ThS D3.3 Methods and tools for environmental footprint assessment

CONCEPTUAL SITE OR PROJECT MODELS FOR SUSTAINABILITY ASSESSMENT

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Abstract

This paper explores adaptation of basic contaminated land risk management methodologies to sustainable regeneration and remediation:

- For a sustainability effect to be manifest there needs to be a "pressure" of some kind, a "receptor" that can be affected by that pressure; and, crucially, a mechanism through which the pressure influences the receptor. All three: pressure, mechanism and receptor need to be present and linked for a sustainability effect to exist – i.e. a *sustainability linkage*;
- A relatively straight forward conceptual model of sustainability can be described on a site specific basis (site conceptual model) using sustainability linkages
- These can be evaluated for their importance (significance) in a consistent way
- Not all effects will be large enough to cause a noticeable benefit or harm and thresholds can often be described

A conceptual site model for sustainability can assist design, option appraisal, verification and valuation for regeneration projects. A site conceptual model of sustainability can facilitate better project design and improve overall project value by explicitly linking the different services a project is intended to provide to a vision of sustainability, and identifying opportunities for additional services and synergies between services. A case study has been used to illustrate these ideas based on a simple brownfield regeneration / remediation project for a risk management and revegetation.

1 Introduction

Brownfield land describes previously used land whose redevelopment has been stalled, for example because of economic reasons such as its perceived value being less that the cost of rehabilitation. HOMBRE (HOlistic Management of Brownfield Regeneration)[1], is a European FP7 funded research project. HOMBRE is developing ways of facilitating the re-use of such sites and so enabling a paradigm shift to "zero-brownfields" in the same way as "zero-waste" has become a widely used concept. One of HOMBRE's concepts is that brownfields re-use is facilitated by exploiting synergies between different "project services" to improve the overall value of a project and so improve the attractiveness of regeneration. This may even leverage brownfields reuse where it was not possible before. Examples of this synergy might be combining remediation services with *in situ* ground heat storage services, or combing rehabilitation of mine spoil heaps with biomass energy production. Many more possibilities exist, but their feasibility depends on a shared appreciation of overall value by a range of stakeholders, in particular those from the Public or Private Sector who would make the necessary financial investment for regeneration to take place.

[1] For full information on HOMBRE and the HOMBRE consortium visit www.zerobrownfields.eu.

A holistic approach to sustainability assessment allows the broadest range of possible project service opportunities (and their value) to be considered, and provides an understanding of their wider effects (positive or negative). However, some find such a broad approach to sustainability assessment overly complex and prefer to focus on just a few readily usable tools and parameters such as carbon or environmental footprinting. Unfortunately these do not describe sustainability as whole, nor do they meet all stakeholder interests. This paper suggests the use of site or project specific conceptual models for sustainability way as a forward that supports a more holistic understanding of services, sustainability and overall value. These models are simple to interpret and exploit methodologies that many stakeholders will already be familiar with from contaminated land risk assessment.

The case study used describes a *soft* end-use (i.e. non-built uses where the soil remains "unsealed", such as green infrastructure or biomass based re-use). This type of re-use may be particularly suited to lower input, longer term remediation strategies, based on biological processes mediated by plants or micro-organisms. These are referred to as "gentle remediation" and are the particular focus of the FP7 funded Greenland project, www.greenland-project.eu, which examines the practical application of phyto-technologies in particular for risk reduction at brownfield and other sites, while simultaneously assessing their wider economic, environmental and social benefit.

2 Developing an approach

HOMBRE's believes that Brownfield regeneration can combine rehabilitation with additional services that create more value for stakeholders, and in parallel improve the overall sustainability of a regeneration project.

A conceptual model for sustainability for a site or a project therefore needs to both represent services and their relationship with sustainability during project scoping and design. It needs to support decisions such as prioritisations, choosing between trade-offs and different types of use. It needs to be fairly simple to allow easy deployment and facilitate communication between stakeholders. It needs to be capable of being a basis for determining overall value of projects. HOMBRE has adapted some well known land contamination risk assessment and risk management representations to develop an approach for *conceptual site models for sustainability*.

