A handbook on environmental impact assessment
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Appendix 4: Assessment of Impacts on Soils

Background

1. Soils occupy a unique position in earth heritage environmental assessment, because although explicitly listed as an environmental factor in the EIA Directive and Regulations, they are not explicitly and routinely covered by any of the existing designated area legislations in Britain. These designations are often used as the basis for assessing threats to biological, geological and geomorphological interests. The Geological Conservation Review (GCR) produced by the UK's Joint Nature Conservation Committee has identified those sites of national and international importance needed to show all the key scientific elements of the geological and geomorphological features of Britain. This includes a range of paleosoil and active geomorphological sites associated with specific soil types (machairs and coastal dunes systems, regoliths soils, alluvial soil along river system) (see Appendix 3: Geodiversity (Earth Heritage) Impact Assessment). The first site notified on the basis of its current soils cover was a Regionally Important Geological and geomorphological Site (RIGS) in Anglesey, Wales in 2004, and further discussion for the development of a network of soils sites across the UK, based on the RIGS (Regionally Important Geological and Geomorphological Sites) approach started in 2012 by the British Society of Soil Science. At present no site has been identified in Scotland where they are also referred as local geodiversity sites[1].

2. Because soils do not fit neatly into this site-based framework, they can be overlooked in EIA. The position of soils at the interface between the geosphere, biosphere and hydrosphere further compounds this, as they cannot be easily compartmentalised. They also play an important part in biodiversity conservation so, it is vitally important that soils information is included as an integral part of the EIA process, as changes to soils can have subsequent effects on other parts of ecosystems, such as vegetation, freshwater and coastal habitats condition and composition. Also key to natural heritage interests is the intrinsic value of the soil resource in its own right and its functional roles in the context of changing climate (e.g. as a carbon repository and source of greenhouse gases). The role of soils in delivering ecosystems services and environmental goods is now widely acknowledged (http://www.hutton.ac.uk/research/themes/safeguarding-natural-capital/soilshutton).

3. The Scottish Soil Framework (SSF), published in 2009, provides links to the body of policy and guidance in place in Scotland providing some direct or indirect protection of soils in wider countryside. The principal aim of the SSF is to "[promote the sustainable management and protection of soils consistent with the economic, social and environmental needs of Scotland". Following on the SSF recommendations, a comprehensive State of Scotland's Soil Report was published in 2011. It, among other things, sets out the drivers and pressures that affect the state of the soil and highlights seven threats to soil functions including contamination, erosion and landslides and compaction. The SSF also lead to the creation of Scotland's soils website part of Scotland Environment website (http://soils.environment.gov.scot/) to provide access to data and information about the soils of Scotland and the development of the soil monitoring action plan for Scotland (http://soils.environment.gov.scot/soils-in-scotland/soil-monitoring/).

Importance of Soil Considerations in Environmental Impact Assessment

4. Soil considerations (for example impacts on organic matter, erosion, compaction, sealing) are an essential element of the EIA process and any significant impacts on soils (properties and functionality) should be included in an Environmental Statement.

5. Annex IV of Directive 2014/52/EU (the EIA Directive), requires that an Environmental impact Assessment Report (EIAR) must include a description of the project, including a description of the main characteristics of the operation phase of the project such as the nature and quantity of materials and natural resources used, including soils. Similarly, the description should also provide an estimate of expected residues and

[1] www.geoconservationuk.org.uk/

emissions such as soil and subsoil pollution. The EIAR must consider aspects of the environment likely to be significantly affected by the development, including, soil (for example organic matter, erosion, compaction, sealing). It also required a description of the likely significant environmental effects of the project resulting from inter alia, the use of natural resources, in particular land, soil, water and biodiversity.

6. Where significant adverse effects are identified, the Environmental Statement must include a description of mitigation measures.

7. Thus, soils can and should be included in an Environmental Statement and throughout the EIA process wherever the effects of a proposal are likely to be significant. Where they are not included the competent authority should require the developer to submit the appropriate level of soil information, commensurate with the scale and type of development and its impact, before they grant any consent for the project.

