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Providing support in relation to the implementation of the EU Soil Thematic Strategy

Policy brief

"Soil quality in spatial planning"

including background sections

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Providing support in relation to the implementation of the EU Soil Thematic Strategy is a three-year contract commissioned by the Directorate-General (DG) for Environment (ENV) of the European Commission (Service contract No 07.0201/2016/742739/SER/ENV.D.I, duration 6 Dec 2016 - 5 Dec 2019). The overall objective is to support DG ENV with technical, scientific and socio-economic aspects of soil protection and sustainable land use, in the context of the implementation of the non-legislative pillars (awareness raising, research, integration) of the Soil Thematic Strategy and the implementation of the European Soil Partnership. The support includes the production of six in-depth reports providing scientific background on a range of soil and soil-policy related issues in Europe, three policy briefs, logistic and organisational support for six workshops, and the organisation and provision of content to the European website and the wiki platform on soil-related policy instruments. The work is performed by: Deltares, The Netherlands (coordinator); IUNG Institute of Soil Science and Plant Cultivation, Poland; UFZ- Helmholtz Centre for environmental research Germany; IAMZ - Mediterranean Agronomic Institute of Zaragoza, Spain; CSIC-EEAD Spanish National Research Council - Estación Experimental de Aula Dei, Spain. This deliverable is a policy brief "Soil quality in spatial planning", supplemented with background sections (Deliverable 1.6).

Document Information

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Content

1 Why considering soil quality in spatial planning

Soil quality is an account of the soil's ability to provide ecosystem and social services through its capacities to perform its functions under changing conditions[1]. Traditional spatial planning does not consider soil quality sufficiently. Land and soil are finite resources facing growing pressures and conflicts over their use. Land use planning and soil management should balance the supply of ecosystem services with society's demands.

Figure 1.1: production function of soil

Soils play an important role in both urban and rural areas. By taking its' characteristics consciously into account in spatial planning on different scales, the benefits can be optimized. For example, saving the most fertile soils for agricultural use and avoiding urban sprawl on these soils contributes to food security. On a smaller scale, soils in urban areas can be used for climate adaptation. By maximizing the presence of green infrastructure and limiting sealing, rainwater can be buffered by soils avoiding costs for the over-dimension of sewer systems and for damage as a result of flooding. Using soil quality as a planning parameter for industrial or urban land can stimulate reuse of urban or brownfield land instead of using greenfields and contributes to zero land take objectives. In section 2 and background section 5.5, a broad range of examples throughout Europe and their benefits are elaborated.

Urban and rural spatial planning and management should safeguard multi-functional and healthy soils - locally and globally to maintain natural capital while satisfying the needs of a prosperous society.

[1] Tóth, G., V. Stolbovoy, et al. (2007). Soil Quality and Sustainability Evaluation – An integrated approach to support soil related policies in the European Union. Luxembourg, Office for Official Publications of the European Communities.

To understand the relation between soil and land management (including spatial planning), the INSPIRATION[2] conceptual model can be used (figure 1.2). The conceptual model considers land and the soil-sediment-water (SSW) system as goods and natural capital stocks that have to be used (**Demand**) in a way that maximizes non-depletion of our ecosystems (**Natural Capital**). There are conflicting interests regarding land use among societal stakeholders, such as farmers, spatial planners, developers, manufacturing industry and residents. For instance, regarding the productivity of areas and/or protecting natural resources. Sustainable **land management** must seek to balance the demand and the supply, with the latter being based on the resources provided by our natural capital. As an integral part of such a sustainable soil management model, the **net impact**, meaning the local to global footprint of human land management decisions, must be assessed and minimised[3].

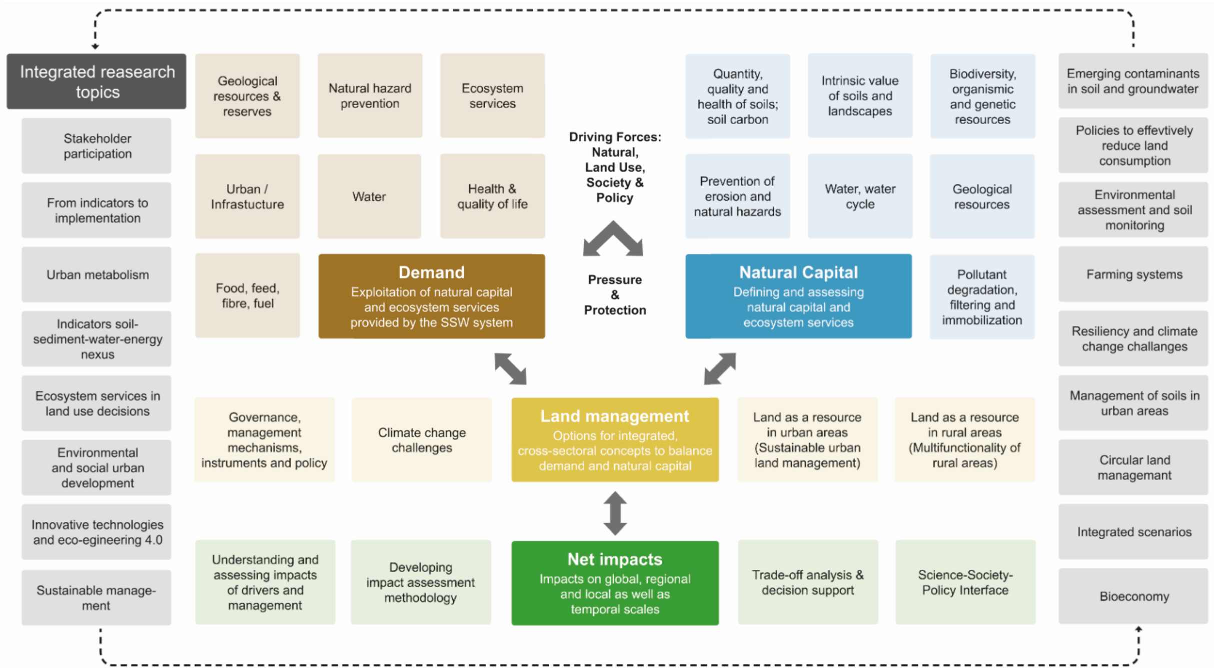

Figure 1.2: INSPIRATION conceptual model including research topics[4]

The INSPIRATION Strategic Research Agenda addresses several research needs (figure 1.3) related to spatial planning considering soil quality. The research questions aim at getting more insight on value of ecosystem services in land use decisions (IRT-2), finding land use scenarios contributing to societal challenges (IRT-5), "better" urban and brownfield planning (IRT-11, IRT-12, IRT-8) and spatial planning as an instrument for coping with effects of climate change (IRT17, LM2) (the codes behind the topics refer to the full research questions in background section 5.6).

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[2] The Horizon2020 project INSPIRATION was a coordination and support action funded by the European Commission in order to develop a Strategic Research Agenda (SRA) for Europe on soil, land use and land management. It ended in February 2018.

[3] Bartke, S., et al. 2018. Soil and land use research in Europe: Lessons learned from INSPIRATION bottom-up strategic research agenda setting. In: Science of the total Environment, 622, 1408-1416.

[4] Makeschin, F., Schröter-Schlaack, C., Glante, F., Zeyer, J., Gorgon, J., Ferber, U., Villeneuve, J., Grimski, D., Bartke, S., 2016. INSPIRATION Report Concluding 2nd Project Phase: Enriched, Updated and Prioritised Overview of the Transnational Shared State-of-the-art as Input to Develop a Strategic Research Agenda and for a Matchmaking Process. Public version of the Final Version as of 30.10.2016 of Deliverable D3.4 of the HORIZON 2020 Project INSPIRATION. EC Grant agreement no: 642372. UBA, Dessau-Roßlau, Germany., http://www.inspiration-h2020.eu/sites/default/files/upload/images/conceptual-model-dec2015_0.jpg

Soils as a robust basis under the UN Sustainable Development Goals

The "Sustainable Development Goals (SDGs)" of the United Nations[5] are internationally agreed goals. A substantial amount of these sustainability goals depends on the ecosystem services provided by resilient and healthy soils. Using the most fertile soils for agriculture and avoid land take, contributes to goal 2 “End hunger, achieve food security and improved nutrition and promote sustainable agriculture”. Goal 11, “Make cities and human settlements inclusive, safe, resilient and sustainable”, depends on taking soil quality into account in urban planning. Spatial planning can be used as a tool to match demands and potential supply of soil energy (e.g. Aquifer Thermal Energy Storage ATES) and to adapt and mitigate climate change. This contributes to goal 7 “Ensure access to affordable, reliable, sustainable and modern energy” and goal 13 “Take urgent action to combat climate change and its impacts”. At the same time, goal 15 “Life on Land” focuses on combating and avoiding land and soil degradation. For long term sustainable use of the soil and avoiding soil degradation, balanced decisions need to be made. Considering soil quality, by matching demand and supply, and the soil’s constraints and boundary conditions in spatial planning, is therefore essential.

Figure 1.3: the Sustainable Development Goals

[5] https://sustainabledevelopment.un.org/

What do we mean with spatial planning taking into account soil quality

Many comparisons between spatial planning systems in European countries were made[6] and they differ a lot. Planning systems are typically driven by national policies while the detailed land use decisions are implemented at a local level. Local decision making and local plans are thus important[7]. The planning system can be described as follows (figure 1.4).

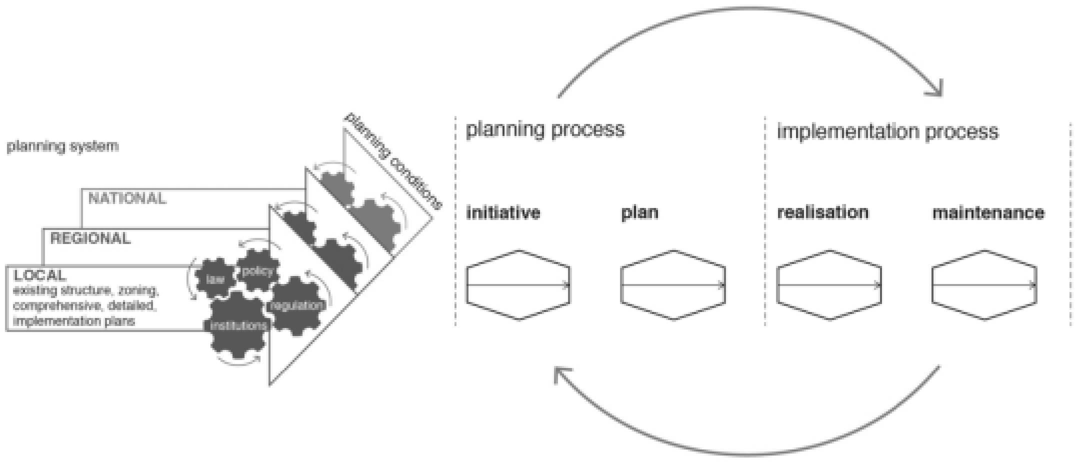

Figure 1.4: overview of planning system, planning and implementation process[8]

It shows how the planning system is a process in which law, regulations, policy and institutions work together on different scales. They influence each other and set the planning conditions. The initiative and plan phase are part of the plan process, the realization and maintenance phases of the implementation process. In the plan phase, it is important for soil experts interact as soon as possible with the planners to ensure timely input of soil quality to the planning process. The planning process is never linear, as it consists of a series of iterations where several exchanges on environmental topics (as soil) are needed (figure 1.5). It is also important to realize that planning processes take place on different scales, from a regional scale (master plans, zoning plans) to project level (project master plans, permitting). The information required and the role of the soil experts will be different in those phases and on different scale levels.

The Balance4P project conducted an inventory of policies and regulations for soil and subsurface to find out what aspects of soil are mandatory to take into account during the planning process and which are optional. In the three studied countries (Netherlands, Belgium (Flanders) and Sweden), best opportunities for subsurface integration in current planning systems were found in: heritage, environment, nature and water (Figure 1.5).

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[6] Commin 2007 www.commin.org,
Oxley Michael, Tim Brown, Vincent Nadin, Dr Lei Qu, Lidewij Tummers, Ana María Fernández-Maldonado, 2009. Review of European planning systems. Centre for Comparative Housing Research Leicester Business School. https://www.dora.dmu.ac.uk/bitstream/handle/2086/7536/NHPAU%20Planning.pdf?sequence=1,
Reimer, M. Getimis, P., Blotevogel, H.H. (eds) 2014., Spatial Planning Systems and Practices in Europe: A Comparative Perspective on continuity and changes. Akademie fur Raumforschung und landesplanung (ARL) ISBN 13: 978-0 – 415-72723-5,
Norrman, J., Volchko, Y., Maring, L., Hooimeijer, F., Broekx, S., Garção, R., Kain, J.-H., Ivarsson, M. Touchant, K., Beames A., 2015a. Balance 4P: Balancing decisions for urban brownfield regeneration – technical report. Report 2015:11. Department of Civil and Environmental Engineering, Chalmers University of Technology. Gothenburg, Sweden
[7] Oxley et al., 2009 (full reference in footnote 6)
[8] Normann et al, 2015a (full reference in footnote 6)

TOPICS IN SURFACE PLANNING →	heritage	environment	nature	water
CHANCES FOR ENHANCING THE SUBSURFACE BY: law and regulation	*chances for* - including the subsurface in planning regulations about heritage, environment, nature and water - including the subsurface in Environmental Impact Assessment and Water Assessment Test - subsurface in zoning plans through paragraphs about heritage, environment, nature and water			
policy and vision	*chances for:* - visions on the subsurface in local and regional plans, local policies, as well as in individual projects			
knowledge exchange	*chances for:* - interdisciplinary cooperation - developing new knowledge by cooperative learning			
design / construction	*subsurface in plan and design process needs:* - better frame of reference - better instruments (subsurface potential map)			
CATEGORIES OF SUBSURFACE QUALITIES →	civil constructions soil	civil constructions soil water energy	water soil energy	water soil energy

Figure 1.5: summary of chances for enhancing subsurface into the current planning systems with regard to four aspects: heritage, environment, nature and water.

Traditionally, soil quality (other than the legally obligatory themes in different countries such as soil contamination, nature, water and archaeology) are not taken into account. In many cases, soil only becomes a topic when in the implementation phase "surprises" arise such as low carrying capacity, seepage, unexpected obstructions in the subsurface. The soil expert is then involved to solve the issue. In many cases this is done by implementing technical solutions.

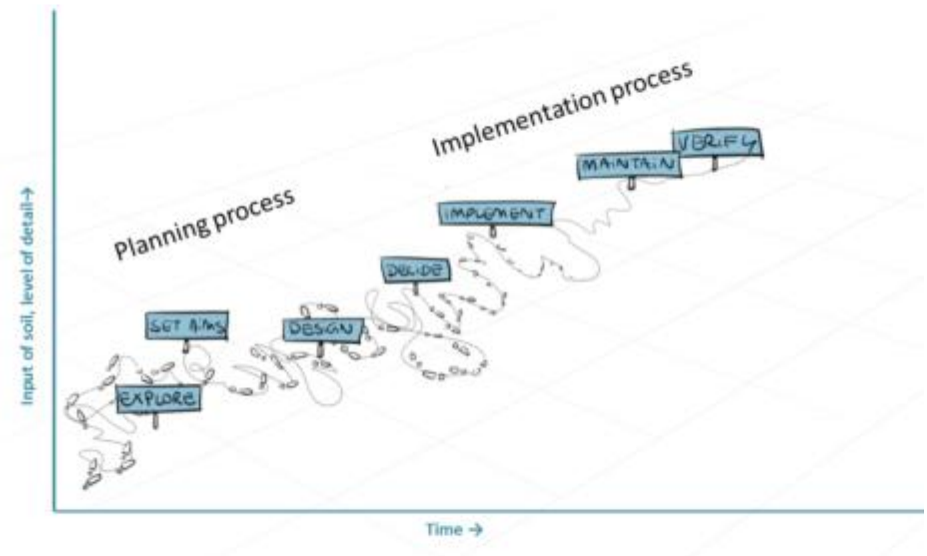

Figure 1.6: iterative planning process[9]

[9] Derived from the original figure in the Hombre final brochure (HOMBRE, 2014)

Figure 1.7 shows the model developed by the city of Rotterdam (The Netherlands) which can help in making spatial considerations for new functions, considering the soil. This starts with an assessment of the existing aboveground (1) and underground (2) functions and the relationship between them. Which functions need to be preserved and where is space for new functions? Which new aboveground (3) and underground (4) functions are required? Where are the natural physical conditions best suited for these new functions? What is the connection between new under- and aboveground use of space and what is the influence of the new development on existing functions? Do different types of underground functions compete and which has priority?

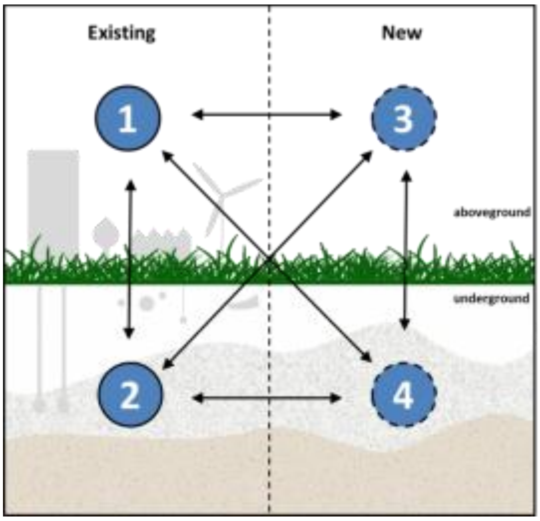

Figure 1.7: model for spatial planning of above- and underground use functions[10]

In the next section a series of examples in which spatial planning has taken soil quality into account are given for both agricultural and urban land.