The key elements to understanding land contamination risks are the connections between sources, pathways and receptors, referred to in the UK as pollutant or contaminant linkages (Defra 2012). These use of these linkages in conceptual site models has been widely used in risk based land management (e.g. Gibbs *et al.* 2010). These models provide a tool for crystallising available and relevant information for "risks" to help stakeholders recognise, prioritise and deal with the risk assessment and risk management for a particular site and project.

An analogous linkage exists for "sustainability". For a sustainability effect to be manifest there needs to be a "pressure" of some kind, a "receptor" that can be affected by that pressure; and, crucially, a mechanism through which the pressure influences the receptor. All three: pressure, mechanism and receptor need to be present and linked for a sustainability effect to exist – i.e. a *sustainability linkage* (see Figure 1).

Figure 1: Sustainability linkage

2 Case study description

Within this paper a simple example of a brownfields problem related to soft-end use, has been used to illustrate the development of a site conceptual model for sustainability. In this example, the project requirements are for two primary *project services:* a risk management service and a revegetation service. However, there are also a wide range of stakeholder interests and supplementary sustainability considerations at the site. The example is based on the Parys Mountain site in

Anglesey, which has been used for copper mining since Roman times, and was provided by one of the HOMBRE case study providers, C-CURE Limited from their UK LINK funded project: *Development and application of soil and water remediation products derived from agricultural crop residues* (LK0875[2]).

The risk management problem at the site is one of wind blow of copper laden dusts from former settlement ponds during dry periods to adjacent housing (see Figure 2). An additional *project service* required is to support the reestablishment of heather vegetation on the settlement ponds. A range of options were considered to provide risk management and support re-vegetation:

1. No intervention
2. Excavation and removal of settlement pond contents and replacement with “clean soil” followed by replanting with heather
3. Containment and cover followed by replanting with heather
4. Stabilisation using lime followed by replanting with heather
5. Stabilisation using modified charcoal from renewable sources followed by replanting with heather

In 2009 an initial qualitative sustainability assessment to support options appraisal was carried out following the then developing SuRF-UK guidance (CL:AIRE 2010). This work has been used to develop a simple conceptual model of sustainability for this paper.

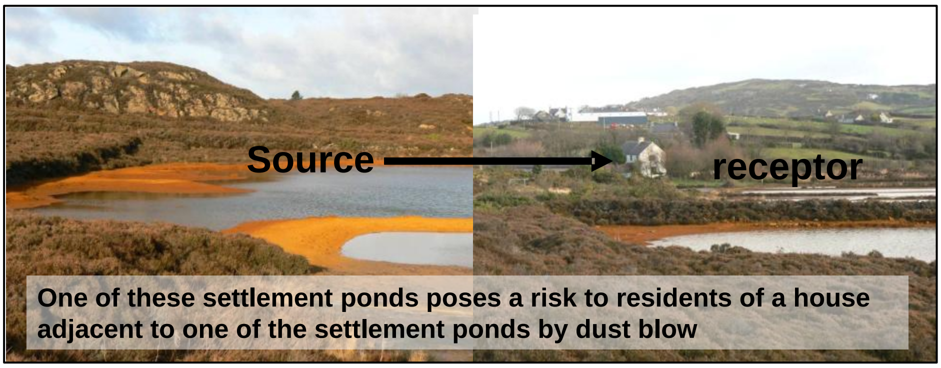

Figure 2: *Risk Management* Site Conceptual Model for the Anglesey site

3 Components of a Conceptual Site Model for Sustainability

3.1 Identifying sustainability linkages

A sustainability linkage is proposed as having three connected components:

- **A source** (pressure or change): this describes a factor that might cause an effect, for example the emission of CO_2 or an increase in road traffic
- **A mechanism**: this describes how harm or benefit might be brought to a particular receptor, for example the emission of PM_{10} particulate matter in road traffic exhaust; or an increase in congestion that causes delay to other road users; or an increased risk of accident from additional vehicle movements
- **A receptor** which is the constituent of economy, environment or society which could be affected by a change / pressure via a mechanism, for example human beings (i.e. society) via PM_{10} particulates or increased risk of accidents; or local economy via costs of road congestion.