8. In absence of specific regulation for soil protection in European and UK law the ways in which soils information is included in Environmental Statements are flexible, and influenced through various forms of guidance and advice issued by the Government and others. For example, some sectors of activities are covered by extensive soil guidelines (e.g. UK Forestry Standard and its associated suite of Guidelines (such as the Forests & Soil Guidelines and Forests & Water Guidelines), GAEC cross compliance, pollution control GBR rules).

9. Although there is no one-size-fits-all soil protection policy for Scotland, there is a range of policies and legislation that gives some additional protection to some aspects of soil and influences how our soils are managed[2]. For example soil is specifically mentioned in to relation t to the application of sewage sludge on agricultural land regulation, principally on the basis of soil acidity and toxic metal concentrations in sludge and the receiving soil. Consideration for soil as a carbon repository is also integral many policy and regulations relevant to activities on Scotland's peatland. The National Planning Framework recognises Scotland's carbon rich soil as a key asset to protect. Areas of carbon rich sol, deep peat and priority peatland habitats are recognised in the setting of windfarm strategic planning. The National Peatland Plan (2014) also enhances the protection of Scotland peatlands soils and promotes action towards restoring this unique resource. The value of certain soil type and soil functionality as natural heritage features of national importance is considered by SNH when considering the impact of development proposals. (Soils of National Conservation Importance in Scotland, http://www.snh.gov.uk/docs/A465864.pdf).

Soil Functions

10. For assessment purposes, soils can be considered to have following general functions (see State of soil, 2011[3])
- growing food and trees.
- filtering water.
- controlling the rate at which rain water reaches watercourses.
- storing carbon and exchanging greenhouse gases with the air.
- supporting valuable habitats, plants and animals.
- preserving cultural and archaeological heritage.
- providing raw materials.
- providing a platform for building on.

11. These functions can be linked to the concept of ecosystem goods and services and natural capital which is underpinned by the principle that human life depends on natural resources and that nature contributes to the fulfilment of human needs. Hence soil functions may be valued in terms of social, economic or ecological forms of land use and management.

Soil Heterogeneity

12. Different soil types have their own characteristic properties, which affect the significance and magnitude of

[2] http://soils.environment.gov.scot/resources/soil-protection/
[3] http://www.sepa.org.uk/media/138741/state-of-soil-report-final.pdf

impacts and their ability to resist and adapt to threats. Some soils are relatively resistant (i.e. how much disturbance they can sustain before responding to change) and resilient (magnitude and persistence of change) and are able to support a wide range of potential applications, whereas others can only be utilised in more limited ways. Soil types and properties can change over short distances, and it is common to find a variety of soils on sites earmarked for development, often leading to some soils being exploited in ways for which their properties are unsuited. Further complexities are introduced by the fact that, unlike geological exposures or landforms, which occupy distinct areas of the landscape and are generally fairly easy to assess, soils form a continuous pattern over the land surface and are for the most part hidden from view. All of these factors combine to create very specific requirements for EIA of soils.

Source of Information

See Sections C.4, C.5 and C.6 of the Handbook

13. In order for informed decisions to be made, an adequate source of soil data and the ability to interpret changes in soil properties that may arise as a result of development impacts are a necessity.. The new Scotland soil website (SSW) has become a hub for soil information in Scotland.

14. It links to the work of the Scottish soil monitoring Action Plan which provides details of key policies, legislation and guidance (http://soils.environment.gov.scot/resources/soil-protection/) which may require soil information as part of their development and implementation and link to possible source of soil information as used in various monitoring activities in Scotland (http://soils.environment.gov.scot/soils-in-scotland/soil-monitoring/) .