[10] Derived from the original figure of SKB and municipality of Rotterdam, The Netherlands (unpublished)

2 Examples of case studies of spatial planning considering soil quality

Parties involved in spatial planning considering soil quality are land and soil users and specialists, spatial (urban and landscape) planners and policy makers in the field of spatial planning and soil. To give more insight in how they can act, examples from different countries in Europe are given below. All examples are case studies showing policies, projects or methodologies where soil quality (figure 2.1) and spatial (urban or landscape) planning were linked.

The case studies are divided in two categories:

- Spatial planning considering soil quality in **agricultural forest and natural land**
- Spatial planning considering soil quality in **urban and industrial** land

In this section, the numbers between brackets [x] refer to the specific examples and their background information. These can be found in the background section 5.5.

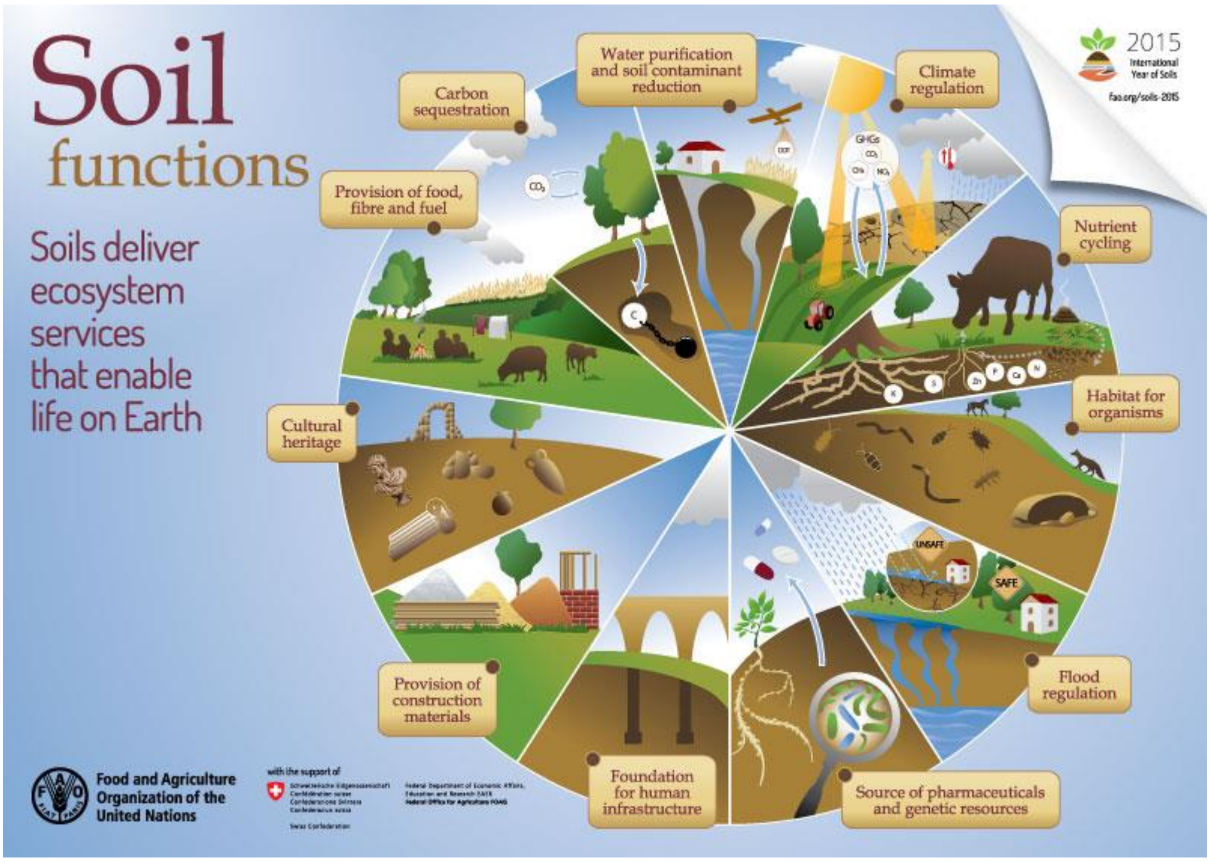

Figure 2.1: examples of soil functions[11]

Mapping soil quality is seen as a powerful ingredient for spatial planning. There are many examples using the concept of ecosystem services to take soil into account. Regulation or "zoning" is seen in both agricultural and urban land in multiple countries. There are examples taking soil quality into account from a broad perspective as well as examples considering soil from a narrow point of view focusing on one aspect such as soil contamination or the role of soil in climate adaptation.

[11] Source: http://www.fao.org/resources/infographics/infographics-details/en/c/284478/

Examples in agricultural, forest and natural land

Agriculture, forests and natural land depend on soil to provide ecosystem services. The type of soil and its condition determine the suitability for a specific crop, tree or natural environment. When the soil quality does not match a planned land use function, many interventions are needed. Unsustainable agriculture is considered as a major threat for soil functions and a key driver of soil degradation processes[12] such as soil erosion, soil contamination, loss of soil biodiversity and soil organic matter. The voluntary guidelines for sustainable Soil Management (VGSSM)[13] give guidelines on how to avoid unsustainable land use practices. (see background section 5.1: Voluntary Guidelines for Sustainable Soil Management).

Figure 2.2: agricultural land

Soil ecosystem services

Taking soil quality into account in land use decisions for agricultural land is common in several countries. In the Links4Soils Interreg project[14] [7], sustainable spatial planning methods include the evaluation of soil ecosystem services (Background section 5.3: the ecosystem services concept). Case studies that integrate the Soil Ecosystem Services (SES) approach into the spatial planning of municipalities are located in upper Bavaria (Germany) and Tyrol (Austria).

Land capability and soil suitability maps

The Emilia-Romagna region in Italy uses land capability maps[15] [3] in agricultural planning since the 70s (figure 2.3). Land capability classification is a system of grouping soils primarily on the basis of their capability to produce common cultivated crops and pasture plants without deteriorating soil quality over time. The maps are also used to promote soil measures in relation to soil functions with the objective to: increase soil organic matter; promote conservation and organic agriculture; promote organic agriculture; restore degraded ecosystems; protect biodiversity; manage extensive grasslands sustainably; afforest agricultural lands; manage animal manure sustainably. Poland [6] uses soil suitability maps, including the soil profile texture, relief and water regime, overall fertility and suitability for different crop types. In the spatial planning process, the maps depict boundaries of both organic soils and the most fertile agricultural land, which is legally restricted for urban development.

[12] Adhikari, K., Hartemink, A. E. 2016. Linking soils to ecosystem services – A global review. Geoderma, 262, 101-111

[13] http://www.fao.org/3/a-bl813e.pdf

[14] https://alpinesoils.eu/best-practices/spatial-planning/

[15] https://applicazioni.regione.emilia-romagna.it/cartografia_sgss/user/viewer.jsp?service=pedologia&bookmark=1%22

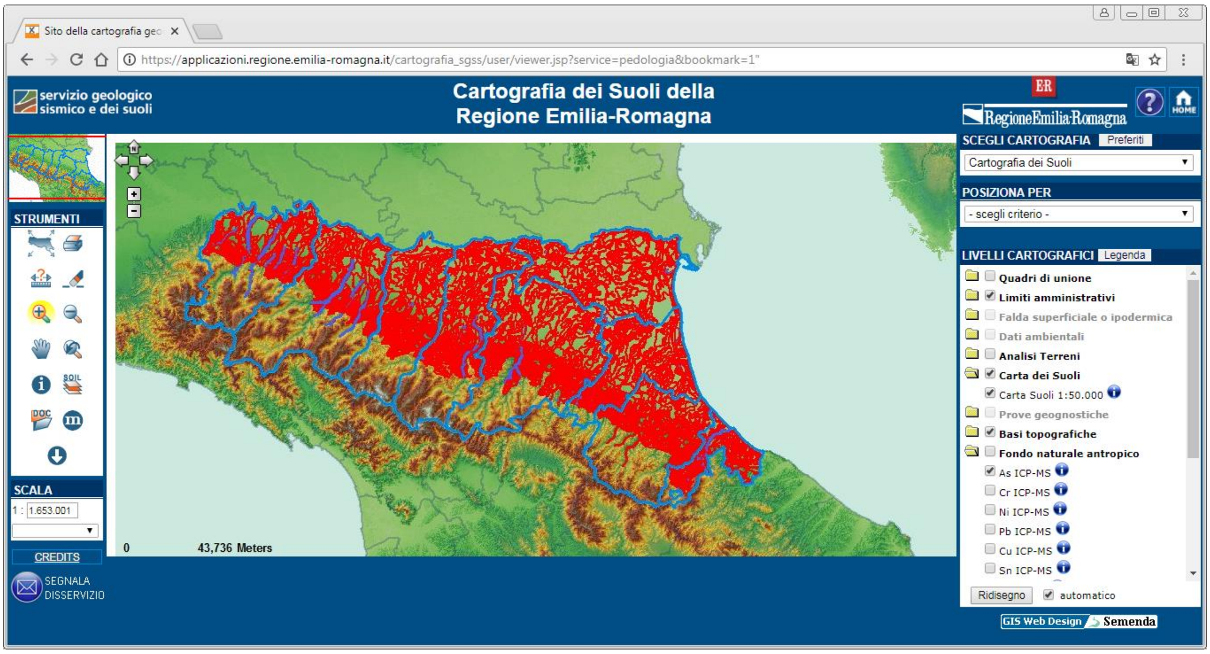

Figure 2.3: land capability maps for the Emilia-Romagna region in Italy

Regulation to avoid urbanisation and land take of good agricultural soils

The use of zoning to prohibit the development of urban land on good agricultural soils and to avoid land take and sealing is common in, for example, Portugal, Spain, Austria and Slovakia (11,12,13,14). In Portugal[16] soil capability is always considered in (urban/rural) spatial planning. The soil is divided in 5 capability classes, with the first two to be agriculture reserve and the last ecologic reserve. These capability classes and other restrictions and conditions related to protected areas are the basis for urban/regional spatial planning. In Spain[17] a “land use matrix” with categories for potential land uses in non-developed land is used. This matrix considers, amongst others, the ecological processes related to soil protection and aquifer recharge and also high agrological value soils. For each of the categories a specific use regulation is applied: 1) Favourable, 2) Admissible, 3) Forbidden. In the Austrian province Steiermark, Tirol, Oberösterreich and Salzburg, soil function maps are made. Municipalities have to use these maps in spatial planning. For instance, a new settlement area cannot be zoned in an area where soils have many functions at high level. Slovakia protects the best agricultural land with compensation payments. Conversion of protected agricultural land to building land requires a fee, depending on the quality of the affected soil, ranging from 6 – 15 Euros per m^2.

Planning of land use functions considering impact on soils

There are also examples where the location of a land use function is planned taking into account the environmental impacts on a certain location. For example, in The Netherlands [15] this was done when searching the best locations for bioenergy production[18]. The method includes the function’s impact on soil quality indicators (SOC, soil erosion) together with water, GHG emissions and biodiversity.

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[16] http://epic-webgis-portugal.isa.ulisboa.pt/

[17] EAEko Lurralde Antolamenduaren Gidalerroen Berrikuspena, 2018. Revisión de las Directrices de Ordenación Territorial de la CAPV. Spain. Available in spanish on: http://www.euskadi.eus/contenidos/informacion/dots/es_1165/adjuntos/APROBACION%20INCIAL/Diligencia%20de%20la%20Aprobaci%C3%B3n%20inicial%20de%20la%20revisi%C3%B3n%20de%20las%20DOT.pdf

[18] Van der Hilst, F., Lesschen, J.P., van Dam, J.M.C., Riksen, M., Verweija, P.A., Sanders, J.P.M., Faaij, A.P.C. 2012. Spatial variation of environmental impacts of regional biomass chains. Renewable and Sustainable Energy Reviews 16, 2053– 2069.

Examples in urban and industrial land

Urban and (former) industrial areas are, in many cases, artificial environments separated from their surrounding landscape and the natural environment. Urban and industrial areas are often heavily sealed, with the result that the natural functions of the soil-water system are lost. Examples are the water storage function that can reduce flooding after heavy rainfall and the production function for growth of plants and trees for a greener city that is less affected by, for example, heat stress. Many examples can be found where chemical soil quality is considered in urban planning. Fewer examples can be found where broader soil functions are taken into account. In some of those cases an ecosystem services framework was used.
The Cost SUBURBAN network, consisting of cities and geological surveys, was entirely dedicated to improve the “sub-urban” planning, by explaining the importance of the subsurface in the urban environment to urban planners. This action has collected many good examples and developed a toolbox[19].

Figure 2.3: flooding by heavy rainfall in urban land

Masterplans and development plans considering subsurface

In Helsinki, a masterplan was developed for the subsurface[20] [24]. The Helsinki Underground Master Plan includes the (potential) locations of underground rock caves, facilities and traffic tunnels and their mutual compatibility. Soil energy heating and cooling are becoming more and more common. The underground city planning pays attention to possible conflicts between several ways to use the bedrock resources. Also the Lisbon Master Plan (PDML) considers a set of underground aspects[21] [26] and in Glasgow (UK)[22] [25] there are plans to incorporate the subsurface environment and resources in the planning policy framework in the new City Development Plan. In Oslo[23] [27] there were plans to develop a municipal sub-plan for the underground. The “Oslo subsurface project” has started the development of such a plan, similar to Helsinki.

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[19] http://sub-urban.squarespace.com/
[20] https://static1.squarespace.com/static/542bc753e4b0a87901dd6258/t/5707847d37013bb703023e29/1460110490550/TU1206-WG1-007+Helsinki+City+Case+Study.pdf
http://sub-urban.squarespace.com/s/TU1206-WG1-007-Helsinki-City-Case-Study.pdf
[21] http://sub-urban.squarespace.com/s/TU1206-WG1-015-Lisbon-City-Case-Study-amn7.pdf
[22] https://static1.squarespace.com/static/542bc753e4b0a87901dd6258/t/57078ac3044262231705b636/1460112086450/TU1206-WG1-005+Glasgow+City+Case+Study.pdf and
http://www.bgs.ac.uk/research/engineeringGeology/urbanGeoscience/Clyde/askNetwork/home.html
[23] https://static1.squarespace.com/static/542bc753e4b0a87901dd6258/t/5707869ae707eb820b4118a5/1460111042910/TU1206-WG1-012+Oslo+City+Case+Study.pdf

Methodologies for urban planning considering a broad range of soil functions
As demonstrated by the URBAN SMS project[24] [17] policies provide more efficient protection of the most fertile land in urban landscapes in Germany, Austria and Italy, as compared to Poland, Czech Republic and Slovakia. It is well established that the integration of unsealed fertile and higher water storage soils in the urban development process also contributes to a reduction of flooding and of air pollution trough wind erosion. In general, fertile soils with well-developed profiles support a higher biodiversity, a larger plant biomass which contributes to water retention, runoff and fugitive dust reduction and provide an efficient cooling effect for heat waves.

SAGISonline[25] [18] from Land Salzburg (Austria) is a methodology for the assessment of individual soil functions that should enable the integration of protected soils into spatial decision-making processes. The approach was developed for municipalities together with planning offices.

The System Exploration Environment and Subsurface[26], that was tested in the Balance4P project in The Netherlands, Belgium and Sweden, was developed by soil scientists together with urban planners and municipalities. [19] It combines aboveground layers with subsurface considerations to be discussed in a workshop with both the planners and soil experts. By exchanging information in an early stage it exposes which opportunities and challenges should be considered in urban and or brownfield (re)developments (figure 2.4).

A Belgium example[27] [35] shows how the natural soil quality was taken along in the design of a housing project ('living in the wastine" = rangelands). The plan was designed together with the neighbourhood and other stakeholders. The soil and water conditions and the ecosystem value of this area were taken along in the plans to enhance nature and biodiversity. In this case traditional spatial planning for the development of rural residential communities was not favourable due to the specific characteristics of the area and therefore a new approach was chosen.