If a sustainability linkage exists, whether beneficial or deleterious, then its connections can be described in a relatively precise way, in terms of cause and effect. This facilitates building a conceptual model of sustainability which can show how different linkages are related to each other. The identification of linkages is affected by “boundaries” and “scope”. Boundary setting is a key initial step in sustainability appraisal, once appraisal objectives have been agreed. Typically boundary setting must consider system and life cycle boundaries, as well as considerations of time and distance (Bardos *et al.* 2011.). The boundary conditions used for the Parys Mountain sustainability assessment are shown in Table 1. Scope describes the range of pressures which are being

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2 http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=ProjectList&Completed=0&ContractorID=74

considered. There are a number of sources of check-lists that can be used to identify possible sustainability pressures, or to benchmark stakeholder led suggestions, to ensure suitable breadth. The Anglesey example drew on SuRF-UK guidance (CL:AIRE 2011) which provides detailed advice about a series of overarching categories of sustainable remediation considerations listed in Table 2.

Table 1: Boundaries used for the Parys Mountain sustainability appraisal

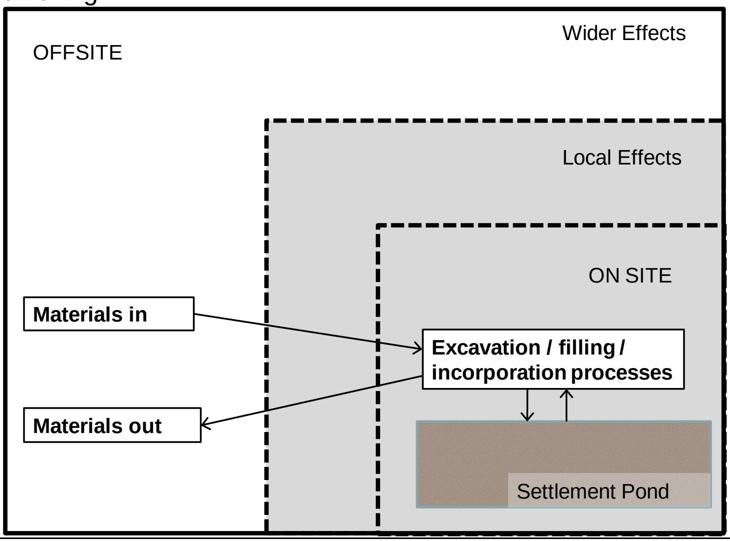
Boundaries- System	Remediation work for the mitigation of human health risks to a residential property adjacent to disused sediment ponds. Movement of all prepared materials to Parys Mountain site, all operations to treat the sediment pond to fully achieve agreed risk management objectives for the remediation. Removal and disposal of all residues.
Boundaries- Life cycle	What is consumed by a process, the effect of operations – such as their emissions, the impacts of depreciation on capital equipment that will be reused and the effects of its maintenance
Boundaries- Proximity	Local effects are those affecting the sediment pond and its adjacent dwelling 
Boundaries- Permanence	Temporary effects are those of duration less than or equal to the remediation project operational period

Table2: Overarching Categories from SuRF-UK (CL:AIRE 2011)

Environment	**Social**	**Economic**
Emissions to Air	Human health & safety	Direct economic costs & benefits
Soil and ground conditions	Ethics & equity	Indirect economic costs & benefits
Groundwater & surface water	Neighbourhoods & locality	Employment & employment capital
Ecology	Communities & community involvement	Induced economic costs & benefits
Natural resources & waste	Uncertainty & evidence	Project lifespan & flexibility

The screening of pressures carried out for Parys Mountain was very simple. Each overarching category was broken down into a series of more explicit considerations. A decision was made on their relevance, and the reason for disregarding any particular factor recorded. It is important to note that the approach taken was one of active exclusion, rather than active inclusion. I.e. the default position was that a pressure was relevant, and therefore to be considered. An explicit reason had to be given for excluding a pressure. This ensures a more rigorous sustainability assessment process, in that factors whose relevance is undecided are still considered.