15. SSW also provides access to soil and soil derived maps, spatial data and their interpretation (http://soils.environment.gov.scot/maps/), The information is mostly provided as coarse scale (1:250,000 scale to 1:25,000), it include three main types of soil maps available on this website as well as point data relating to specific locations where soils have been sampled and analysed for a range of properties.
    - Soil maps show the distribution of soils across the land.
    - Capability maps classify land based on the potential for what it could grow and how well it could grow it. These take into account soils, climate and landscape.
    - Thematic maps show the distribution of a specific soil property such as soil organic matter content.
    - Point data are data that relate to soils at a specific location (from national scale survey).

16. The website is maintained and developed as part of Scotland's Environment web access and updated to include new soil information as it become available.

17. On a more local scale, existing spatial soil data tend to be patchy and of variable quality through being obtained by a range of methods. Moreover they are often difficult to consult, often being unpublished and held by a number of different organisations and individuals. Some local authorities (e.g. West Lothian, Angus) have produced geodiversity and soil audits which do provide additional information on soil state and pressures.

18. There is, however, a particular scarcity of data in urban and peri-urban areas (with the exception of Glasgow conurbation BGS urban survey), as soil surveys have traditionally been carried out almost solely for agricultural or forestry purposes. As most environmental assessments are made at the more site specific level, it is essential that the authorities involved seek appropriate professional advice where it is evident that soil factors will be integral to the assessment. The scoping stage is of particular importance here, as the time to consider the effects on soils is at an early stage.

19. The ability to interpret routine soil measurement is constrained by our understanding of the complexity of soil processes. Standard operational protocols for the measurement and interpretation of soil state and change are only available for a limited number of soil pressures and functions, such as soil nutrient requirement for biomass production, physical soil properties for soil engineering assessment, and chemical loading for pollution control. Agreed standards are more variable in other fields such as soil biodiversity assessment or interpretation of impacts on natural and semi-natural soils and habitats. The state of understanding, however, is improving through the development of strong research drivers to support establishment of national and European soil protection frameworks.

References

20. Useful sources of soil information for EIA have been collated under Scotland's soil website (part of Scotland Environment web) - http://soils.environment.gov.scot/ including;

- Visualisation and download information for a range of soil maps and soil data
    - Soil maps show the distribution of soils across the land. Soil maps were originally produced by field surveyors who walked over the landscape, looking at the soils and other features such as vegetation, and drew boundaries between different soil types. Mapping methods have evolved over time, and now make use of techniques such as aerial photography and satellite-based Global Positioning Systems (GPS).
    - Capability maps classify land based on the potential for what it could grow and how well it could grow it. These take into account soils, climate and landscape. Capability maps are available for both agriculture and forestry.
    - Thematic maps show the distribution of a specific soil property such as soil organic matter content.
    - Point data are data that relate to soils at a specific location. At these points, soils have been described, sampled and later analysed for a range of properties. The point data maps show where the soils were sampled and selected properties of interest.

- Information about other sources of soil data under the soil monitoring section http://soils.environment.gov.scot/soils-in-scotland/soil-monitoring/

- Resources for land managers and developers (http://soils.environment.gov.scot/resources/land-managers-planners-and-developers/) also provide
    - Links to supporting guidance relevant to soil in development management and EIA
    - Information on tool kits / soil surveying and how to develop skill set / seek expert advice

Predicting Soil Impacts: Projects Likely to Give Rise to Impacts on Soils

See Sections C.4, C.7 and C.8 of the Handbook

21. The most extreme impact on soils is a total coverage of soil (so-called burial or sealing) by an impermeable surface, which may or may not be associated with a physical removal of topsoil and subsoil. Soil sealing is often considered as irreversible as any remediation and restoration efforts to return a soil to its previous condition and functionalities will be beyond reasonable mind. Where activities take place on carbon rich (peat and peaty)soil, any loss or disturbance of surface horizon will also lead to irreversible loss of soil carbon by exposing the threat of carbon oxidation or erosion. Oxidation of disturbed peat soil will contribute to increase pool of atmospheric greenhouse gases whereas dissolved and particulates carbon loss form soil erosion and runoff will impact on water and biodiversity quality. (