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[24] Blumlein P., H.J. Kircholtes, M. Schweiker, G. Wolf, B. Schug, I. Wieshofer, Sigbert Huber, M. Parolin, F. Villa, A. Zelioli, M. Biasioli, P. Medved, Tomaz Vernik, Borut Vrščaj, Grzegorz Siebielec, Josef Kozák, I. Galuskova, E. Fulajtar, Jaroslava Sobocká, S. Jaensch, 2012 Soil in the City. Urban Soil Management Strategy. ISBN: 978-3-943246-07-0, City of Stuttgart – Department for Environmental Protection, Germany, http://www.umweltbundesamt.at/en/services/services_resources/services_soil_spatial/en_urbansms/urbansms_casestudies/

[25] https://www.salzburg.gv.at/sagisonline/(S(rpsurzeb45bolbt30ejwlmnn))/init.aspx?karte=basis&geojuhuschema=Adressen/Namensgut&defaultlogo=agrarwald&gdiservices=Landnutzung/Landbedeckung&gdiservices=rohstoffe_und_geologie&gdiservices=landforstjagd&gdiservices=raumordnung&gdiservices=hoehen&gdiservices=umwelt&gdiservices=natur&gdiservices=boden&sichtbar=Nat%C3%BCrliche%20Bodenfruchtbarkeit&massstab=50000&koord=434000;306000

[26] Norrman et al., 2015a (full reference in footnote 6)
Norrman, J., Volchko, Y., Hooimeijer, F., Maring, L., Kain, J-H., Bardos, P., Broekx, S., Beames, A., Rosén, L., 2016. Integration of the subsurface and the surface sectors for a more holistic approach for sustainable redevelopment of urban brownfields. Science of the Total Environment, 563-564, pp 879–889.,
Hooimeijer & Maring (2018) . In: Journal of Urbanism: International research on placemaking and urban sustainability. pp 1-12
https://publicwiki.deltares.nl/display/SEES/HOME+English (consulted July 2018)

[27] https://www.oostkamp.be/download.ashx?id=44139

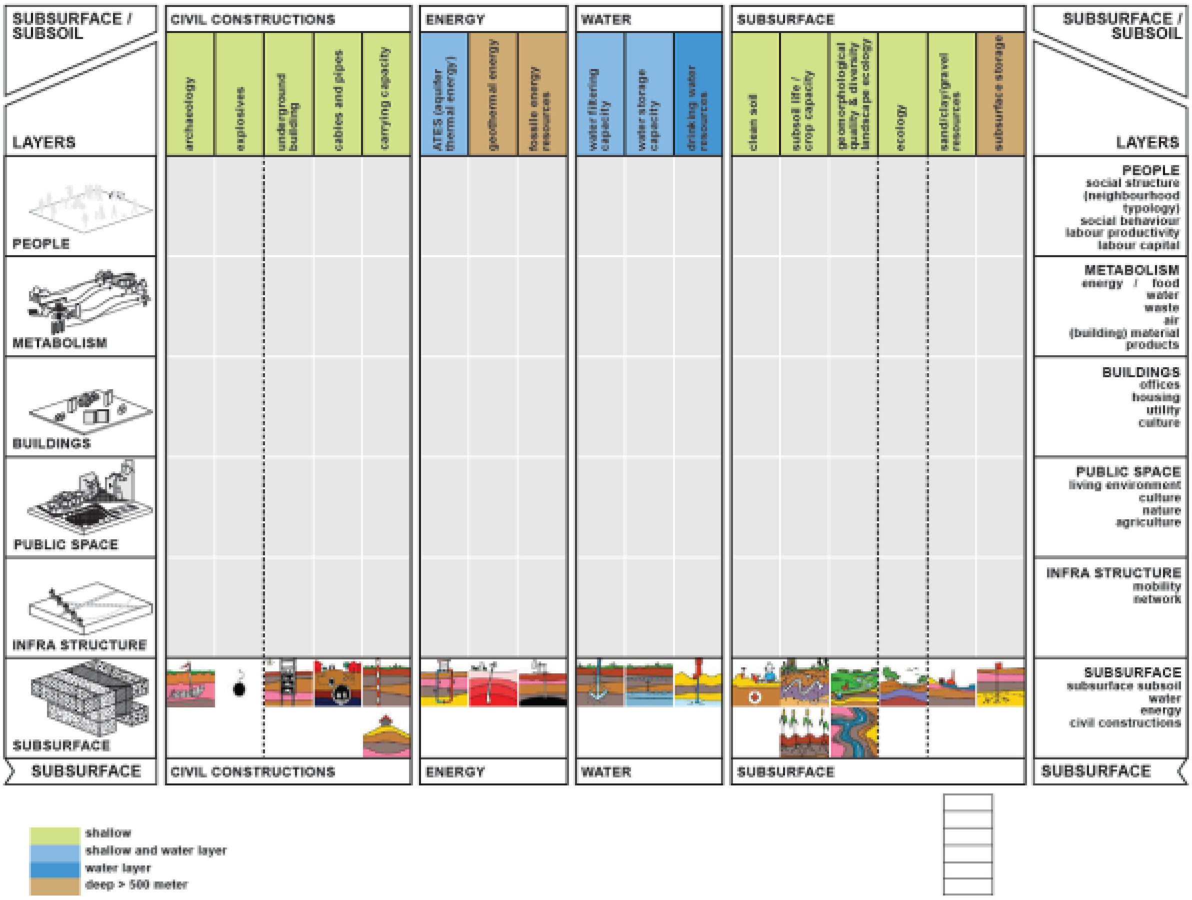

Figure 2.4 System exploration environment and subsurface

Soils and climate change adaptation in urban planning

In recent years there have been few studies[28] demonstrating the important role of the soil in combating the urban heat island effect. Processes are the solar energy absorbed by different urban surfaces that warm up the air above these surfaces, the evaporation of moisture and the storage of heat by different land covers (different soil and plant habitats, artificial surfaces, waters etc). Soil properties such as water holding and capacity to buffer urban heat are important assets to adapt to effects of climate change. The protection of the best soils in urban development should be considered as an important adaptation measure to climate change, contributing to the comfort and wellbeing of citizens.

A tool that supports planning climate change adaptation measures in urban areas is the Dutch Adaptation Support Tool (AST)[29] [34]. Amongst other themes, the AST considers soil quality in terms of its storage capacity and unsealed area. The AST is applied in case studies in Berlin, London, Utrecht (Figure 2.5) and Amsterdam.

[28] E.g. Santamouris M. (2014) Cooling the cities - a review of reflective and green roof mitigation technologies to fight heat island and improve comfort in urban environments Sol. Energy, 103: 682-703. http://dx.doi.org/10.1016/j.solener.2012.07.003 or Gunawardena K.R., Wells M.J., Kershaw T. (2017) Utilising green and bluespace to mitigate urban heat island intensity. Science of The Total Environment Vol. 584–585: 1040-1055
https://doi.org/10.1016/j.scitotenv.2017.01.158

[29] ast.deltares.nl

Figure 2.5 in Utrecht the AST was used to create one of the most green, sustainable, healthy and climate resilient urban districts in Europe.

Spatial planning to avoid soil sealing and land take

Soil sealing is one of the main causes of soil degradation in the EU and very much related to the spatial planning practice. The European Commission has formulated best practices to limit soil sealing or mitigating its effects[30]. There are many examples reducing soil sealing and land take, either through policy [36] as e.g. in Austria, Germany, Belgium, Luxembourg, Netherlands and the UK, either by financial support for strategic land development [37] as in Belgium /Flanders and Germany.

In different Member States quantitative limits for annual land take exist. In Austria and Germany the limits are defined in hectare per day for a target year. In Belgium (Flanders), Luxembourg and the Netherland, limits are based on inner urban development: 60% of new developments should be planned within defined inner urban boundaries. The Soil Compensation Account [38] from Dresden (Germany) sets a limit for built-up land for settlements and traffic that is confined to 40% of the total urban land. New developments on undeveloped land require compensating de-sealing or “greening” measures somewhere else but within the city boundaries.

The regeneration of brownfield [39] land is another strategy to avoid the further development of green areas and urban sprawl. By recognizing land and soil as vital resources and with a broad view on opportunities, networks such as CABERNET[31] and research projects such as Hombre[32] and Timbre[33] have contributed to strategies for brownfield regeneration, where the opportunities delivered by soil quality are taken into regeneration of this derelict land, preventing land take elsewhere. The United Kingdom (England) limits its land take by promoting brownfield redevelopment; new housing should be planned on already developed land.

[30] Prokop, Gundula, Heide Jobstmann, Arnulf Schönbauer 2011. Report on best practices for limiting soil sealing and mitigating its effects. European Communities Technical Report 2011 - 050 doi : 10.2779/15146

[31] Ferber, U, Grimski, D, Millar K., Nathanail, P. (2006-II). Sustainable Brownfield Regeneration: CABERNET (The Concerted Action on Brownfield and Economic Regeneration
Network) Network Report

[32] Zerobrownfields.eu

[33] http://www.timbre-project.eu/en/brownfield.html


Figure 2.5: permeable pavement in a parking area as a measure against soil sealing

Urban planning considering chemical soil quality
Spatial planning and land management decisions should be made in consideration of the effects on risks that arise from contaminated soils. In Italy, a method was designed to indicate the potential level of human health risks due to heavy metal concentrations in urban soils, accounting for the potential impact of land use on such risks and providing suggestions on the most suitable land use to reduce the risk, including agricultural use. Soil data and information were taken from a soil survey and the effects of different types of land use on soil properties and on the capacity of the soil to fulfil certain functions were taken into account[34] [29].

The Site Assessment and Re-use Planning Tool (SAT) [33] was developed for brownfield land in the TIMBRE project[35]. It is a web-based tool optimizing and visualizing of re-use options, based on contamination data. It shows the consequences of the re-use options with respect to criteria such as remediation costs, sustainability, market values, etc. and it enables the communication between stakeholders. It was applied on cases in Poland and Germany (Figure 2.6).

[34] Poggio, L., Vrscaj, B., Hepperle, E., Schulin, R. Marsan, F. 2008. Introducing a method of human health risk evaluation for planning and soil quality management of heavy metal-polluted soils—An example from Grugliasco (Italy). Landscape and Urban Planning 88, 64-72.
[35] http://www.timbre-project.eu/en/site-assessment-tool.html

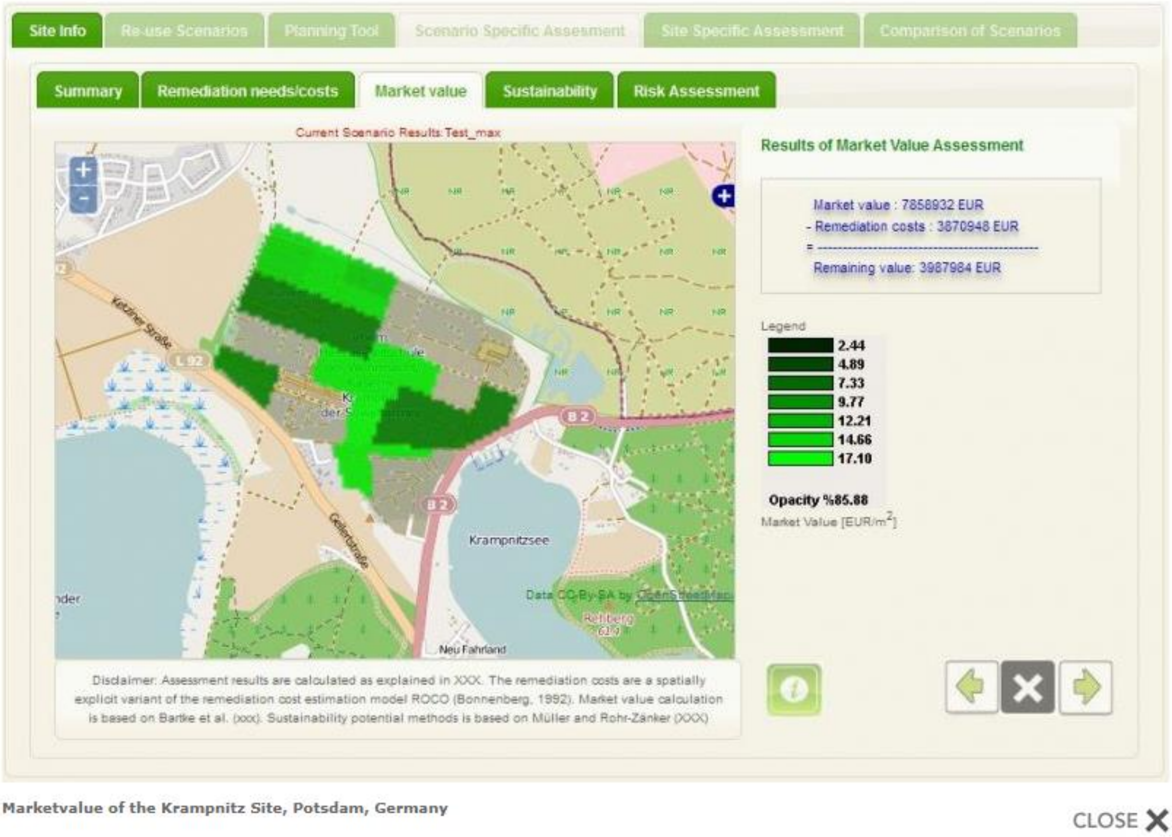

Figure 2.6: Site Assessment and Re-use Planning Tool (SAT)

The main need of city planners in relation to the geochemical quality of soils and subsoils is to have reasonable and representative visualisation of the data in a form, which enables them to be used effectively and in an integrated way with other datasets (socio-economic, health, etc.). 2D and 3D mapping of soil geochemistry are useful tools, where 2D topsoil acquisition is particularly well suited for addressing health issues. 3D geochemical knowledge is still uncommon but can be very useful in optimizing urban redevelopment projects, anticipating contamination problems, and managing excavated materials (e.g. local reuse possibilities, disposal costs etc.). Because all of these aspects can have important economic, environmental and social consequences, they are considered essential for urban sustainable development. The cost suburban network has made an overview of good practice and best efforts[36] [28].

[36] http://sub-urban.squarespace.com/new-index-1/#geochemistry-wg-26

3 Main barriers

In the examples above many benefits are described of spatial planning considering soil quality and soil functionalities. What are the reasons that it is not done yet on a wide scale? A (non-exhaustive) summary of the main barriers are given here. In section 4, the main recommendations for action are given.

No law, policy, regulation and/or institutions

- There is a lack of regulatory and policy support specifically aimed at integrating soil quality in the planning phases. When there is no rule or policy that asks for the effort to take soil quality into account, it depends on the specific public administration at different levels (local, regional) and / or project/process manager if they consider the topic to be important.
- The complexity of governance and fragmentation of responsibilities regarding spatial planning hampers possibilities to integrate soil quality in the spatial planning practice.
- The lack of a common approach to risk assessment in many jurisdictions is some countries resulting in development on sites which pose a risk to a human health or/and ecosystem functioning.
- Environmental assessment (EA) is the assessment of the positive and negative environmental consequences of a plan, policy, program (strategic environmental assessment SEA), or actual project (environmental impact assessment EIA), prior to the decision to move forward with the proposed action. The impacts on people, human health, fauna and flora, soils, land use, material assets, water quality and hydrology, air quality, climate, noise and vibration, the landscape and visual environment, historic and cultural heritage resources, and the interactions between are described for the different alternatives. Although helpful tools for assessing the impact on soil by spatial plans, EIA and SEA traditionally have a limited scope in scale and time (direct and on-site) and on the topic soil. Their role in the planning process and influence on spatial decisions is limited.

Figure 3.1: Land slide hazard

No awareness on the topic, continue traditional practice

- Who is in the lead when taking soil quality into account in spatial planning? The soil specialist or the spatial planner?
- When involving the soil expert, it is in many cases the person who knows about soil remediation. By considering soil quality just as contamination, spatial planners interpret “soil” as extra costs, time and work and not as an opportunity.

- There is limited interest of stakeholders and planners in including soil quality and sustainability assessments in early planning due to complexity. Adding more topics to the planning process without seeing the added value complicates the project. [40].
- The cultural background of professionals, their education and training, knowledge and experience play an important role in how they do their work. Deviation from traditional practice should be substantiated with examples and added value.

Financial arrangement, division costs and benefits

- In most cases there is limited urban planning project budget and unbalanced risk cost distribution between developers and planners. This hinders a broader investigation of the soil quality's barriers and opportunities in the planning phase, which in many cases can lead to unexpected events during the development and maintenance phase. Other ways of tendering and contracting (e.g. Design Build Maintain contracts) can help to overcome this obstacle.

Insufficient (availability of) data and tools

- Information on soil quality is not always available. The development leads to extra costs.
- Data and (decision support) tools considering soil quality are not always specifically targeted to spatial planners. The data and tools can be hard to find and to use and their added value is not always clear to the spatial planner.
- Compatibility of IT systems is needed to exchange information, map layers and data.

Lacking communication and collaboration, lacking information and knowledge exchange

- The multidisciplinary dialogue between planners and soil experts is often hampered by the difference in language and jargon.
- The quality of the information transfer is not secured during the redevelopment process when the actors and/or regulatory frameworks change. In many cases huge information loss is the result.
- Networks and education play an important role in knowledge exchange. It requires more time and effort to acquire knowledge about innovation, experiments and new methods. In contrast to people with a specific interest or task on the topic, the "peloton" is insufficiently involved in these networks and exchanges.

Figure 3.2: soil erosion

4 Recommendations for action

Integrate the topic in law, policy, regulation and/or institutions

- Policymakers on both spatial planning and development issues and on soil and water issues have a joint responsibility to enhance the practice of spatial planning by taking soil quality into account. This can be done by introducing this in their policies and as a requirement in the task description for area and urban developments.
- Turpin et al., propose in their assessment of policies affecting Sustainable Soil Management in Europe, to embed public and/or private interests affected by the management of agricultural soils in policy frameworks. These public and/or private interests include in the first place the protection and improvement of the soil itself, notably the integrity and quality of soils for use in agriculture and in the provision of other ES. The quality of soils relates to the status of the soil itself. Among these, the retention of topsoil by protection against erosion by water and wind, the protection of soil structure against compaction, and the conservation and enhancement of soil organic carbon (SOC) and soil biodiversity can be distinguished. Besides their obvious importance to farming, additional interests can be mentioned that include the provision of landscape- based ecosystem services such as water quality, air quality, and (aboveground) biodiversity[37].
- Integration of soil quality in a broad sense (e.g. soil ecosystem services) in Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA) can be an opportunity for better integration in spatial planning, because plans, policies, programs and projects will take the integration of soil quality into account in their assessment.

Figure 4.1: collaboration between spatial planners and soil experts

Increase awareness on the topic, continue traditional practice

- To integrate soil quality better into spatial planning, it requires a new field of interdisciplinary research. In urban renewal and the redevelopment of brownfield land, the subsurface and surface, and particularly where the natural and man-made systems connect, should not merely co-exist but work together. Turning to an approach that starts from the merits of natural systems and balance these out with state-of-the-art technology will lead to innovative solutions. This approach involves a change in attitude, organization and design in urban projects, and it requires close cooperation between urban designers and engineers[38].

[37] Turpin et al., 2017 An assessment of policies affecting Sustainable Soil Management in Europe and selected member states

[38] Hooimeijer and Maring, 2018, see footnote 29

- The Balance 4P project[39] concluded the following. Next to “people, planet and profit”, the fourth P: the process is crucial for the success of sustainable projects. This includes a process leader who stays on top of the objectives and boundary conditions that are set for the project. This includes being specific that all parties involved should take soil quality into account when performing their tasks. Otherwise this will end up on the end of the list as “extra work”, or “complicating” or “difficult”.
- Soil quality is more than contamination. By recognizing this, a broader range of relevant soil experts can be involved at the beginning of projects and initiatives: e.g. engineers with knowledge of the hydrogeological, geotechnical and ecological aspects, soil energy, and civil engineers.
- Exchange, show and tell: Awareness is needed on the fact that the soil, subsurface and planning sector can benefit from each other’s practices. The policymakers and practitioners in spatial planning and development issues and on soil and water issues need to be aware on, and communicate about the contribution of soil quality in spatial (urban and land scape) planning. This can be done by education, by showing added value or costs and damage when soil quality is considers, or neglected by spatial planning, and by exchanging examples on good and bad practices (Background section 5.5).