For each pressure possible pathways and receptors were identified and used to compile a listing of *complete potential* sustainability linkages. 67 *potential* linkages were identified. So while the risk management problem and desired project services were relatively simple, the complicated context of the site, for example its historical and conservation significance, and its consequent importance to different stakeholders meant that its sustainability context was not that simple.

3.2 Significance and thresholds

The precision of using sustainability linkages allows clearer rationales for both the prioritisation of sustainability considerations, and any applicable thresholds. Importance is easier to determine because the receptor, mechanism of effect and pressure causing a sustainability effect are made explicit. A common strategy for determining importance (and also prioritisation) can then be applied across all linkages. This provides a means of identifying *significant* sustainability linkages, i.e. linkages that *ought to be considered in a sustainability assessment and as part of the overall value of a project*. Thresholds are easier to assign because only *significant* linkages need to be considered further, so fewer linkages need be considered, and because a common approach for determining thresholds can be applied. Clearly, for any assessment of importance, priorities and thresholds to gain acceptance across the stakeholders involved in a project, the overall strategy for determining importance and thresholds needs to be agreed in advance. While assessments will likely be highly site / project specific, four guiding principles can be suggested, as follows.

1. The **importance** of a sustainability linkage to providing one or more of the **project services** desired of the project: **Thresholds** can be defined to express minimums required to deliver the project service,
2. The **importance** of a sustainability linkage to **meeting regulatory requirements**: Regulatory requirements may operate at national, regional and local level. **Thresholds** can therefore be related to what is specified in the regulatory requirement.
3. The **importance** of a sustainability linkage to **meeting policy requirements**: These policy requirements may be governmental, set at European, national, regional or local levels, or corporate. **Thresholds** may be related to norms expressed in policy documents, or may need to be agreed in a project specific way related to different policies.
4. The **importance** of a sustainability linkage to **meeting broader stakeholder requirements**: Local issues and particularly strongly held perceptions and views may also be very important developing a more generally acceptable model of sustainability for a site / project. The identification of an unmanageable number of such linkages may be a major fear for stakeholders at the core of a decision. **Thresholds** will be related to desired outcomes. An important wider stakeholder consideration is that some stakeholders may feel that **thresholds** set on the basis of policies, regulations or delivery of project services are not sufficiently stringent and that either additional thresholds are needed.

All of the sustainability linkages identified in (1) to (4) should be regarded as important or *significant.* (It should be noted that some of the sustainability linkage thresholds described above are absolute: those related to regulatory thresholds and project services, which determine whether or not a particular process or project approach is viable).

It is possible that these significant linkages will need to be prioritised, with the delivery of some outcomes being seen as more important than others. Combining sustainability linkages in a general conceptual model enables prioritisation decisions by clarifying possible conflicts, trade-offs and opportunities for synergy. Initial significance assessment, *based on site owner interests*, for Parys Mountain resulted in the identification of 48 *significant* sustainability linkages, so 19 of the initial set of *possible* linkages were not seen as "important". It is possible that a further iteration of sustainability appraisal involving a larger number of stakeholders would identify additional linkages as significant.

3.3 Representation – network diagrams

Developing a conceptual site model based on linkages allows for duplications to be identified and discarded, and a clearer way for combined effects on a particular receptor from several sources to be understood. Using sustainability linkages clarifies which pressures are affecting which receptors and how this effect is occurring. Sustainability linkages can have pressures, mechanisms or receptors in common. A network diagram can exploit this to simplify the representation of sustainability, removing duplications, and showing common features across linkages that can be used for better sustainability assessment and management. The simple rule of thumb is that each pressure, mechanism and receptor is (as far as possible) only shown **once** in the network diagram, and arrows are used to show how they are interconnected by sustainability linkages. Figure 3 shows a network diagram developed for Parys Mountain options appraisal.