22. More often, project developments likely to give rise to impacts on soils in EIA will only partly modify the soil. Changes can be directly relevant to the functional capacity, sensitivity, vulnerability and general condition of soils. The range of type of projects likely to give rise to impacts on soils may include but not be limited the following:

- urban planning and infrastructure development (included housing, SUDS, transport and power supply infrastructure, footpath development);
- other developments such as landfill, sewage works, hazardous installations and industrial developments;
- activities associated with the reclamation of contaminated and derelict land prior to development;
- land stabilisation (not associated with site preparation phase in development control) (e.g. soft and hard engineering for road networks, and river and coastal management and realignment);
- land drainage for improving land productivity or access to land;
- mineral, gravel, sediment and peat extractions ;
- archaeological, geological or soil excavations;
- land and habitat creation, restoration and enhancement;
- recreation (e.g. footpaths, sports facilities, park and greenfield);
- land use changes associated with forestry;
- land use changes associated with agriculture (including energy crops).

23. Some of these activities may not be subject to EIA depending on size of application or specific context. For detail in the Interpretation of definitions of certain project categories of annex I and II of the EIA Directive (http://ec.europa.eu/environment/eia/pdf/cover_2015_en.pdf)

24. Some of the main project types likely to give rise to impacts on soils in EIA on how it impacts on-site and off-sites on soil and the wider environment is illustrated in Figure 1 below.

Predicting Soil Impacts: Impacts on Soils

See Sections C.4, C.7 and C.8 of the Handbook

25. The impacts of these projects on soil properties and soil processes are complex and may include amongst others:

- increased sensitivity to soil erosion. This may lead to direct loss of the soil resource itself, loss soil nutrients and potential mobilisation of inherent soil contaminants. Soil erosion is often associated with significant off-site impacts (water quality, silting/ sedimentation of water reservoirs, landslides).
- changes to soil water regime. In organic soils, drying up of peat will lead to oxidation of organic matter and increase erosion. Increased runoff and leaching may also contribute to greater off-site pollution and loss of soil nutrients.
- changes in pH (acidification or alkalinisation). This will impact on soil biodiversity and many of the soil bio-chemical processes (nutrient and carbon turnover, pollution degradation).
- alteration of soil physical properties, including soil compaction and structural deterioration from heavy machinery, trampling and handling of soil.
- increase in soil pollution loading, e.g. from heavy metals, organic compounds, industrial wastes, fertilisers and pesticides.
- decline in soil fertility, e.g. removal of soil nutrients or decline in nutrient input sources.
- loss of or change in biodiversity (both above ground vegetation and soil biodiversity), e.g. soil macrofauna, fungi and microbial communities. This may also include contamination by invasive species.
- loss of organic matter. This may lead to increased dissolved organic carbon (DOC) in watercourses and increased emission of greenhouse gases.
- homogenisation and loss of characteristic horizons, e.g. during stripping and storage of topsoil and subsoil in planning development.
- damage to soil historical and archaeological value, including destruction or modification of palaeosoils and other buried archaeological artefacts, imprints of past land use and land practices and environmental markers (e.g. past climatic records from pollen sequences in peat and rig and furrow systems).
- other direct impacts on geodiversity features, including removal or alteration of parent material., especially when associated with dynamic systems (coastal and fluvial geomorphology)
- loss or sealing (burial) of soil.
- loss of soil water buffer and storage capacity relevant to control of water supply and flood control.

26. Figure 1 below summarises the main pressures on soils and examples of the various types of on-site and off-site impacts they may cause.

Soil Properties and Functions: Mitigating Measures

See Section C.9 of the Handbook

27. In relation to soil properties and functions it is essential to remember that soils are a non-renewable resources at a human time-scale. At the outset, a fundamental principle should be to avoid or at least significantly limit the severity of impact before considering mitigation measures rather than seeking any potential trade-off of soil values.