Ensure sufficient (availability of) data and tools

- Soil data must be accessible and understandable. The development of soil databases is therefore required when not yet available in member states. Data and figures are also needed to show the added value of spatial planning where soil quality was considered. Research programs and projects should give priority to disseminate the data and results to enhance the collaboration between planning and soil on both policy as practice level.
- There are methodologies and tools available. Making them available for planners and practitioners and initiatives such as learning by doing might help changing business as usual.
- There is a multitude of tools developed in the EU and member states. The choice which tool fits best depends on data availability, project phase, ability, legal framing but also personal taste. The most important aspect when choosing a tool is that stakeholders involved accept the tool and its outputs. A good design matters for sustainable solutions. It is worth to spend the perceived extra effort in the beginning of the project for a better, more resilient and robust design. This avoids unexpected events and pays off in the maintenance phase[40].

[39] Norrman, Jet al;., 2015a (full reference in footnote 6)
[40] Overviews of tools for soil in spatial planning are made in e.g.:

- the URBAN SMS project: http://www.umweltbundesamt.at/fileadmin/inhalte/urbansms/pdf_files/Final_Conference/Posters/PP07_AIS_tools_description.pdf ,
- Balance 4P project, Normann et al., 2015a footnote 7

The HOMBRE and TIMBRE projects have developed and made overviews of tools for brownfield regeneration (www.zerobrownfields.eu, http://www.timbre-project.eu/)
The EC has worked on tools such as the Voluntary Guidelines for Sustainable Soil Management and the best practices for limiting soil sealing and mitigating its effects. http://www.fao.org/3/a-bl813e.pdf
Also tools such as SIA and EIA are valuable.

Figure 4.2: "augmented reality" as a tool to show subsurface information on site

Improve financial arrangement, division costs and benefits, Private-public ownership

- In development projects, other ways of tendering and contracting (e.g. Design Build Maintain contracts) can help to overcome the obstacle that soil and subsurface characteristics are ignored during the planning phase. In this case, the developer would avoid potential costs arising in the maintenance phase (e.g. due to building on soils with a low carrying capacity, figure 4.3) by alternative building methods and materials (which might involve higher realization costs, that will be earned back during maintenance).

Improve communication and collaboration, information and knowledge exchange

- For researchers, policy makers and practitioners in the fields of soil and subsurface and spatial planning, better collaboration, earlier knowledge exchange and tools and policies support the collaboration.
- Knowledge exchange is key to success in sustainable (re)development projects. It is not only of importance of which knowledge is delivered, also how and when. People should be capable to understand the information delivered and be able to use it for their specific task. Therefore it is also important not to overload people involved with all information in the beginning of the project, but dose the information supply: the right information to the right person in the right time, and give an explanation when needed. Knowledge exchange is a continuous activity that needs planning.
- Networks (existing and new) could give an impulse to collaboration between spatial planners and soil experts. An example is the Cost SUB-URBAN network[41] where Geological Surveys, Cities and Research Partners work together to "improve how we manage the ground beneath our cities".

[41] www.sub-urban.eu

- It starts with education. Soil scientists should understand the planning system in a country and planners should get some introduction on soil and water. At BOKU, the University of Natural Resources and Life Sciences, in Austria, all Landscape Planners have to learn soil science (4 European Credit Transfer System) when starting their bachelor. The urban planning students at the Technical University of Delft (Netherlands) get lectures on soil and water (Sustainable Urban Engineering of Territory). In Italy the Polytechnic University (POLITO), besides Engineer and Architecture, has since about 10 years a course for the degree in Urban Planning, which includes a couple of exams on geology. Chalmers university in Sweden includes in the education program for “landscape architecture” some basic quaternary geology and basic soil science. And the other way around, at the University of Nottingham, the environmental management and contaminated land management students get an introduction on spatial planning.

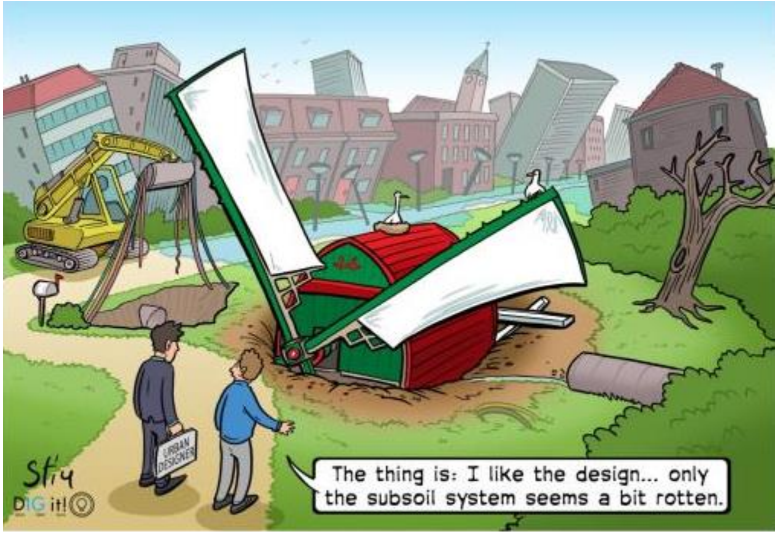

Figure 4.3 Cartoon Building on soils with a low carrying capacity in the Netherlands (©Hooimeijer)

5 Backgrounds

5.1 Voluntary Guidelines for Sustainable Soil Management

The SDGs identify the need to restore degraded soils and improve soil health. There is widespread agreement that we must nurture and unlock the full potential of soils, so as to be able to not only support food production but also to store and supply more clean water, maintain biodiversity, sequester carbon and increase resilience in a changing climate. This is a goal that requires the universal implementation of sustainable soil management. The Voluntary Guidelines for Sustainable Soil Management (VGSSM)[42] provide the following definition of sustainable soil management: "*Soil management is sustainable if the supporting, provisioning, regulating, and cultural services provided by soil are maintained or enhanced without significantly impairing either the soil functions that enable those services or biodiversity. (…)*". Although the guidelines focus on soil management, they also call for: responsible land use planning to minimize soil sealing and for considering the value of soils for other uses before covering it; carefully planning of land-use changes to avoid negative effects such as soil erosion; assessing the suitability of the land for a given land use, to avoid soil degradation (e.g. nutrient imbalances, lower soil carbon, biodiversity losses). Many of the guidelines' principles and considerations can be applied in spatial planning.

5.2 Sustainable development Goals

SDGs and the role of soils
SDG 1. End poverty: access to land and natural resources. This includes the use of land and soils and their services.
SDG 2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture has a direct link with soils and their (long term) functioning as the basis for food production.
SDG 3. Ensure healthy lives and promote well-being: avoid health damage by air, water and soil pollution and contamination.
SDG 6. Ensure availability and sustainable management of water and sanitation: Access to safe and affordable drinking water, improve water quality and water-use efficiency (quantity). Groundwater can be used for drinking or non-drinking purposes. Land (and soil) use plays a role by tuning activities to (ground)water quality and quality.
SDG 7. Ensure access to affordable, reliable, sustainable and modern energy although the link might be less obvious, groundwater and subsurface, as well as geothermal energy, can be used as a sustainable energy source. Soils are also used for subsurface infrastructures for energy transport.
SDG 9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation Soils provide space for subsurface infrastructures. Building with nature as sustainable innovation for infrastructure. The use of infrastructures in circular economy (biomass production, reuse of soils).
SDG 11. Make cities and human settlements inclusive, safe, resilient and sustainable: soils in urban areas can play a role by mitigating and adaptation to climate change and disaster resilience.
SDG 12. Ensure sustainable consumption and production patterns: as SDG 3, this goal Is aimed at reduction of the release of chemicals and wastes to air, water and soil to minimize impacts on human health and the environment.
SDG 13 Take urgent action to combat climate change and its impacts. Soils play a role in resilience when speaking about climate change (SDG 2 for agricultural and SGD 11 for urban land).

[42] These VGSSM, endorsed by the FAO Council in December 2016 at its 155th Session, complement the World Soil Charter (which contains key principles and guidance for action towards sustainable soil management) by further elaborating principles and practices for incorporation into policies and decision-making. Available on: http://www.fao.org/3/a-bl813e.pdf

SDGs and the role of soils
Next to that soils have an important role in cycles avoiding emissions greenhouse gases to the atmosphere.
SDG 14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development: involves **the** prevention and reduction of marine pollution of all kinds, in particular from land-based activities. This involves agricultural use as a source of nutrient pollution and soil as a medium for emissions.
SDG 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss: this SDG aims at conservation, restoration and sustainable use of ecosystems and their services**,** promote sustainable management of forests, restore degraded land and soil, including desertification, drought and floods, strive to achieve a land degradation-neutral world.

5.3 The ecosystem services concept

The concept of ecosystem services, as mentioned in the VGSSM, can be helpful to consider soil quality in spatial planning. When applied to soils, it increases awareness on the importance and value of soil functions and related ecosystem services for different purposes. This helps more, multifunctional, sustainable and efficient use of soil ecosystem services and gives arguments for their protection, management and restoration of soil ecosystems[43]. Spatial planning is an instrument for this. Next to the ecosystem services concept, there are other methodologies that can be used (some of them are elaborated in background section 5.5).

Table: Soil ecosystem services and indicators (summary of table 3.2 in Van der Meulen et al., 2018 [43])

Provisioning ecosystem Service (ES)	CICES class	Indicator [unit]	Supply or Use	Relevant spatial extent
Biochemical and pharmaceuticals	No class provided in CICES (CICES Division= Materials)	Raw materials for medicines [...]	S	Regional
Food, wood and fibre	Cultivated terrestrial plants (incl. fungi, algae) grown for nutritional purposes or as a source of energy; Fibres and other materials from cultivated pants fungi, algae and bacteria for direct use or processing.	Surface area of organic crops [ha] Yields (ton/ha) Forest biomass stock (tons)	S	Regional
Fresh water	Ground (and subsurface) water for drinking or non-drinking purposes	Water retention index [dimensionless, between 0-10] Water abstraction (m^3 /yr)	S U	Regional Regional
Carrying capacity for infrastructure, buildings and animals [support of animals and infrastructure] [carrier function]	*No class provided in CICES*	Suitability classes for building [-]	S	Local
Raw materials	Mineral substances used for nutritional or material purposes or as energy source	Raw material extraction (tons/yr)	S	Regional
Thermal energy	Ground water (and subsurface) used as an energy source; Geothermal	Suitability classes for ATES [-], Demand based on aboveground land use [PJ]	S U	Local Local

[43] Van der Meulen, S.M., L. Maring 2018 Mapping and Assessment of Ecosystems and their Services - Soil ecosystems. Soils4EU deliverable 1.2.

Regulation and maintenance ES	CICES class	Indicator [unit]	Supply or Use	spatial extent
Water purification and soil contamination reduction	Bio-remediation by micro-organisms, algae, plants, and animals; Filtration /sequestration /storage/accumulation by micro-organisms, algae, plants, and animals; Mediation of waste toxics and other nuisances by non-living processes	Nitrogen removal [dimensionless scale of 1-5] Concentration of pollutants in soil (mg/kg)	S U	Regional Local
Water regulation	Hydrological cycle and water flow regulation (including flood control and coastal protection);	Retention capacity of water in soils [dimensionless, between 0-10]	S	Regional
Pest and disease control	Pest control (including invasive species); Disease control	For agricultural land: density of hedgerows (m / ha)	S	Regional
Carbon Sequestration	Weathering processes and Decomposition and fixing processes and their effect on soil quality	Carbon Sequestration [ton/ha/yr]	S	Regional
Regulation of greenhouse gasses	Regulation of chemical composition of atmosphere and oceans	Net ecosystem productivity	S	Regional
Regulation of local climate/temperature	Regulation of temperature and humidity, including ventilation and transpiration	Water retention index if applied at the scale of e.g. a city Uncovered soil	U U	Local Local
Noise abatement	Noise attenuation	Leaf Area Index + distance to roads (m)	S	Local
Air quality regulation	Filtration/sequestration/storage/accumulation by micro-organisms, algae, plants, and animals; Mediation of waste toxics and other nuisances by non-living processes	Pollutants removed by vegetation (in leaves, stems	S	Local
Cultural Ecosystem Service	**CICES class**	**Indicator [unit]**	**Capacity or Demand**	**Relevant spatial extent**
Recreation and tourism	Characteristics of living systems that enable activities promoting health recuperation or enjoyment through active or immersive interactions; or through passive or observational interactions; natural abiotic characteristics of nature that enable active or passive and experiential interactions	Number of visitors Distribution of sites	U S	Local Regional
Knowledge/scientific research, Cultural heritage and education	Characteristics of living systems that: enable scientific investigation or the creation of traditional ecological knowledge; enable education and training; are resonant in terms of culture or heritage; enable aesthetic experiences; natural abiotic characteristics of nature that enable intellectual interactions.			
Spiritual and symbolic experience	Elements of living systems: that have symbolic, sacred or religious meaning; used for entertainment or representation; natural abiotic characteristics or features of nature that enable spiritual, symbolic and other interactions.			

5.4 Policies on spatial planning taking into account soil quality

The overview underneath was derived from the Soil WIKI inventory (“Inventory and Assessment of Soil Protection Policy Instruments in EU Member States”)[44]. Note that is has not been cross checked with other sources of information. Spatial planning policy can be very complex. Some countries have legislation on both national and regional level. For some countries, the WIKI contains more detailed information than for others.

Overview of policy instruments taking into account both spatial planning and soil functions (source, WIKI “Inventory and Assessment of Soil Protection Policy Instruments in EU Member States”)
*land use is described as A=Agricultural / U= Urban / N=Natural /F= Forest land

Country	Instrument	land use*	Soil functions addressed		Soil threats addressed		Binding?
			explicitly	implicitly	explicitly	implicitly	
Austria	Spatial Planning Act [Raumordnungsgesetz]	A, F	platform for human activity	biomass production storing filtering transforming nutrients water hosting biodiversity pool providing raw materials	-	flooding landslides loss of soil organic matter compaction soil sealing loss of soil biodiversity	Y
Belgium (Wallonia)	Territorial Development Code National (Regional) [Code du Développement Territorial (CoDT)]	U, A, N, F	biomass production platform for human activity providing raw materials storing filtering transforming nutrients water storing geological archeological heritage	hosting biodiversity pool acting as carbon pool	erosion water flooding landslides contamination industrial point source soil sealing	-	Y
Belgium (Wallonia)	Walloon Code on Land Planning, Urbanism and Heritage [Code wallon de l'aménagement du territoire, de l'urbanisme et du patrimoine (CWATUP)]	A / U / N / F	biomass production platform for human activity providing raw materials storing filtering transforming nutrients water storing geological archeological heritage	hosting biodiversity pool acting as carbon pool	erosion water flooding landslides contamination industrial point source soil sealing	-	Y
Belgium (Wallonia)	Plan for the Prevention of Floods and Their Effects on Flood Victims [Plan de Prévention et de LUtte contre les inondations et leurs effets sur les Sinistrés (P.L.U.I.E.S.)]	A / U / N / F	biomass production storing filtering transforming nutrients water platform for human activity providing raw materials	hosting biodiversity pool acting as carbon pool	erosion water flooding landslides soil sealing	loss of soil organic matter contamination diffuse compaction loss of soil biodiversity	N
Belgium (Flanders)	Flemish Spatial Planning Code [Vlaamse Codex Ruimtelijke Ordening]	A / U / N / F	hosting biodiversity pool providing raw materials platform for human activity	biomass production acting as carbon pool	-	flooding landslides loss of soil organic matter contamination diffuse contamination industrial point source soil sealing loss of soil biodiversity	Y
Bulgaria	Spatial Planning Law [Закон за устройство на територията]	A / F	-	-	erosion water flooding landslides	-	Y
Czech	Act Concerning the Protection of Agricultural Soil [Zákon č. 334/1992 Sb., o ochraně zemědělského půdního fondu, ve znění pozdějších předpisů]	A	-	biomass production storing filtering transforming nutrients water hosting biodiversity pool platform for human activity providing raw materials acting as carbon pool storing geological archeological heritage	erosion water erosion wind flooding landslides contamination diffuse compaction soil sealing	loss of soil organic matter loss of soil biodiversity	Y
Finland	National Land Use Guidelines [Valtakunnalliset alueidenkäyttötavoitteet]	A / U / F / N	biomass production storing filtering transforming nutrients water hosting biodiversity pool providing raw materials	-	flooding landslides contamination industrial point source	loss of soil biodiversity soil sealing	Y

[44] Frelih-Larsen, Ana; Albrecht, Stefanie; Kemper, Melanie; Naumann, Sandra; Landgrebe-Trinkunaite, Ruta; Bell, Stephen et al. (2017): Final Report to DG Environment. Updated Inventory and Assessment of Soil Protection Policy Instruments in EU Member States. Ecologic Institute. Berlin. Available online at http://ec.europa.eu/environment/soil/pdf/Soil_inventory_report.pdf.