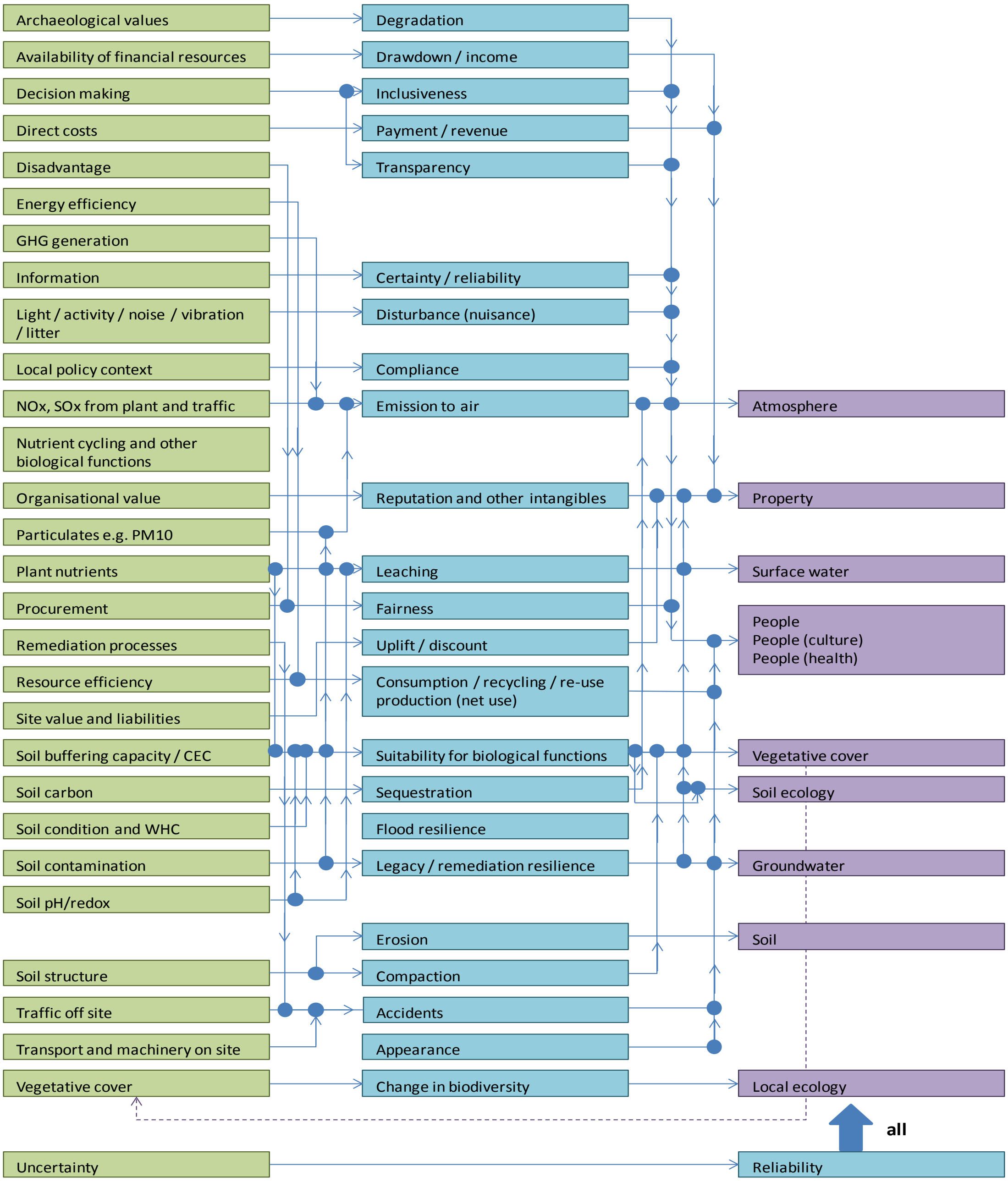


Figure 1: Parys Mountain Conceptual Site Model for Sustainability (Network Diagram)

This diagram was simply constructed by repeatedly sorting the spread sheet of linkages so that common pressures, mechanisms and receptors could be identified in a preliminary assessment. Any conceptual model will likely develop iteratively along the phases of decision making and project implementation.

