figure 19: Rejuvenate DST: Stage 3: Value Management. Red-yellow traffic light (bottom, middle) means that a suitable biomass option may exist but would require that the starting objectives are revisited.

- ***Stage 3.3: Sustainability appraisal.*** This stage uses qualitative sustainability appraisal based on a series of indicators of sustainability, representative of the economic, environmental and social factors identified as important by the project team and the other stakeholders involved in the project (e.g. applying the SURF-UK (2011) process and indicators)

Project options may be eliminated during Stage 3 as failing to reach adequate value for the project team. The output of Stage 3 is one or possibly more economically viable project concepts worthy of detailed appraisals, along with an initial sustainability assessment of these concepts.

Stage 4: Project risk management

Stage 4 considers by the following steps the project risks for the viable project opportunities identified at the end of Stage 3 (Figure 20):

- ***Stage 4.1: Stakeholder views*** during this stage the project team offers their plans for detailed external comment and scrutiny now that a complete project concept exists. This stage includes seeking the necessary permissions and permits for activity from regulators and planners and engagement with the local community to involve them and other partner organisations if this has not already taken place. It also includes the confirmation of public financial support prior to step 4.2. Stakeholder engagement needs to begin at an early stage of planning (CUNDY et al., 2013), and it will be prudent to seek initial stakeholder views about the various site management interventions under consideration from the start of the project and especially during Stage 2, and the Stage 3 sustainability appraisal, to reduce the risk of major surprises at this Stage.

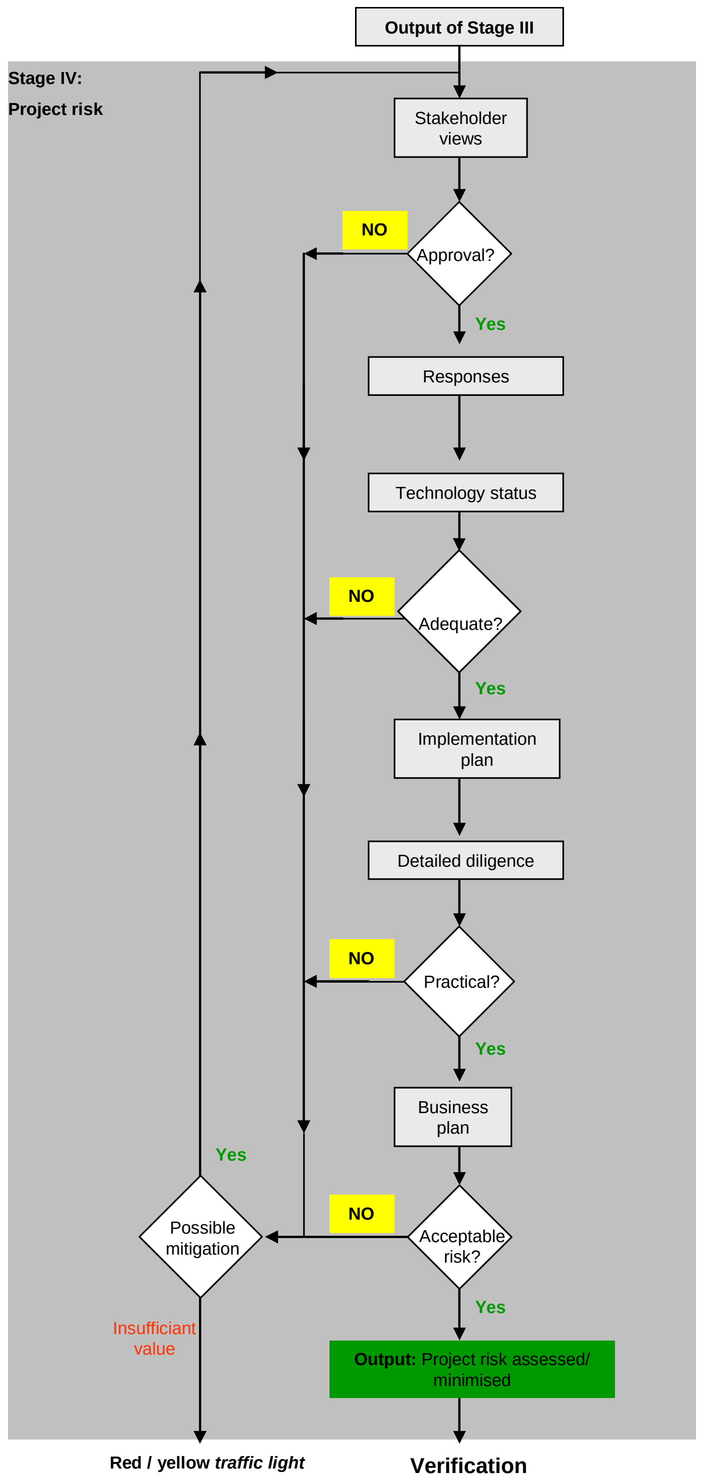

Figure 20: Rejuvenate DST: Stage 4: Project Risk Management. Red-yellow traffic light (bottom, left) means that a suitable biomass option may exist but would require that the starting objectives are revisited.

- ***Stage 4.2: Technology status:*** this consideration is a detailed assessment of the project components, for example: will the crop really grow and provide the predicted yields, will the site risk really be managed, and will the conversion really work in practice? What needs to be tested before the project starts in full, what preparatory studies are needed? This stage may include detailed biomass and possibly conversion technology trials to demonstrate proof of concept. Large scale trial work may also be important in satisfying stakeholder requirements, for example building regulatory and investment confidence.

- ***Stage 4.3: Detailed diligence*** during this stage the project team seeks firm prices and formulates the project business plan in detail, checking in detail that they can raise capital, employ people, are in line with environmental legislation and that the partners they want to work with are reliable, across the whole site management and biomass production (and conversion) system. This is also the point when any investment, or public or regional funding or tax breaks, have to be finally consolidated.

The output of Stage 4 is a firm project concept where project risks are known, and mitigated where necessary, that is ready for detailed planning and implementation.

Verification of project performance

Verification of project performance needs to consider both the specific environmental project goals agreed with regulators and the project economic goals needed to achieve suitable economic performance. It will also need to consider the wider sustainable development performance of the project, in particular if sustainability goals have been agreed as a part of the investment in the project.

Implementation and business planning information should largely be met by the four stages of decision making described above. *Verification* is the process by which stakeholders can be assured that the project has met its planned objectives. The project verification can therefore also follow the same structure as the four stages of decision making outlined.