Country	Instrument	land use*	Soil functions addressed		Soil threats addressed		Binding?
			explicitly	implicitly	explicitly	implicitly	
			storing geological archaeological heritage				
France	Land Planning Code [Code d'Urbanisation]	A / U / F / N	platform for human activity	biomass production storing filtering transforming nutrients water hosting biodiversity pool	loss of soil organic matter contamination diffuse contamination industrial point source compaction soil sealing	loss of soil biodiversity	Y
France	Law for Access to Housing and Renewed Urban Planning [Loi pour l'accès au logement et un urbanisme rénové (Loi ALUR)]	U	platform for human activity	-	contamination industrial point source soil sealing	-	Y
Croatia	Spatial Planning Act [Zakon o prostornom uređenju (Official Gazette, No. 153/13)]	A / U / F	platform for human activity providing raw materials storing geological archaeological heritage	-	-	soil sealing	Y
Croatia	Spatial Planning Strategy [Strategija prostornog uređenja Republike Hrvatske]	A / U / F / N	platform for human activity storing geological archaeological heritage	acting as carbon pool	-	erosion water erosion wind contamination diffuse contamination industrial point source loss of soil biodiversity	N
Cyprus	Town and Country Planning Law [Ο ΠΕΡΙ ΠΟΛΕΟΔΟΜΙΑΣ ΚΑΙ ΧΩΡΟΤΑΞΙΑΣ ΝΟΜΟΣ ΤΟΥ 1972]	-	-	platform for human activity	-	-	N
Denmark	The Planning Act [Lov om Planlægning]	-	biomass production platform for human activity	-	soil sealing	contamination diffuse	Y
Estonia	Building Code [Ehitusseadustik]	A / U / F / N	-	platform for human activity	-	-	Y
Estonia	Planning Act [Planeerimisseadus]	A / U / F / N	-	biomass production hosting biodiversity pool platform for human activity providing raw materials storing geological archaeological heritage	-	erosion water, erosion wind loss of soil organic matter contamination diffuse contamination industrial point source compaction soil sealing	Y
Estonia	National Spatial Plan "Estonia 2030+" [Üleriigiline planeering "Eesti 2030+"]	A / U / F / N	-	biomass production storing filtering transforming nutrients water hosting biodiversity pool platform for human activity providing raw materials acting as carbon pool storing geological archaeological heritage	soil sealing	-	Y
Germany	Building Code [Baugesetzbuch (BauGB)]	-	hosting biodiversity pool platform for human activity providing raw materials storing geological archaeological heritage	storing filtering transforming nutrients water	flooding landslides loss of soil organic matter compaction soil sealing loss of soil biodiversity	erosion wind erosion water contamination diffuse	Y
Germany	Spatial Planning Act [Raumordnungsgesetz]	A / U / F / N	platform for human activity storing geological archaeological heritage	biomass production storing filtering transforming nutrients water hosting biodiversity pool providing raw materials acting as carbon pool	-	erosion water erosion wind flooding landslides loss of soil organic matter contamination diffuse contamination industrial point source compaction soil sealing loss of soil biodiversity	Y

Country	Instrument	land use*	Soil functions addressed		Soil threats addressed		Binding?
			explicitly	implicitly	explicitly	implicitly	
Germany	Mining Act [BundesBerggesetz (BBergG)]	A / U / F / N	providing raw materials	storing filtering transforming nutrient water hosting biodiversity pool platform for human activity acting as carbon pool storing geological archaeological heritage	loss of soil organic matter	erosion water erosion wind contamination diffuse contamination industrial point source flooding landslides salinisation compaction soil sealing loss of soil biodiversity	Y
Greece	Law on Sustainable Urban Planning [Νόμο 2508/1997 για τη «Βιώσιμη οικιστική ανάπτυξη των πόλεων και οικισμών της χώρας»]	A / N	platform for human activity	-	-	soil sealing	Y
Greece	Joint Ministerial Decision on Criteria for Agricultural Land Quality [ΚΥΑ 168040/2010 ΦΕΚ 1528/07-09-10. Καθορισμός κριτηρίων με τα οποία διαβαθμίζεται η αγροτική γη σε ποιότητες και κατατάσσεται σε κατηγορίες παραγωγικότητας]	A	biomass production platform for human activity	-	-	erosion water erosion wind loss of soil organic matter salinisation compaction soil sealing	Y
Hungary	Act on the Formation and Protection of the Built Environment [1997. évi LXXVIII. Törvény az épített környezet alakításáról és védelméről]	U	-	platform for human activity biomass production	soil sealing	-	Y
Hungary	Act on Regional Development and Spatial Planning [1996. évi XXI. Törvény a területfejlesztésről és a területrendezésről]	-	-	platform for human activity	-	soil sealing	Y
Hungary	Act on the National Spatial Plan [2003. évi XXVI. Törvény az Országos Területrendezési Tervről]	A / U / F / N	-	platform for human activity	-	soil sealing	Y
Ireland	National Spatial Strategy	U / F / N	-	biomass production platform for human activity	-	soil sealing	N
Ireland	Planning and Development Act	A / U / F / N	platform for human activity	-	flooding landslides	contamination industrial point source contamination diffuse soil sealing	Y
Italy	Environmental Code [Norme in materia ambientale]	A / F / N	-	biomass production storing filtering transforming nutrients water hosting biodiversity pool platform for human activity	erosion water erosion wind flooding landslides loss of soil organic matter contamination diffuse contamination industrial point source	salinisation compaction soil sealing loss of soil biodiversity	Y
Latvia	General Regulation for the Planning, Use and Building of the Territory [Vispārīgie teritorijas plānošanas, izmantošanas un apbūves noteikumi]	A / U / F / N	platform for human activity	hosting biodiversity pool producing raw materials	erosion water flooding landslides compaction soil sealing	-	Y

Country	Instrument	land use*	Soil functions addressed		Soil threats addressed		Binding?
			explicitly	implicitly	explicitly	implicitly	
Lithuania	Land Productivity Evaluation Methodology [Lietuvos Respublikos Žemės Ūkio Ministro Įsakymas Nr. 3D-359 Dėl žemės našumo vertinimo metodikos atnaujinimo (Žin. 2007, Nr. 87-3468, be pakeitimų)]	A / N	biomass production	-	-	-	?
Luxembourg	Master Programme for Spatial Planning [Programme directeur d'aménagement du territoire (2003)]	A / U / F / N	biomass production hosting biodiversity pool platform for human activity	providing raw materials	erosion water flooding landslides contamination diffuse contamination industrial point sources soil sealing	compaction loss of soil biodiversity	Y
Malta	Strategic Plan for Environment and Development	A / U / F / N	-	hosting biodiversity pool platform for humanactivity storing geological archaeological heritage	erosion water erosion wind flooding landslides salinisation contamination industrial point source contamination diffuse soil sealing loss of soil biodiversity	loss of soil organic matter compaction	Y
Netherlands	Environmental and Planning Act (Draft) [Omgevingswet]	A / U / F / N	biomass production storing filtering transforming nutrients water hosting biodiversity pool platform for human activity providing raw materials storing geological archaeological heritage	platform for human activity acting as carbon pool	contamination diffuse contamination industrial point source	erosion wind erosion water salinisation compaction soil sealing	Y
Poland	Tools for Local Spatial Development Planning [Studium uwarunkowań i kierunków zagospodarowania przestrzennego and/or miejscowy plan zagospodarowania przestrzennego]	A / U / F / N	-	biomass production storing filtering transforming nutrients water hosting biodiversity pool platform for human activity providing raw materials acting as carbon pool	-	erosion water erosion wind flooding landslides loss of soil organic matter contamination industrial point source contamination diffuse compaction soil sealing loss of soil biodiversity	Y
Poland	Regional Spatial Development Plans [Plan zagospodarowania przestrzennego województwa]	A / U / F / N	-	biomass production hosting biodiversity pool platform for human activity acting as carbon pool	soil sealing contamination industrial point source	erosion water flooding landslides loss of soil organic matter compaction loss of soil biodiversity	Y
Poland	National Spatial Development Concept 2030 (NSDC 2030) [Koncepcja Przestrzennego Zagospodarowania Kraju 2030]	A / U / F / N	biomass production platform for human activity acting as carbon pool	hosting biodiversity pool providing raw materials	erosion water flooding landslides contamination industrial point source compaction soil sealing	loss of soil organic matter loss of soil biodiversity	Y
Portugal	National Ecological Reserve [Decreto-Lei n.º 166/2008, (…) e 80/2015, (…) que estabelece o	A / U / F / N	storing filtering transforming nutrients water hosting biodiversity pool	-	erosion water flooding landslides soil sealing	loss of soil organic matter compaction loss of soil biodiversity	Y

Country	Instrument	land use*	Soil functions addressed		Soil threats addressed		Binding?
			explicitly	implicitly	explicitly	implicitly	
	Regime Jurídico da Reserva Ecológica Nacional (REN)]						
Romania	Law on Regulating and Managing Urban Green Areas [Legea nr. 24/2007 privind reglementarea şi administrarea spaţiilor verzi din intravilanul localităţilor, cu modificările şi completările ulterioare]	U	-	storing filtering transforming nutrients water hosting biodiversity pool platform for human activity acting as carbon pool	soil sealing	loss of soil organic matter loss of soil biodiversity	Y
Romania	Government Decision on the Methodology for Landslides and Flooding Risk Maps [HOTĂRÂRE Nr. 447 / 2003 pentru aprobarea normelor metodologice privind modul de elaborare şi conţinutul hărţilor de risc natural la alunecări de teren şi inundaţii]	A / U / F / N	platform for human activity	biomass production storing filtering transforming nutrients water hosting biodiversity pool providing raw materials acting as carbon pool storing geological archaeological heritage	flooding landslides erosion water	loss of soil organic matter loss of soil biodiversity	Y
Slovakia	Land Consolidation Act [Zákon 330/1991 Zb. o pozemkových úpravách, usporiadaní pozemkového vlastníctva, pozemkových úradoch, pozemkovom fonde a o pozemkových spoločenstvách]	A /F	biomass production storing filtering transforming nutrients water hosting biodiversity pool acting as carbon pool	platform for human activity providing raw materials storing geological archaeological heritage	erosion water erosion wind flooding landslides soil sealing loss of soil biodiversity desertification	loss of soil organic matter salinisation compaction	Y
Slovenia	Spatial Planning Act [Zakon o prostorskem načrtovanju]	A / U / F / N	-	platform for human activity	soil sealing	-	Y
Spain	Decree on the Forestation of Agricultural Plots of Land [REAL DECRETO 6/2001, de 12 de enero, sobre fomento de la forestación de tierras agrícolas]	A / F	-	storing filtering transforming nutrients water	erosion water ersosion wind desertification flooding landslides	loss of soil organic matter loss of soil biodiversity	?
Sweden	Swedish Planning and Building Act [Plan- och Bygglagen]	A / U / F / N	platform for human activity	hosting biodiversity pool acting as carbon pool	erosion water flooding landslides contamination industrial point source contamination diffuse	compaction soil sealing	Y
UK (England)	A Housing Strategy for England	A / U / F / N	platform for human activity providing raw materials	-	contamination industrial point source	soil sealing	N
UK	Town and Country Planning	A / U / F / N	platform for human activity providing raw materials	-	soil sealing	-	Y
UK (England)	National Planning Policy Framework	A / U / F / N	platform for human activity	providing raw materials	soil sealing	flooding landslides contamination industrial point source	N
UK	Agricultural Land (Removal of Surface Soil) Act 1953	A	biomass production platform for human activity providing raw materials	storing filtering transforming nutrients water hosting biodiversity pool acting as carbon pool storing geological archaeological heritage	-	-	Y

*Agricultural / Urban / Natural / Forest land

5.5 Examples

In this background section a list of examples that were gathered for elaborating policy brief is given. Note that this list is far from complete. It gives some insight in different tools, methods and projects taking soil quality into account in spatial planning. Special regards go to the INSPIRATION and COST-SUBURBAN networks, for providing so many valuable examples.

Example	Country
Agriculture, forest, nature	
Examples using multiple soil functions for land use planning	
1. Soil security concept	multiple countries
2. Uncertainty assessment of a soil quality index using geostatistics	Italy
3. Agriculture planning with Land capability maps	Italy
4. Land Planning and Soil Evaluation Instruments	EEA Member & Cooperating Countries
5. Soil Evaluation for Planning Procedures (SEPP), providing a basis for soil protection in Alpine regions	Austria
6. Agricultural soil suitability maps	Poland
Examples using ess for agricultural land	
7. Links4Soils	Germany, Austria, France, Italy, Slovenia
8. Ecosystem service indicators & maps for spatial planning in agricultural land	Netherlands
9. Soil-specific agro-ecological strategies for sustainable land use	Spain
10. Alliance for the protection of our soils	Austria
Zoning, regulation as a tool to avoid agricultural and natural land take	
11. Ecologically sensitive areas and prime agricultural soils in Portuguese Municipal Master Plans	Portugal
12. Spatial Planning Guidelines of the Basque Country	Spain
13. Agricultural priority areas and soil function maps	Austria
14. Reducing Soil Sealing and Land Take Compensation of soil loss: protection of best agricultural land	Slovakia
Specific examples (1 soil theme)	
Example on bio-energy	
15. Spatial variation of environmental impacts of regional biomass chains	Netherlands
Natural area characteristics as planning aspect	
16. Species richness in dry grassland patches of eastern Austria	Austria
Urban, industrial	
Examples using multiple soil functions in urban planning	
17. Urban SMS	EU / multiple countries
18. Soil protection in spatial planning – SAGISonline	Austria
19. System Exploration Environment and Subsurface / Balance4P	Netherlands, Belgium, Sweden
20. TUSEC IP: Technique of Urban Soil Evaluation in City Regions	Germany Italy, Switzerland
Ecosystem services for urban planning	
21. TEEB	Germany, Netherlands
22. Ecosystem services considered in spatial planning	Belgium
23. LIFE SAM4PC	Italy
Zoning, regulation as a tool in urban planning	
24. Masterplan of subsoil Helsinki	Finland
25. Glasgow city development plan	UK
26. Lisbon Master Plan (PDML)	Portugal

27. Oslo municipal sub-plan for the underground	Norway
Specific examples (1 soil theme)	
Examples using soil contamination for land use planning	
28. COST Sub-Urban Geochemistry review,	Europe
29. Introducing a method of human health risk evaluation for planning and soil quality management of heavy metal-polluted soils	Italy
30. SURGE (Soil Urban Geochemistry)	Ireland
31. Health Effect Screening (HES)	Netherlands
32. Soil bioindicators as a useful tool for land management and spatial planning processes	France
33. Site Assessment and Re-use Planning Tool (SAT)	Poland, Germany
Climate change	
34. Adaptation support tool	Netherlands / different countries
Nature, biodiversity & groundwater	
35. Living in the “wastine” (rangelands)	Belgium (Flanders)
Soil sealing	
36. Reducing Soil Sealing and Land Take by policy	Austria, Germany, Belgium, Luxembourg, Netherlands, UK
37. Reducing Soil Sealing and Land Take by Financial support for strategic land development	Belgium /Flanders and Germany
38. Reducing Soil Sealing and Land Take Soil Compensation Account	Germany
39. Brownfield Redevelopment / circular land use	EU / multiple countries

Agricultural

Examples using all soil functions for land use planning

[1] Case study / project name: soil security concept			
Type:	research project / methodology	Target group:	Policy makers / planners / experts / other
Countries:	EU / global	level	Local /regional
Project summary including key outputs and outcomes:			
The soil security concept aims to take the full range of functions of soil and subsurface into account when using land and soil. The concept of soil security is divided in five “C’s”: 1) Capability, 2) Condition, 3) Capital, 4) Connectivity, and 5) Codification. In this section, these C’s are applied to spatial planning considering soil functions. 1) Capability: What functions does the soil have? What are the potential functions of the soil for a specific area? 2) Condition: what is requested for that area in terms of land use functions, societal challenges and needs, and what can the soil deliver? In this step, the connection is between the aboveground and the soil-subsurface system. Where there is a mismatch, solutions should be found in design or technical solutions. 3) Capital: using land for hard uses and infrastructures will provide most income, but in (re)-development areas, other values will be of importance to reassure the success of a project. Next to profit, also the people and planet aspects of sustainability are important. Examples of these values can help to promote the approaches of planning with soil and subsurface. 4) Connectivity: This dimension is crucial for realizing urban planning which considers soil and subsurface functions. When land owners, project leaders or important stakeholders do not know or care about soil and subsurface, soil and subsurface information will not be used in the planning process. Again: good examples can help to improve connectivity dimension. 5) Codification: policy, regulation, legislation, governance tools, but also initiatives and examples are all drivers that can help to support taking soil and subsurface into account in urban redevelopment projects. However, urban planning with soil and subsurface is an emerging field of expertise. When all five dimensions of soil security are used we can talk about good land, soil and subsurface management. Soil security is applied on agricultural land but seems to be applicable to urban land as well.			
Soil functions addressed in spatial planning**:**		SDGs addressed:	
Potentially all		2,15	

More information:			
McBratney, A., Field, D.J., Koch, A., 2014. The dimensions of soil security. Geoderma 213, pp 203-213			
[2] Case study / project name: Uncertainty assessment of a soil quality index using geostatistics			
Type:	research project	Target group:	Policy makers / planners / experts / other
Countries:	Italy	level	Local /regional /member state /EU
Project summary including key outputs and outcomes:			
Based on a combination of multivariate geostatistics and GIS technique, Castrignano et al. (2009) estimate soil quality and established regions in south Italy into zones with different soil properties. The practical interest is to characterize the area for establishing the best management to exploit the soil potential. The idea is to create ''thematic-dynamic maps'' of soil quality that may become a useful tool in decision making and land use planning.			
Soil functions addressed in spatial planning**:**		SDGs addressed:	
Provision of food, fibre and biomass		2,15	
More information:			
Castrignano, A. Buondonno, A., Odierna, P., Fiorentino, C., Coppola, E. 2009. Uncertainty assessment of a soil quality index using geostatistics. Environmetrics 20, 298–311.			