3.4 Providing a framework to determine overall value

A draft valuation approach for brownfield regeneration into soft re-use has been developed. The approach considers services and sustainability provided by regeneration options as overarching principles for value creation. Motivation for investment in a project will depend on “project services”, such as managing risks, meeting an area planning policy requirement or biomass energy. However, determining overall value requires an understanding of wider project effects. The value of a project will mean different things to different groups of stakeholders. However, *overall value* is most likely to have three components factors: (1) direct financial returns (costs vs. financial benefits); (2) wider effects which are nonetheless economically tangible (such as improving local property values, or impacts such as impacts on infrastructure); and (3) wider effects which cannot be readily monetised - intangibles (such as effects on a landscape, or community acceptance) – which nonetheless affect the value of a project's "goodwill". Goodwill can have an important bearing on project implementation and outcome, for example in terms of how easily it can meet planning requirements and how attractive it is for use; as well as having significant commercial and organisational importance, for example via reputational risks and benefits.

4 Applications of sustainability conceptual site models

There are several stages in the emergence and realisation of a Brownfields regeneration project. There is a period of initial design work which includes the first scoping of the opportunities of what might make a viable project and consequent setting of aims. These aims lead to options for further consideration and evaluation, typically with a range of stakeholders. Decisions are then made on a final project configuration, which is then implemented. Aftercare encompasses the ongoing maintenance of the restored site and verification that the project outcomes meet the project aims.

4.1 Initial design work

HOMBRE describes a *project service* as a benefit that a project is designed to provide, e.g. manage risks or grow biomass. Any proposal for a Brownfields regeneration project will include a one or more possible *project services* that together add value and make the initial case for investment. Project services contribute to sustainability, but do not necessarily encompass all of the sustainability benefits and impacts of a project. Figure 4 summarises the link between project services and wider sustainability effects at Parys Mountain. In the Parys mountain example the project services required were: risk management for the householders' exposure and revegetation with heather, while the .conceptual model of sustainability for the site (Figure 3) shows a wider range of potential effects on various receptors (atmosphere, water, property, people, soil and ecology).

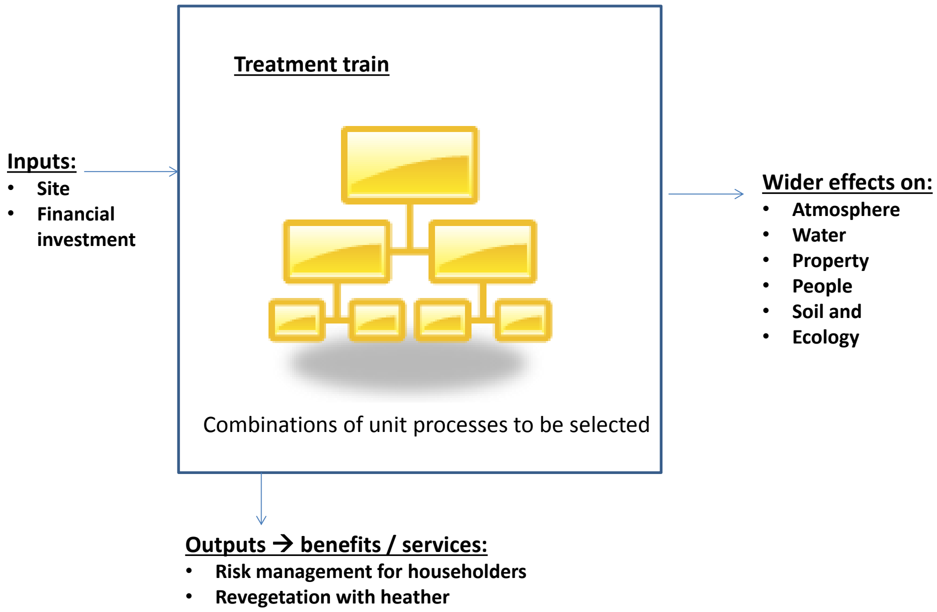


Figure 4: Services and Wider Effects for the Parys Mountain Initial Assessment: a conceptual service model