28. In assessing soil mitigation measures, consideration should be given to the following:

(a) By contrast with mitigation measures for other aspects of the environment, a significant impact on a specific soil function or properties may be mitigated through the adaptation of other soil functions and soil properties (e.g. loss of basis for biomass production trade against increase support to habitats). This, however, can only be justified in cases where the restoration or remediation of a soil function and soil properties to their

pre-existing conditions is not possible within reasonable operational standards according to current good practice and state of knowledge. None of the above should be equated as a trade-off and must always be supported by monitorable evidence of the overall benefit of the selected measures on the soil functionality and its interaction with associated biodiversity and geodiversity.

(b) Soil mitigation measures cannot be designed to address aspects of climate change unless the impacts on a soil are likely to lead to significant reduction of its resilience and resistance to climatic factors or lead to potentially increased emission of greenhouse gases. Where this is the case, the mitigation measures must provide appropriate options to account for these longer term impacts.

(c) Most mitigation measures aiming to create or restore soil properties and soil functions will not immediately deliver fully functional soils. They will only initiate a direction of change towards a new or improved soil state. It is therefore important for the applicant to demonstrate the effectiveness of the whole mitigation process, not just the initiation of the process or the success of interim stages.

29. By matching as far as possible particular developments with appropriate soils, the consequences of many of these impacts can be minimised. In this context, EIA involves the consideration of key soil properties and characteristics in relation to the proposed development or change of land use. Mitigation measures should consider how important soil properties these properties are to maintain the function soils considering;

(a) The soil physical characteristics of the whole profile including
- Soil texture
- Soil structure
- Soil horizonation (i.e. nature and arrangement of individual horizons)
- depth – both total and of individual horizons
- soil stoniness

(b) The soil chemistry surface and sub soil including
- organic matter content
- soil pH
- nutrient status
- salinity parent material characteristics
- soil water regime – vertical drainage and runoff characteristics
- vegetation cover, especially peat forming communities
- slope gradient

(c) and soil biological indicators (when appropriate)

30. The mitigation measures should consider how the above properties, either separately or when relevant in combination, may act as limiting factors to any desirable soil functionality.

31. Appendix 4 Figure 1

Examples of Pressures and their Impacts on Soils

Pressure	On-site impacts	Off-site impacts
Reclamation of contaminated land	Disposal of contaminants. Changes in chemistry. Lack of suitable quality soil.	Leakage of contaminants to watercourses.
Location of developments	Soil and carbon loss; contamination; structural damage; changes to soil water regime; disposal of wastes; effects on soil biota.	Leakage of contaminants to watercourses. Groundwater contamination. Effects of waste products on vegetation.
Urban and infrastructure development	Soil loss or burial (sealing); contamination; structural damage.	Ground and surface water contamination.
Land instability	Shrinkage/swelling of clays; compaction; erosion.	Movement of soil off-site, landslide.
Land stabilisation (river and coastal protection)	Nutrient flushed from newly flooded areas, soil water change, salinization.	Reduced sediment yield, leading to erosion elsewhere, leaching of soil contaminant to water course.

Land drainage	Oxidation of organic matter; physical damage; soil water changes; effects on pH.	Sedimentation of water courses. Changes to water chemistry.
Mineral extraction	Loss of soil; physical damage; effects on biota; contamination; soil stripping and storage.	Contamination of water courses. Changes to sediment load.
Archaeological and other soil excavations	Damage to palaeosols, soil palaeoenvironment records.	Compound loss of historical landscape features
Land restoration	Problems associated with reinstatement of previous soil conditions, suitability of soil properties to support restored habitats.	Changes to water chemistry.
Recreation	Erosion; compaction; loss of organic matter.	
Forestry	Erosion; changes to pH; changes to horizons; changes to soil water; effects on soil biota.	Increased sediment yield. Pollution of surface water. Changes to run-off. Changes in water chemistry.
Agriculture	Loss of organic matter; erosion; changes to nutrient status; compaction; structural damage; effects on biodiversity; pH changes; homogenisation.	Pollution of groundwater. Pollution of surface water. Increased sediment yield.