[3] Case study / project name: Agriculture planning with Land capability maps			
Type:	Case study / mapping	Target group:	planners
Countries:	Italy	level	Local /regional
Project summary including key outputs and outcomes:			
Land capability maps at 1:50,000 scale (2005 edition). Land capability classification is a system of grouping soils primarily on the basis of their capability to produce common cultivated crops and pasture plants without deteriorating over a long period of time (U.S. Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook). For each delineation, according to the specific proportion of major soil components, the assessment table SINA 2000 provides general guidance for assignments of the class and subclass and for describing limiting factors for the use of the soil. Also Salinity Map at 1:250,000 scale, and Ksat map and Hydrologic Soil Group Map at 1:50.000 scale . This is a WebGis site in Italian language where it is possible to view and query soil maps and other derived thematic of Emilia-Romagna region of Italy. This project started in the middle of the 70s as a support of land planning and it has produced maps at different scales (from 1:10k to 250k). Regarding the Rural Development Plan (RDP) of the Emilia-Romagna (ER) region, the most relevant measures in relation to soil functions are aimed to: (1) increase in soil organic matter; (2) promotion of conservation agriculture; (3) promotion of organic agriculture; (4) ecosystem restoration; (5) biodiversity conservation; (6) sustainable management of extensive grasslands; (7) afforestation of agricultural lands; (8) sustainable management of animal manure. Each of these measures directly impacts one or more of the five soil functions in question.			
Soil functions addressed in spatial planning**:**		SDGs addressed:	
Provision of food, fibre and biomass Carbon storage (incl. climate regulation) Support for biodiversity and nature		2,15	
More information:			
https://applicazioni.regione.emilia-romagna.it/cartografia_sgss/user/viewer.jsp?service=pedologia&bookmark=1%22			

[4] Case study / project name: Land Planning and Soil Evaluation Instruments in EEA Member and Cooperating Countries			
Type:	research project	Target group:	Policy makers / planners / experts / other
Countries:	EU	level	EU
Project summary including key outputs and outcomes:			
The review of land planning and soil evaluation instruments in EEA member and cooperating countries aimed to capture the Europe-wide experience of land-related resource efficiency management tools. Especially those involving land planning instruments, linked to the consideration of soil evaluation, i.e. the assessment of the quality and performance of soils for a specific purpose/use. The report is largely based on a survey run through the European Environmental Information and Observation Network (EIONET) and the National Reference Centre for Land Use and Spatial Planning (NRC LUSP). The analysis of responses to the questionnaire provides insight into current experience of a total of 22 respondent European countries in respect of land use planning and soil evaluation instruments in action. The results are not scientifically representative of Europe-wide experience –given partial nature of the responses. Examples are: Q7: *What are the policies and procedures for addressing soil evaluation as part of land planning? Is the soil evaluation mandatory or voluntary*? In most countries soil evaluation is not addressed , as part of LP except if contamination is suspected. Only in few countries soil evaluation is mandatory. General regulations or laws on soil protection are at NUTS0 level, while land planning changes are often proposed at local level. *Q8a. Which soil characteristics are used in the soil evaluation (geophysical/chemical/biological data)?* Soil characteristics most frequently identified include physical, sometimes chemical and almost never biological (except Finland). In many cases, the answers confirm that in urban planning or in cadastral assessment, soil characteristics are taken into account. Q8b: *In this context, do you categorise/classify soils according to their economic value?* Agricultural land is often classified according to its potential fertility, that is connected to its value.			
Soil functions addressed in spatial planning**:**		SDGs addressed:	
Potentially all		2,15	
More information:			
Ludlow, D., Falconi, M., Carmichael, L., Croft, N., Di Leginio, M., Fumanti, F., Sheppard, A., Smith, N., 2013. Land Planning and Soil Evaluation Instruments in EEA Member and Cooperating Countries (with inputs from Eionet NRC Land Use and Spatial Planning). Final Report for EEA from ETC/SIA (EEA project managers: G. Louwagie and G. Dige). Available at: http://www.eea.europa.eu/themes/landuse/document-library.			

[5] Case study / project name: Soil Evaluation for Planning Procedures (SEPP), providing a basis for soil protection in Alpine regions			
Type:	Case study / research project	Target group:	Policy makers / planners / experts / other
Countries:	Austria	level	Local /regional /member state /EU
Project summary including key outputs and outcomes:			
The starting point of this project was the detected lack of adequate information about soils and soil quality. Most important sources of information for soil evaluation on the regional level are soil maps (or more precisely: maps of soil types) in scales from 1:5,000 to 1:50 000, which are available for open land in most Alpine countries. For Austria, these sources are presented and discussed in detail in a publication by the Austrian Society of Soil Science (Österreichische Bod- enkundliche Gesellschaft 2001).			
Soil functions addressed in spatial planning**:**		SDGs addressed:	
Provision of food, fibre and biomass		15	
More information:			
Geitner, C. & M. Tusch (2007, im Druck): Soil Evaluation for Planning Procedures. Providing a Basis for Soil Protection in Alpine Regions. – Proceedings of “Managing Alpine Future”, International Conference on Global Change in Innsbruck, 15-17 Oct 2007. Innsbruck. https://www.uibk.ac.at/geographie/bola/projects/sepp/			

[6] Case study / project name: agricultural soil suitability maps			
Type:	methodology	Target group:	Policy makers / planners / experts
Countries:	Poland	level	Country
Project summary including key outputs and outcomes:			
soil suitability maps have been developed with full-country coverage in scales of 1:5000 and 1:25 000. The latter has been digitised and updated to reflect current land use status (of 2016). The information on the map includes soil profile texture, relief and water regime, overall fertility and suitability for different crop types. There is a data base of 10 000 geo-referenced soil profiles containing laboratory analyses of texture, organic matter content, pH, cation exchange capacity, etc. Geo-coding techniques were employed in order to link soil profile information with soil suitability polygons on the map. This layer is used for the delineation of less favoured areas, forestation projects, elaboration of management plans of river basins. In the spatial planning process, such information resources, along with cadastral and soil bonitation maps, are used to depict boundaries of organic soils and the most fertile agricultural land, which is legally restricted for urban development. Digital soil maps are also used for drought monitoring, which is based on the climatic water balance, as the threshold criteria for taking support action following drought event are based on a combination of climatic water balance and soil profile texture. A set of pedotransfer functions and models were developed or adopted to derive additional information, such as soil organic matter stock, wind and water erosion risk, nitrogen leaching to ground and surface waters. The database contains analyses of metals (Zn, Pb, Ni, Cu, Pb, Cr), texture pH and OM for 50 000 geo-referenced samples taken from a horizon throughout the country – this data allows risk modelling of metal transfer to the food chain. There is also a continuous monitoring, repeated in 5-year cycle, for over 200 soil profiles, located throughout the country on arable land. The purpose of this project, which started in 1995, is to assess the impact of urbanization, transport and industry on soil properties, as well as on concentrations of heavy metals and polycyclic aromatic hydrocarbons.			
Soil functions addressed in spatial planning:		SDGs addressed:	
Provision of food, fibre and biomass		2,15	
More information:			
Siebielec G., Smreczak B., Klimkowicz-Pawlas A., Maliszewska-Kordybach B., Terelak H., Koza P., Hryńczuk B., Łysiak M., Miturski T., Gałązka R., Suszek B. 2012. The monitoring of the chemistry of Polish arable soils in 2010-2012. Puławy: IUNG, 4-25. (in Polish) http://www.gios.gov.pl/images/dokumenty/pms/monitoring_jakosci_gleb/monitoring_chemizmu_gleb_2010_2012.pdf Stuczynski T., Helios Rybicka E., Pechalski J. 2003 Environmental Studies of Agricultural Soils in Poland. Journal of Soils & Sediments 3 (4) 254 – 256. Białousz S., Marcinek J. , Stuczyński T. Turski R. 2005. Soil Survey, Soil Monitoring and Soil Databases in Poland. European Soil Bureau. Research Report No. 9. Pages 263-273.			

Examples using ecosystem services for agricultural land

[7] Case study / project name: Links4Soils			
Type:	Case studies	Target group:	Policy makers / planners / experts / other
Countries:	Germany, Austria, France, Italy, Slovenia	level	regional
Project summary including key outputs and outcomes:			
The Alpine Soils Platform (5 EU countries plus Switzerland) Links4Soils Interreg project. Sustainable spatial planning includes evaluation of soil ecosystem services. Case studies on integrating the Soil Ecosystem Services (SES) approach into spatial planning sector of municipalities are Upper Bavaria, Germany and Tyrol Austria. Results will be transferred into practical regional/local management plans and then exchanged within Alpine stakeholder			
Soil functions addressed in spatial planning:		SDGs addressed:	
Potentially all		15	
More information:			
https://alpinesoils.eu/best-practices/spatial-planning/			

[8] Case study / project name: ecosystem service indicators and maps for spatial planning in agricultural land			
Type:	research projects	Target group:	experts
Countries:	Netherlands	level	Local /regional /member state /EU
Project summary including key outputs and outcomes:			
A rapid and efficient instrumentation to assess land use sustainability is still needed. Land-use expectations can be linked to quantifiable soil features in a defendable and transparent way. This is a step-wise approach with land user consultations and contributions of soil professionals in order to arrive at a site-specific indication system for ecosystem services. Soil chemical and biological characteristics are considered. (Rutgers et al. 2012) Maps play an important role during the entire process of spatial planning and bring ecosystem services to the attention of stakeholders' negotiation more easily. A tool for raising awareness and environmental assessment and planning is to express the performance of ecosystems on maps. A map of the natural attenuation of pollutants is developed based on several properties of Dutch soils. The different agricultural land uses are related to soil types. The link between current planning systems and GIS analyses offers several possibilities to inform and eventually regulate agricultural land use in The Netherlands (Van Wijnen et al., 2012).			
Soil functions addressed in spatial planning**:**		SDGs addressed:	
Water purification and soil contaminant reduction		2,15	
More information:			
Rutgers, M., van Wijnen, H.J., Schouten, A.J., Mulder, C., Kuiten, A.M.P., Brussaard, L., Breure, A.M. 2012. A method to assess ecosystem services developed from soil attributes with stakeholders and data of four arable farms. Science of the Total Environment 415, 39–48. Van Wijnen, H.J., Rutgers, M., Schouten, A.J., Mulder, C., de Zwart, D., Breure, A.M. 2012. How to calculate the spatial distribution of ecosystem services — Natural attenuation as example from The Netherlands. Science of the Total Environment 415, 49–55.			

[9] Case study / project name: Soil-specific agro-ecological strategies for sustainable land use			
Type:	research project / case study	Target group:	experts
Countries:	Spain	level	Local /regional /member state /EU
Project summary including key outputs and outcomes:			
De la Rosa et al. (2009) designed sustainable land use and management practices for Mediterranean sites in Sevilla (Spain) using input data collected in standard soil surveys. By applying their quality models, their results show that some current land uses are entirely wrong with respect to agro-ecological potentialities and limitations, especially, many marginal areas are dedicated to agriculture. The outputs of their model recommend machinery type, soil inputs, workability timing, crop diversification, etc. and established the sensitive soil types for the different management practices in the area studied.			
Soil functions addressed in spatial planning**:**		SDGs addressed:	
Provision of food, fibre and biomass		2,15	
More information:			
De la Rosa, D., Anaya-Romero, M., Heredia, N., Shahbazi, F. 2009. Soil-specific agro-ecological strategies for sustainable land use – A case study by using MicroLEIS DSS in Sevilla Province (Spain). Land Use Policy 26, 1055–1065.			

[10] Case study / project name: Alliance for the protection of our soils			
Type:	Initiative	Target group:	Policy makers / planners / experts / other
Countries:	Austria	level	Local /regional /member state /EU
Project summary including key outputs and outcomes:			
In 2014, the "**Alliance for the protection of our soils**" (the Austrian "Bodencharta 2014") was signed by ten organizations (Ökosoziales Forum, Climate Alliance, Municipal Association, BMLFUW, Chamber of Agriculture Austria, Federal Environmental Agency, Austrian Hail Insurance, Trade Association, Federal Research Center for forest, etc.) to preserve the Austrian soil and stop the massive use of land of an average of 22.4 hectares per day. Goals are the future avoidance of development high-quality agricultural soils and increasing the use of already developed areas. The GREEN INFRASTRUCTURE PRACTICES FROM AUSTRIA (Environment Agency Austria) aims to integrate biodiversity and ecosystem services in spatial planning.			
Soil functions addressed in spatial planning:		SDGs addressed:	
Provision of food, fibre and biomass Support for biodiversity and nature Soil sealing and land take		2,15	
More information:			
http://www.lebensraumvernetzung.at/publikationen/LRV_Endbericht_Teil%201_web.pdf			

Zoning, regulation as a tool to avoid agricultural and natural land take

[11] Case study / project name: ecologically sensitive areas and prime agricultural soils in Portuguese Municipal Master Plans			
Type:	policy	Target group:	Policy makers / planners / experts
Countries:	Portugal	level	regional
Project summary including key outputs and outcomes:			
Soil capability is always considered in (urban/rural) spatial planning of Portugal. More specifically in Portugal the soil is divided in 5 capability classes, with the first two to be Agriculture reserve and the last ecologic reserve. This is the base when we start urban/regional spatial planning and after it is added more restrictions and conditions related to protected areas, water bodies etc..			
Soil functions addressed in spatial planning:		SDGs addressed:	
Provision of food, fibre and biomass		2,15	
More information:			
http://epic-webgis-portugal.isa.ulisboa.pt/			

[12] Case study / project name: Spatial Planning Guidelines of the Basque Country			
Type:	tool	Target group:	Policy makers / planners / experts / other
Countries:	Spain	level	Local /regional /member state /EU
Project summary including key outputs and outcomes:			
These Spatial Planning Guidelines do include a particular tool or instrument called "Matriz de usos" (see pages 355-367 of the document for details). This matrix aims at establishing the "categories for potential land uses" in the non-developable land, which considers, amongst other criteria, the ecological processes related to soil protection and aquifer recharge and also high agrological value soils. There are 6 categories of physical environment management defined according to their territorial vocation. For each of this categories a series of conditions are identified. Subsequently, a list of types of land use is defined, which may be detailed by land use planning instruments and general urban planning plans if necessary. Then, a specific use regulation is applied to those zones or categories (Favourable, Admissible, Forbidden). In turn, this specific regime of uses established for each category of management can be conditioned by those identified as "overlapping conditions", related to natural risks and climate related (geological, flooding, sea level rise).			

• Eg Category 2a.1 a *SPECIAL PROTECTION: applies to well-preserved native forests, to the estuaries and estuaries, to the river complexes in good condition, to the beaches, to the interior humid areas, to the coastal cliffs, the culminating or singular vegetation areas and, in general, to all the valuable elements from the point of view of ecology, culture, landscape, or all of it together. Specifically, this category will be included: The areas that play an important role in the maintenance of essential ecological processes such as the protection of soils, or the recharge of aquifers, for example.(…)* • Eg Category *2a.4 AGRICULTURAL/ livestock: groups soils of very different agrological capacity, from the mosaics of the Cantabrian countryside, irrigated lands or with horticultural uses, the vineyards and areas of extensive agriculture to broken soils but with low agricultural performance. The category Agroganadera and Campiña is subdivided into two subcategories: AGRICULTURAL/ livestock a of High Strategic Value: soils with greater agrological capacity and land of agricultural operations that, due to their modernity, profitability or sustainability, are considered strategic for the sector.*	
Soil functions addressed in spatial planning:	SDGs addressed:
Provision of food, fibre and biomass	2, 15
More information:	
EAEko Lurralde Antolamenduaren Gidalerroen Berrikuspena, 2018. Revisión de las Directrices de Ordenación Territorial de la CAPV. Spain http://www.euskadi.eus/contenidos/informacion/dots/es_1165/adjuntos/APROBACION%20INCIAL/Diligencia%20de%20la%20Aprobaci%C3%B3n%20inicial%20de%20la%20revisi%C3%B3n%20de%20las%20DOT.pdf	

[13] Case study / project name: agricultural priority areas and soil function maps			
Type:	policy	Target group:	Policy makers / planners / experts
Countries:	Austria	level	regional
Project summary including key outputs and outcomes:			
Some examples from Austria are the provinces Steiermark, Tirol (where the spatial planning authority (at the province level) designates “agricultural priority areas” which must not be zoned as building land) and Oberösterreich, Salzburg. Both provinces have produced soil function maps for their provinces. Municipalities have to use these maps within spatial planning. For instance, a new settlement area must not be zoned in an area where soils have many functions at a high level.			
Soil functions addressed in spatial planning:		SDGs addressed:	
Provision of food, fibre and biomass		2,15	
More information:			
Personal communication from Gundula Prokop, Department for soil and land use management, Umweltbundesamt GmbH, Federal Environment Agency Austria. For both examples there are guidance documents and maps available, in German only. Refs UFZ			

[14] Case study / project name: Reducing Soil Sealing and Land Take Compensation of soil loss: protection of best agricultural land			
Type:	policy	Target group:	Policy makers / planners / experts
Countries:	Slovakia	level	Local / regional/ national
Project summary including key outputs and outcomes:			
Compensation of soil loss: protection of best agricultural land, to steer new infrastructure developments to areas with less valuable soils, to establish a soil protection funds ○ Compensation payments for agricultural soils (Slovakia) Conversion of protected agricultural land to building land requires a fee, depending on the quality of the affected soil, ranging from 6 – 15 Euros per m^2 21 % of the Slovakian are subject to a compensation fee.			
Soil functions addressed in spatial planning:		SDGs addressed:	
Soil sealing and by that: • Water flows regulation (incl. water/ discharge storage) • Provision of food, fibre and biomass		11,13,15	

• Soil related cultural services (incl. cultural heritage, archaeology, landscape) • Climate regulation	
More information:	
presentation of Gundula Prokop (Federal Environment Agency Austria), GREEN WEEK, 2011, at http://ec.europa.eu/environment/archives/greenweek2011/sites/default/files/3.2_prokop.pdf sealing http://adsabs.harvard.edu/abs/2017EGUGA..19.8418L EC guidelines on best practice to limit, mitigate or compensate soil sealing	

Specific examples (1 soil theme)

Example on bio-enenergy

[15] Case study / project name: Spatial variation of environmental impacts of regional biomass chains			
Type:	research project	Target group:	Policy makers / planners / experts / other
Countries:	Netherlands	level	Local /regional /member state /EU
Project summary including key outputs and outcomes:			
Study about the effects of land use change (agriculture) and establishes sustainability criteria of bioenergy production. It is assumed that only agricultural land (both arable land and pastures) is used for the cultivation of bioenergy crops . The assessment demonstrates a framework to identify areas with potential negative environmental impacts of bioenergy crop production and areas where bioenergy crop production have little negative or even positive environmental impacts. Methods include soil quality indicators (SOC, soil erosion) together with water, GHG emissions, and biodiversity.			
Soil functions addressed in spatial planning**:**		SDGs addressed:	
Provision of food, fibre and biomass Support for biodiversity and nature		7,15	
More information:			
Van der Hilst, F., Lesschen, J.P., van Dam, J.M.C., Riksen, M., Verweija, P.A., Sanders, J.P.M., Faaij, A.P.C. 2012. Spatial variation of environmental impacts of regional biomass chains. Renewable and Sustainable Energy Reviews 16, 2053– 2069.			