Regeneration is a process of transforming a site from a starting condition to a regenerated state. A regeneration project is carried out to *change* sustainability linkages in a project, mitigating negative effects and seeking opportunities for positive effects. The transformation process will include a variety of processes, which will carry their own wider effects, modifying or adding sustainability linkages. HOMBRE emphasises the importance of thorough project scoping and design. Design should identify opportunities for additional project services and synergies between services, as well as deal with possible trade-offs to ***increase the overall value of the project***. A structured conceptual model increases the chances of identifying these opportunities. Synergies and trade-offs can be explicitly addressed in terms of their impacts on sustainability linkages. Synergies imply an improvement that can be described across several sustainability linkages. A trade-off implies that there is a beneficial effect on one linkage, which may be offset by an undesirable effect via another linkage. Hence the use of sustainability linkages, and relating them to project services, provides a transparent basis for understanding trade-offs, synergies and, indeed, avoiding net losses, as well as priority and threshold setting. This process of "optioneering" allows the development of a range of feasible design options including different combinations of services, which than can be taken forward for more detailed evaluation and consideration.

The application of sustainability linkages in a conceptual model therefore supports designing in increased overall value for a project in three ways. (1) Its use during optioneering in the design stage maximises the likelihood of finding feasible opportunities for adding value through additional services and improving the balance of wider effects. The conceptual model identifies both the project services which are the value drivers that can motivate financial investment in a project, and also the wider effects which may improve or reduce value, depending on effect and circumstance. (2) The sustainability linkages provide a framework for better understanding overall value, as individual linkages can be assigned to different components of overall value. Individual sustainability linkages may be related to *just one of the following:* direct financial performance, an economically tangible wider effect, or an intangible effect. This provides a rationale for an evaluation approach that might be acceptable to a broad range of stakeholders. (3) Identifying the non-financial investments a project may need to succeed, for example, related to in-kind support provided by other services, such as access to the restored site; or contributions from community involvement and acceptance.

4.2 Decision making: sustainability assessment for options appraisal involving stakeholders

The conceptual site model for sustainability will change over time as better information becomes available and activities take place. The design process, particularly for combined approaches for soft end uses, incorporates sustainability considerations, and stakeholder dialogue. However, its interim or final outputs will need a process of evaluation to ensure that any choices between alternatives maximise overall value. The conceptual model directly provides a framework for this detailed sustainability or cost-benefit assessment. It is possible also that combined approaches will be compared against a "no intervention" strategy, to ensure that there is a general overarching set of benefits. In the Parys Mountain example, in addition to several key regulatory and service thresholds the no intervention strategy did turn out to be the least sustainable approach based on a simple qualitative sustainability assessment carried out by the service provider.

4.3 Implementation and maintenance including monitoring and verification

There are three ways in which a conceptual site model for sustainability can assist implementation:

- Identification of good management practices to improve benefits and reduce negative impacts during the project implementation process;
- Providing a rationale for verification of sustainability
- Identifying mitigating actions or maintenance requirements if project services or sustainability outcomes are not met.

The site conceptual sustainability model can provide a clear rationale for maximising the effectiveness of monitoring and verifying "sustainability" as a project is implemented, and targeting any consequent maintenance requirements. It can provide a means of showing how monitoring the narrowest range of verification indicators can provide the greatest benefit in terms of sustainability linkages covered. The means of achieving this is by focusing monitoring mechanisms and receptors, and selecting indicators on this basis.

An example of this from Parys Mountain is shown in Figure 2. In this example a single mechanism "suitability for biological functions" mediates a number of pressures for a particular receptor the required vegetative cover by heather. In this situation the easiest component of the sustainability linkage to monitor is the receptor rather than the mechanism, i.e. the growth of the heather. Hence the simple monitoring of heather cover provides reassurance that a wide range of sustainability linkages are being managed "correctly" and their contribution to the *overall value* of the project is being achieved.

If monitoring indicates that the expected project services / sustainability outcomes are not being delivered (i.e. verification is not achieved), then reviewing mechanisms and, where necessary, the pressures that they link to provides a means of rigorously identifying where project failures have taken place and some form of intervention (mitigation) is necessary. The benefit of the use of the sustainability conceptual model is that it targets effort and so reduces the cost of investigating verification failures and project maintenance.