Natural area characteristics as planning aspect

[16] Case study / project name: Species richness in dry grassland patches of eastern Austria: a multi-taxon study on the role of local, landscape and habitat quality variables			
Type:	research project	Target group:	Policy makers / planners / experts / other
Countries:	Austria	level	regional
Project summary including key outputs and outcomes:			
The Pannonian part of eastern Austria was characterized by large, extensively used grassland areas until the Second World War. Agricultural use of the fragmented grassland, though gradually ceased during the 1960s and 1970s, has been re-established during the last decades, encouraged by EU agri-environmental schemes. Zulka et al. (2016) integrates the study of soil quality variables together with biodiversity variables aiming at selecting high quality areas for conservation strategies of native grasslands. As a first step, soil type is addressed by selecting suitable grassland areas only on Tertiary or Quaternary materials, avoiding the areas with poor soils. The work is supported by at least 6 different Austrian research Institutes and two management and protection Agencies.			
Soil functions addressed in spatial planning**:**		SDGs addressed:	
Provision of food, fibre and biomass Support for biodiversity and nature		15	
More information:			
Zulka, K. P., Abensperg-Traun, M., Milasowszky, N., Bieringer, G., Gereben-Krenn, B.-A., Holzinger, W., Hölzler, G., Rabitsch, W., Reischütz, A., Querner, P., Sauberer, N., Schmitzberger, I., Willner, W., Wrbka, T., Zechmeister, H. 2014. Species richness in dry grassland patches of eastern Austria: a multi-taxon study on			

the role of local, landscape and habitat quality variables. Agriculture, Ecosystems & Environment 182 : 25–36.

Urban

Examples using multiple soil functions in urban planning

[17] Case study / project name: URBAN SMS			
Type:	Case study / research project / "business as usual"	Target group:	Policy makers / planners / experts / other
Countries:	Multiple EU	level	Local /regional /member state /EU
Project summary including key outputs and outcomes:			
The URBAN SMS project is advocating a broader view on soils in the city. Soil is a basis for space for housing, industrial and commercial purposes as well as infrastructure, recreational areas and food production. But soils in the urban environment also offer sustaining biological activity, diversity and productivity; regulating and partitioning water and solute flow; filtering, buffering, degrading, immobilizing and detoxifying of harmful substances originating from industrial and municipal by-products as well as from atmospheric depositions; storing and cycling nutrients and other elements within the earth's biosphere; production of renewable primary products; control of microclimate and mesoclimate, and providing support for socioeconomic structures and protecting archaeological treasures. Sustainable urban soil management means taking the broad range of soil functions into account.			
Soil functions addressed in spatial planning:		SDGs addressed:	
multiple functions		11,15	
More information:			
http://www.umweltbundesamt.at/en/services/services_resources/services_soil_spatial/en_urbansms/urbansms_casestudies/ Blumlein P., H.J. Kircholtes, M. Schweiker, G. Wolf, B. Schug, I. Wieshofer, Sigbert Huber, M. Parolin, F. Villa, A. Zelioli, M. Biasioli, P. Medved, Tomaz Vernik, Borut Vrščaj, Grzegorz Siebielec, Josef Kozák, I. Galuskova, E. Fulajtar, Jaroslava Sobocká, S. Jaensch, 2012 Soil in the City. Urban Soil Management Strategy. ISBN: 978-3-943246-07-0, City of Stuttgart – Department for Environmental Protection, Germany			

[18] Case study / project name: soil protection in spatial planning – SAGISonline			
Type:	Tool	Target group:	planners / soil experts
Countries:	Austria	level	Local
Project summary including key outputs and outcomes:			
Soil takes on important functions in the natural environment. It is the site of natural vegetation and crops of agriculture and forestry. It acts as a storage and balancing body in the water balance, and serves as a filter, buffer and transformer for pollutants that are introduced into the soil. The soil protects the groundwater from contamination. In addition, Soil is a document of landscape and cultural history in recognizing and preserving historical developments in its structure. After all, he is also the carrier of various uses. Nevertheless, the diverse functions of the soil are often disregarded in the planning. A transparent and comprehensible methodology for the assessment of the individual soil functions should enable an integration of the protected property soil into spatial decision-making processes. For this purpose, the state of Salzburg provides a comprehensive soil function assessment in the SAGISonline on the basis of the soil estimation data of the Federal Ministry of Finance. To facilitate the interpretation of the function maps, a reading aid was developed in collaboration with planning offices, which is made available to the municipalities, town planners and specialist planners. The reading aid is intended to assist users in the use of the data provided and provides appropriate background information on the subject and shows examples of use and measures for soil protection.			
Soil functions addressed in spatial planning:		SDGs addressed:	
Soil contamination		3,11,15	
More information:			

https://www.salzburg.gv.at/sagisonline/(S(zfxenlb4a0q1iz3vzc2rpzgy))/init.aspx?karte=basis&geojuhuschema=Adressen/Namensgut&defaultlogo=agrarwald&gdiservices=Landnutzung/Landbedeckung&gdiservices=rohstoffe_und_geologie&gdiservices=landforstjagd&gdiservices=raumordnung&gdiservices=hoehen&gdiservices=umwelt&gdiservices=natur&gdiservices=boden&sichtbar=Nat%C3%BCrliche%20Bodenfruchtbarkeit&massstab=50000&koord=434000;306000			
[19] Case study / project name: System Exploration Environment and Subsurface / Balance4P			
Type:	Case study / research project / tool	Target group:	planners / experts
Countries:	Netherlands, Belgium, Sweden	level	Local
Project summary including key outputs and outcomes:			
The background to the Balance 4P project is the idea that a better cooperation between urban developers and subsurface specialists in early phases of the redevelopment process can accelerate urban and brownfield redevelopment and potentially identify more sustainable strategies. Balance 4P was developed in close cooperation with three case studies in the three countries involved: Sweden, Belgium and The Netherlands. In the project were, next to the end-users, soil and subsurface engineers and urban planners involved. In this example the System Exploration Environment and Subsurface SEES tool is elaborated. SEES is about gathering information and investigation of what demands, objectives and boundary conditions exist for the urban project. This is done for the “aboveground” matters. How many houses, offices, amenities and other functions are needed, what objectives exists in the area in terms of meeting societal needs (food, drinking water, energy production, shelter, infrastructure) and overcoming societal challenges (climate change mitigation and adaptation, increasing demands on non-renewable natural resources, environmental justice). This is also done for soil and subsurface qualities. These qualities consists of challenges (problems or boundary conditions) for the aboveground developments and of opportunities (soil functions and services) that can be employed within the urban brownfield regeneration. Examples of the challenges are contamination, low carrying capacity of the soil, existing subsurface constructions or infrastructures that might hinder new constructions, or unexploded ordnance. Examples of opportunities are: possibility to use aquifer thermal energy storage (ATES), water storing capacity in the upper layer of the soil to mitigate peak discharges, production capacity for green areas and parks, and building conditions. To investigate this connection between the aboveground and subsurface, the stakeholders should be involved. For this the, System Exploration Environment and Subsurface (SEES) was developed. Note that the subsurface topics are divided in themes that recognizable and appeal to urban developers: civil structures, energy, water and soil (green). Output of this step is project redevelopment alternatives based on subsurface conditions. Outcome of this step is the co-creation, the networking and the cooperative learning on site-specific surface and subsurface conditions and ambitions.			
Soil functions addressed in spatial planning**:**		SDGs addressed:	
multiple functions		11, 15	
More information:			
https://publicwiki.deltares.nl/display/SEES/HOME+English Norrman, J., Volchko, Y., Maring, L., Hooimeijer, F., Broekx, S., Garção, R., Kain, J.-H., Ivarsson, M. Touchant, K., Beames A., 2015a. Balance 4P: Balancing decisions for urban brownfield regeneration – technical report. Report 2015:11. Department of Civil and Environmental Engineering, Chalmers University of Technology. Gothenburg, Sweden. Norrman, J., Volchko, Y., Hooimeijer, F., Maring, L., Kain, J-H., Bardos, P., Broekx, S., Beames, A., Rosén, L., 2016. Integration of the subsurface and the surface sectors for a more holistic approach for sustainable redevelopment of urban brownfields. Science of the Total Environment, 563-564, pp 879–889. Hooimeijer & Maring (2018) The significance of the subsurface in urban renewal. In: Journal of Urbanism: International research on placemaking and urban sustainability. pp 1-12			

[20] Case study / project name: TUSEC IP: Technique of Urban Soil Evaluation in City Regions – Implementation in Planning Procedures			
Type:	Case study / research project	Target group:	Policy makers / planners / experts / other
Countries:	Germany Italy, Switzerland	level	Local /regional
Project summary including key outputs and outcomes:			
Soil Evaluation in Spatial Planning. A contribution to sustainable spatial development. Results of the EU-**Interreg IIIB Alpine Space Project TUSEC-IP.** Results include the Soil Evaluation Procedure TUSEC, UNITO Soil Evaluation Method, and their implementation in planning procedures. There are no statutory requirements which dictate mandatory integration of soil evaluation results in spatial planning processes. Together, soil scientists and town planners are developing a procedure for ecological soil evaluation to help make sensible, sustainable use of the capabilities of soils. The Alpine Soil Information & Decision Support Platform encourages stakeholders from cross-cutting sectors like forestry, agriculture, spatial planning to benefit from the first Alps-wide Soil Information and Decision Support Platform that includes an expert Soil Consultancy Service, sectoral best-case practices, soil information etc. in order to integrate soil topic into **local and regional management and planning**. The Alpine Soil Web-Platform aims to disseminate the best soil management practices. (there were 10 test areas/case studies)			
Soil functions addressed in spatial planning:		SDGs addressed:	
Multiple functions		11,15	
More information:			
http://www.provinz.bz.it/umweltagentur/download/tb-english_definitiva__stampa.pdf 2006			

Examples using ecosystem services in urban planning

[21] Case study / project name: TEEB			
Type:	tool	Target group:	planners / soil experts
Countries:	Germany, Netherlands	level	Local
Project summary including key outputs and outcomes:			
What is the return on an investment in greenery? Permanent investments in urban greenery require better insight into the value of greenery. TEEB City (The Economics of Ecosystems and Biodiversity) substantiates these values. The tool provides immediate insight into the value of green and blue measures envisaged in a project. The TEEB City tool is a generic instrument that can be used in actual practice by assigning values to “green” and “blue” measures. For example, the effect of green roofs on energy-saving or water storage, or the construction of a park driving up rateable values. The tool does not just provide insight into the value of greenery and water in a city, but also shows which parties benefit from the measures.			
Soil functions addressed in spatial planning:		SDGs addressed:	
Potentially all functions		3,11	
More information:			
https://www.teebstad.nl/			

[22] Case study / project name: ecosystem services considered in spatial planning			
Type:	research projects	Target group:	Policy makers / planners / experts / other
Countries:	Belgium	level	Local /regional
Project summary including key outputs and outcomes:			
In 2017, the Environment Department of the Flemish Government drew up a framework for the consideration of residential development areas. The assessment framework should help the government to make well-considered choices: Which areas provide essential ecosystem services to nearby urban areas? Where can open space be built and where preferably not? The supply of and demand for ecosystem services in the most urbanized part of Flanders were also examined.			
Soil functions addressed in spatial planning:		SDGs addressed:	
multiple functions		11, 15	
More information:			

<table>
<tr><td colspan="4">https://www.ruimtelijkeordening.be/NL/Diensten/Onderzoek/Studies/articleType/ArticleView/articleId/9078
https://www.ruimtelijkeordening.be/NL/Diensten/Onderzoek/Studies/articleType/ArticleView/articleId/9012</td></tr>
<tr><td colspan="4">[23] Case study / project name: LIFE SAM4CP</td></tr>
<tr><td>Type:</td><td>Project / tool</td><td>Target group:</td><td>Policy makers / planners / experts</td></tr>
<tr><td>Countries:</td><td>Italy</td><td>level</td><td>Local</td></tr>
<tr><td colspan="4">Project summary including key outputs and outcomes:</td></tr>
<tr><td colspan="4">The LIFE SAM4CP project aims to create an easy-to-use simulator allowing territorial decision makers to include the ecological functions of soil within the assessment of the environmental and economic costs and benefits associated with possible urban planning and land-use measures and choices.
The simulator allows different territorial transformation scenarios to be assessed according to the seven main ecological functions (carbon capture, biodiversity, purification of water –characterized by nutrient retention and water availability –, erosion of soil, timber production, pollination, crop production) provided by soil in order to integrate these functions – and their potential gain or loss – into the decision-making process. The tool aims to help avoid land-use decisions that disproportionately reduce soil functions. It also aims to enable a proper evaluation of the potential costs and benefits of specific measures aimed at reducing soil sealing. It will be used to help draft a municipal land-use plan to preserve the ecosystem services provided by soils.
This tool has been applied in four Municipalities of the Metropolitan City of Turin. These Municipalities were selected by a public request of interest in addition to their diverse characteristics from a morphological, demographic and socioeconomic point of view.
Objectives of the project were:
•showing to what extent land planning, that integrates in decision making processes an evaluation of environmental benefits granted by free soil, provides a considerable reduction inland take and an overall saving for the community, thanks to the preservation of natural and public financial resources;
•enhancing and complementing in local government tools 7 E.C. (carbon capture, biodiversity, purification of water –characterized by nutrient retention and water availability –, erosion of soil, timber production, pollination, crop production);
•protecting and providing a sustainable use of soil resource, highlighting the negative effects of land take for the environmental evaluation of a land;
•preserving and enhancing the overall ecosystem functions freely offered by soil to the community;
•avoiding public costs from the restoration of ecosystem functions provided by soil as well as land maintenance;
•protecting agricultural functions of soil by keeping the other functions unaltered.</td></tr>
<tr><td colspan="2">Soil functions addressed in spatial planning:</td><td colspan="2">SDGs addressed:</td></tr>
<tr><td colspan="2">Provision of food, fibre and biomass
Water purification (and soil contaminant reduction)
Carbon storage (incl. climate regulation)
Support for biodiversity and nature</td><td colspan="2">11,15</td></tr>
<tr><td colspan="4">More information:</td></tr>
<tr><td colspan="4">www.sam4cp.eu/en
www.sam4cp.eu/playsoil
www.sam4cp.eu/simulsoil</td></tr>
</table>

Zoning, regulation as a tool in urban planning

[24] Case study / project name: Masterplan subsurface Helsinki			
Type:	policy	Target group:	Policy makers / planners
Countries:	Finland	level	Local
Project summary including key outputs and outcomes:			
The City of Helsinki has more than 200 km of technical maintenance tunnels, 60 km of which are utility tunnels used by a number of operators. The raw water for the Helsinki region comes via a rock tunnel measuring more than 100 km. Wastewater treatment is carried out centrally at an underground wastewater treatment plant. Approximately 9 million cubic meters, consisting of about 400 separate facilities or tunnels, have been built under the city. The Helsinki Underground Master Plan controls the locations, space allocations and mutual compatibilities of the newest, largest and most important underground rock caves, facilities and traffic tunnels. 40 new areas and 100 new space allocations are reserved as rock resources for future rock construction. Energy wells of ground-source heating and cooling are becoming more and more common. Large energy fields for large targets such as shopping centres, office buildings, hotels, and public buildings have also been brought in use. The underground city planning has to pay attention to possible conflicts between different ways to use the bedrock resources.			
Soil functions addressed in spatial planning**:**		SDGs addressed:	
Existing obstacles and structures in soils (Cables and pipes, Underground structures, Unexploded Ordnance, Old mines, Sinkholes etc) Provision of energy (ATES, geothermal, fossil resources)		7,11	
More information:			
https://static1.squarespace.com/static/542bc753e4b0a87901dd6258/t/5707847d37013bb703023e29/1460110490550/TU1206-WG1-007+Helsinki+City+Case+Study.pdf http://sub-urban.squarespace.com/s/TU1206-WG1-007-Helsinki-City-Case-Study.pdf			

[25] Case study / project name: Glasgow City Development Plan			
Type:	Case study	Target group:	planners / experts
Countries:	UK	level	Local
Project summary including key outputs and outcomes:			
In the city of Glasgow (UK) the geological survey has worked with the Glasgow City Council on developing and exchanging data sets and methods about the ground beneath Glasgow and beyond in the "Accessing subsurface knowledge – ASK Network". They have made 3D models available for the public to improve both awareness about what is under our feet and make the information available. Also, following the sustained collaboration between BGS and GCC, the proposed new City Development Plan now incorporates consideration of the subsurface environment and resources in the planning policy framework. This development reflects an increasing awareness of the role of the subsurface in supporting a sustainable economy and vibrant, healthy society and environment. The proposed City Development Plan is the first planning policy for Glasgow to explicitly recognize the environmental and economic value of the subsurface.			
Soil functions addressed in spatial planning**:**		SDGs addressed:	
Potentially all functions		11	
More information:			
https://static1.squarespace.com/static/542bc753e4b0a87901dd6258/t/57078ac3044262231705b636/1460112086450/TU1206-WG1-005+Glasgow+City+Case+Study.pdf and http://www.bgs.ac.uk/research/engineeringGeology/urbanGeoscience/Clyde/askNetwork/home.html			