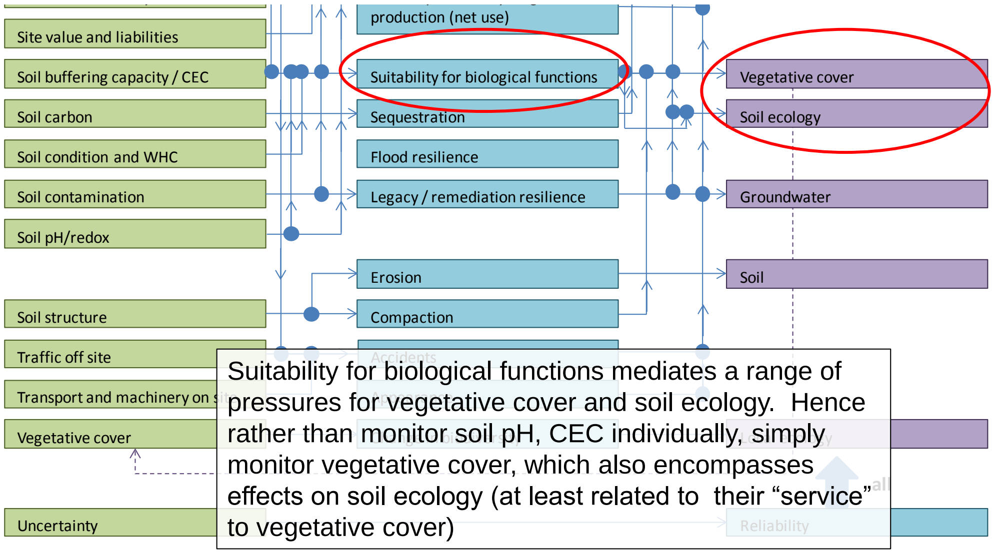


Figure 2: Using a Site Conceptual Model of Sustainability to Determine Verification Needs

5 Concluding remarks

An iterative approach to developing project services and sustainability allows design to be improved. The conceptual model facilitates this by i) identifying opportunities for project services that directly support investment decisions (including mitigation of potential costs); ii) considering trade-offs and synergies between different project services and their wider effects; iii) identifying opportunities for good management practice and policies that improve the overall performance of a project (for example related to operating hours, noise etc)[3]; and iv) facilitating dialogue with stakeholders.

The benefits of a site conceptual model for sustainability appraisal are:

1. A diagrammatic approach provides clarity, documenting and illustrating sustainability objectives (project services), boundaries, scope of "sustainability", how uncertainties such as differences in stakeholder opinions will be considered, and reporting.
2. Making the model (i.e. in particular the network diagram) eliminates duplications in sustainability considerations because the diagram does not multiply connections between pressures, mechanisms and receptors.
3. Integration is possible with risk management contaminant linkages
4. The model avoids the consideration of irrelevant possible pressures on sustainability because only pressures that are linked via a mechanism to a receptor qualify. A network diagram also clearly shows where a particular pressure has multiple sustainability effects via different mechanisms and receptors;
5. Simplification of the sustainability assessment: assessment criteria / indicators can be limited to the common pressures identified in the network diagram as these are representative of all sustainability linkages.

[3] SuRF-UK is developing guidance on good management practices for supporting sustainable remediation over 2012-13

6. Providing a rationale for thresholds that are clearly described and linked to both sustainability and project services, and hence to the overall value of the project.
7. The conceptual model provides a framework for how qualitative and quantitative information can be combined to provide an overall representation of sustainability at a site; and as it develops through iterations identifying which linkages are most in need of and capable of quantitative evaluation (a tiered approach).
8. Transparency and reporting and the ability to review different contexts, for example considerations of time or distance may be of particular interest to some stakeholders. Some sustainability linkages may be related to local effects, and some may be related to temporary effects

The acceptability of the assessment approach will be critically dependent on an appropriate level of stakeholder engagement, to ensure that all key parties can be confident that decision making is transparent, and that rationales are clearly discussed (even if not all stakeholders agree with particular outcomes).

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