[26] Case study / project name: The Lisbon Master Plan (PDML)			
Type:	Case study	Target group:	planners / experts
Countries:	Portugal	level	Local
Project summary including key outputs and outcomes:			
Lisbon Master Plan (PDML), published on 30th August 2012, is a territorial planning instrument, mandatory to all public entities and private contractors, covering all municipal territory. It establishes a spatial organizational model and development strategy, urban policies and orientations to the municipal territory, soil classification and the rules and parameters to its occupation, use and transformation. In the first version of 1994, the PDML did not take into account the importance of geology, subsurface environment and resources in its planning policy. As an increasingly awareness of the importance of these matters, the new PDML integrates initiatives and measures, through the maintenance of natural systems to promote mitigation and to reduce the vulnerability of natural and human systems against the effects from: natural hazards (floods, landslides, soils seismic vulnerability), soils contamination and climate changes, actual or expected, with the implementation of complementary solutions, for example by creating a Green Structure based on continuous green corridors, and intervention in risk areas. The PDML also introduces several new concepts, patent in Maps and Regulation (figure underneath), such as “Geomonuments”, “Hydro mineral Occurrences”, “Pluvial Water Storage Structures”, “Susceptibility to Landslide”, “Flood and Tidal Effect Vulnerability”, “Soils Seismic Vulnerability”, “Permeability index”, “Soil Permeability”, “Vegetal Pondered Surface”, “Hydrogeology Characterization Data” and “Hydrogeology Studies”, among others, aiming towards the preservation and conservation of natural heritage and environmental resources and values.			
Soil functions addressed in spatial planning:		SDGs addressed:	
obstacles and structures in soils (Cables and pipes, Underground structures, Unexploded Ordnance, Old mines, Sinkholes etc) Provision of energy (ATES, geothermal, fossil resources)		11	
More information:			
http://sub-urban.squarespace.com/s/TU1206-WG1-015-Lisbon-City-Case-Study-amn7.pdf			

[27] Case study / project name: Oslo municipal sub-plan for the underground			
Type:	Case study	Target group:	planners / experts
Countries:	Norway	level	Local
Project summary including key outputs and outcomes:			
In the city of Oslo (Norway), underground space is already widely used for transportation, storage, extraction of heat and for foundations of buildings and infrastructure. Due to the rapid growth of the city the underground use is expected to develop rapidly. The city of Oslo deals with geological challenges such as deep horizons of clay, often containing a large amount of organic matter, alum shale’s that contains enhanced levels of radium and uranium, and quick clays. Oslo is presently developing the first generation of a legally binding land use master plan, according to the 2008 law revision. The most significant achievement for the underground is that the plan proposal contains a demand to consult with infrastructure owners before drilling wells within a shown boundary. This is to protect future major infrastructure such as a new railway tunnel and a new metro tunnel through central parts of the city. It may be relevant for Oslo to develop a municipal sub-plan for the underground, and the “Oslo Sub surface project” has passed a recommendation to start the development of such a plan, much like the one developed for Helsinki. Main constructions to include in the planning process of a municipal sub plan for the underground are: future railway tunnels, future metro tunnels, future main road tunnels. Other structures that are considered to include in the municipal sub plan for the underground are: expansion of the main district heating pipe system, major electricity cables, future development of the central water and sewage system etc.			
Soil functions addressed in spatial planning:		SDGs addressed:	
obstacles and structures in soils (Cables and pipes, Underground structures, Unexploded Ordnance, Old mines, Sinkholes etc) Provision of energy (ATES, geothermal, fossil resources)		11	
More information:			
https://static1.squarespace.com/static/542bc753e4b0a87901dd6258/t/5707869ae707eb820b4118a5/1460111042910/TU1206-WG1-012+Oslo+City+Case+Study.pdf			

Specific examples (1 soil theme)

Examples using soil contamination for land use planning

[28] Case study / project name: COST Sub-Urban Geochemistry review			
Type:	review	Target group:	planners / soil experts
Countries:	Austria, UK, France	level	Local
Project summary including key outputs and outcomes:			
The main need of city planners in relation to the geochemical quality of soils and subsoils is to have reasonable and representative visualisation of the data in a form, which enables them to be used effectively, and in an integrated way with other datasets (socio-economic, health, etc.). The current state of knowledge in relation to soil geochemistry (when available) is overwhelmingly based on surface (topsoil) and very near surface sampling of subsoils. This is expressed in the form of 2D mapping, based on interpolation between sample sites. 2D topsoil acquisition is particularly well suited for addressing health issues; deeper acquisitions are needed in relation to urban (re)development, construction work and remediation of contamination. 3D geochemical knowledge, although as yet uncommon, could be very useful in optimizing urban redevelopment projects, anticipating contamination problems, and managing excavated materials (e.g. local reuse possibilities, disposal costs etc.). Because all of these aspects can have important economic, environmental and social consequences, they are considered essential for urban sustainable development. To meet these future 3D and potentially even 4D (temporal and predictive) needs, improved development of data acquisition, management, visualisation and use of these are crucial steps. Some examples of good practice, or at least of best efforts, are illustrated by case studies. For instance, the Vienna (Austria) and Glasgow (UK) case studies illustrate urban geochemical sampling surveys. The examples of Nantes and of the French BDSolU (Base de données sur les Sols Urbains - French national database on urban soils), may be referred to as good efforts with respect to 3D geochemical databases. The example of Nantes is also suggested as an example of best effort in terms of use of 3D urban geochemical data.			
Soil functions addressed in spatial planning**:**		SDGs addressed:	
Soil contamination		3,11,15	
More information:			
http://sub-urban.squarespace.com/new-index-1/#geochemistry-wg-26			

[29] Case study / project name: Introducing a method of human health risk evaluation for planning and soil quality management of heavy metal-polluted soils			
Type:	Case study	Target group:	planners / soil experts
Countries:	Italy	level	Local
Project summary including key outputs and outcomes:			
Spatial planning and land management decisions should be made in consideration of the effects on risks that arise from **contaminated soils**. Poggio et al. (2008) designed a method to indicate the potential level of human health risks due to heavy metal concentrations in urban soils, accounting for the potential impact of land use on such risks and providing **suggestions on the most suitable land use** to reduce the risk, including agricultural use. Soil data and information were taken from a soil survey and the effects of different types of land use on soil properties and on the capacity of the soil to fulfil certain functions were taken into account.			
Soil functions addressed in spatial planning**:**		SDGs addressed:	
Soil contamination		3,11,15	
More information:			
Poggio, L., Vrscaj, B., Hepperle, E., Schulin, R. Marsan, F. 2008. Introducing a method of human health risk evaluation for planning and soil quality management of heavy metal-polluted soils—An example from Grugliasco (Italy). Landscape and Urban Planning 88, 64-72.			

[30] Case study / project name: SURGE (Soil Urban Geochemistry) Project			
Type:	Case study	Target group:	planners / soil experts
Countries:	Ireland	level	Local
Project summary including key outputs and outcomes:			
The Dublin SURGE (Soil Urban Geochemistry) Project is Dublin's first baseline survey of heavy metals and persistent organic pollutants in topsoils and is part of a Europe-wide initiative to map urban geochemical baselines in ten cities. The geochemistry of rural Irish topsoil was mapped and some localized elevated concentrations of elements were identified in relation to urban areas, mining and intensive agricultural activities. The project results provide a basis for the inclusion of soil geochemical concentrations as an important consideration in urban land use planning.			
Soil functions addressed in spatial planning:		SDGs addressed:	
Soil contamination		3,11,15	
More information:			
Glennon, M.M., Harris, P., Ottesen, R.T., Scanlon, R.P., O'Connor, P.J. 2014. The Dublin SURGE Project: geochemical baseline for heavy metals in topsoils and spatial correlation with historical industry in Dublin, Ireland. Environ Geochem Health 36, 235–254			

[31] Case study / project name: Health Effect Screening (HES) (gezondheidseffectscreening GES)			
Type:	Tool	Target group:	planners / soil experts
Countries:	Netherlands	level	Local
Project summary including key outputs and outcomes:			
HES stands for health effect screening. HES has been developed to clarify the actual health risks from some environmental factors in spatial planning, in addition to legal environmental standards or agreements, which are not always sufficient to avoid risks and complaints. The HES is a health-based translation of spatial environmental information. It makes the health risks (also under the standards) visible. The ambition is to stimulate the municipalities to go under the standards (even then health effects can occur) and to strive for a better environmental quality. Using GES health risks are made comparable (air, smell, noise, external safety, soil contamination, electromagnetic fields). This makes it possible to weigh up spatial plan variants. The GES is a screening instrument, not a legal assessment tool. There is consensus among various agencies about how it can be used and interpreted.			
Soil functions addressed in spatial planning:		SDGs addressed:	
Soil contamination		3,11	
More information:			
Fast T., P.J. van den Hazel2, D.H.J. van de Weerdt. 2012. Handboek GES versie 1.6. GGD Nederland https://www.ggdghorkennisnet.nl/thema/ges/publicaties/publicatie/5888			

[32] Case study / project name: Soil bioindicators as a useful tool for land management and spatial planning processes: a case-study of prioritization of contaminated soil remediation			
Type:	Research / case study	Target group:	planners / soil experts
Countries:	France	level	Local
Project summary including key outputs and outcomes:			
When setting up new land management, contaminated site remediation or soil use change are sometimes necessary to ensure soil quality and the restoration of the ecosystem services. The biological characterization of the soil can be used as complementary information to chemical data in order to better define the conditions for operating. Then, in the context of urban areas, elements on the soil biological quality can be taken into consideration to guide the land development. To assess this "biological state of soil health", some biological tools, called bioindicators, could provide comprehensive information to understand and predict the functioning of the soil ecosystem.			
Soil functions addressed in spatial planning:		SDGs addressed:	
Soil contamination		3,11	
More information:			
Grand, Cécile; Pauget, Benjamin; Villenave, Cécile; Le Guédard, Marina; Piron, Denis; Nau, Jean-François; Pérès, Guénola, 2017, Soil bioindicators as a useful tools for land management and spatial planning processes: a case-study of prioritization of contaminated soil remediation, 19th EGU General Assembly, EGU2017, proceedings from the conference held 23-28 April, 2017 in Vienna, Austria., p.9647			

[33] Case study / project name: Site Assessment and Re-use Planning Tool (SAT)			
Type:	Research / case study	Target group:	planners / soil experts
Countries:	Poland, Germany	level	Local
Project summary including key outputs and outcomes:			
The TIMBRE web based site assessment and re-use planning tool (SAT) is intended to serve the purpose of initiating and fostering communication among stakeholders with respect to (i) the joint design of brownfield reuse options, and (ii) the evaluation of the consequences of these options with respect to criteria such as remediation costs, sustainability, market values, etc. The tool is specifically designed for use by interested stakeholders including non-experts. There is a full desktop version and a "light", online version available. The "light" version of the tool can be used by a wide group of users. Only a subset of input parameters is changeable by the user, i.e. those kinds of parameters that can reasonably be specified by non-experts. This version, therefore, has limited capabilities in terms of interactive data handling by end-users, but has full assessment and modelling features and works on the full data set used by the expert version. The tool is distinguished between: • site-specific assessment modules that evaluate the situation/conditions at a site with respect to a particular aspect (e.g. bioenergy potential) in general (for the site but not specific to a certain re-use option), and • option-specific assessment modules that evaluate the situation/conditions at a site with respect to a particular aspect and a particular re-use option (e.g. estimation of costs for remediation required to implement the re-use option)			
Soil functions addressed in spatial planning:		SDGs addressed:	
Soil contamination		3,11	
More information:			
http://www.timbre-project.eu/en/site-assessment-tool.html			

Urban planning and soils considered for climate change

[34] Case study / project name: Adaptation support tool			
Type:	tool	Target group:	Planners, designers and experts
Countries:	EU - World	level	Local
Project summary including key outputs and outcomes:			
The AST is a touch-table-based system to support planning for climate resilience. In workshops or behind a desk stakeholders can select adaptation interventions, situate them in a project area and immediately assess effectiveness and cost to (co)create a design. The AST shows a ranked list of measures in the left panel, based on local conditions. The centre panel shows a map of the project area in which base layers (e.g Google maps) and thematic layers (e.g. digital elevation model) can be shown. Users can draw/design the measures on the map the AST provides an assessment of the effects of the measures in key metrics. These metrics are shown on the AST dashboard in the right hand panel. These metrics are based on characteristics of the measures, multi-reservoir models and literature values. Key metrics include storage capacity, flood reduction, groundwater recharge and evapotranspiration, heat stress, the effects on water quality. The AST now includes 72 blue, green and grey measures for ecosystem-based adaptation. Typical examples of "blue-green" solutions are green roofs, bioswales, porous pavements and retention soil filters. The AST is part of the Adaptation Planning Support Toolbox to support the complete collaborative design process in both the initiative phase and the planning phase. In the initiative phase the AST can be used to explore the full range of green infrastructure and traditional measures and show an approximate effect to create a more climate resilient environment. The AST has been applied in for example Berlin, London, Amsterdam and Utrecht. In Utrecht is was used to explore the options to achieve the ambition to create one of the most green, sustainable, healthy and climate resilient urban districts in Europe.			
Soil functions addressed in spatial planning:		SDGs addressed:	
Water flows regulation (incl. water/ discharge storage) Drinking water resources		11,13,15	
More information:			
ast.deltares.nl			

Urban planning considering nature, biodiversity & groundwater

[35] Case study / project name: Living in the "wastine" (rangelands)			
Type:	Case study	Target group:	planners / developer
Countries:	Belgium	level	Local
Project summary including key outputs and outcomes:			
"Wonen in de Wastine": the architects convinced the developer to change the initial plan to build a housing estate in marshland. Instead they developed piers on which they developed housing. The project is unique because of its concept - more than two-thirds of the building land is being reallocated to ecologically valuable nature and the soil is included as a design parameter - and through its process - the plan was designed together with the neighborhood and other stakeholders. This master plan is an exercise to new housing with the creation of nature and the increase of biodiversity. The swampy soil and the ecosystem value of this area are enhanced in the plans. The center is located on a slightly higher sand ridge surrounded by lower lying woodland with a high groundwater table. The rainwater that seeps through the sand back stagnates on the underlying clay layer, spreads horizontally and returns to the surface by seepage and in pools. The site in question is such a water-rich place where ponds reach the surface and where - if one leaves nature on its course - a specific rangeland or "wastine' with typical fauna and flora will form. The site has a very high potential for nature enhancement and upgrading of biodiversity. These qualities, in combination with the swampy subsoil and the need to take account of the specific water management, make it strongly advised not to follow traditional spatial planning at this location. Moreover, we note that the classical urban planning schemes for the development of rural residential communities very rarely take into account their effects on nature and landscape. In Flanders, which is built up with fragmented buildings in low density, it is time for a new approach.			
Soil functions addressed in spatial planning**:**		SDGs addressed:	
Carrying capacity of soils Soil related cultural services (incl. cultural heritage, archaeology, landscape) Water flows regulation (incl. water/ discharge storage) Support for biodiversity and nature		11,15	
More information:			
https://www.oostkamp.be/download.ashx?id=44139			

Urban planning and soil sealing

[36] Case study / project name: Reducing Soil Sealing and Land Take by policy			
Type:	Policy	Target group:	Policy makers / planners / experts
Countries:	Austria, Germany, Belgium, Luxembourg, Netherlands, UK	level	Local / regional/ national
Project summary including key outputs and outcomes:			
Prokop (2011) presented some best practices to avoid and reduce Soil Sealing and Land Take within spatial planning. This best practice concerns reducing Soil Sealing and Land Take by policy: Policy targets can be: • Quantitative limits for annual land take exist in 6 Member States (Austria & Germany – limits are defined in hectare per day for a target year; Belgium (Flanders), Luxembourg, the Netherlands – limits are based on inner urban development i.e. 60% of new developments within defined inner urban boundaries; • the United Kingdom (England) limits are based on brownfield redevelopment i.e. new housing on already developed land			
Soil functions addressed in spatial planning**:**		SDGs addressed:	
Soil sealing and by that: • Water flows regulation • Provision of food, fibre and biomass • Soil related cultural services (incl. cultural heritage, archaeology, landscape)		11,13,15	

• Climate regulation	
More information:	
presentation of Gundula Prokop (Federal Environment Agency Austria), GREEN WEEK, 2011, at http://ec.europa.eu/environment/archives/greenweek2011/sites/default/files/3.2_prokop.pdf sealing http://adsabs.harvard.edu/abs/2017EGUGA..19.8418L EC guidelines on best practice to limit, mitigate or compensate soil sealing	

[37] Case study / project name: Reducing Soil Sealing and Land Take by Financial support for strategic land development			
Type:	Presentation with case studies	Target group:	Policy makers / planners / experts
Countries:	Belgium /Flanders and Germany	level	Local / regional/ national
Project summary including key outputs and outcomes:			
Prokop (2011) presented some best practices to avoid and reduce Soil Sealing and Land Take within spatial planning. This best practice concerns Reducing Soil Sealing and Land Take by Financial support for strategic land development: realisation of sustainable land development projects; i.e. acquisition of land for strategic development projects, remediation of run down areas and the establishment of green urban areas. • Belgium /Flanders: The local governments submit their proposals to the spatial planning department of the Flemish government, where they are ranked for approval. (2010 budget: 2.1 million euro). http://www.rsv.vlaanderen.be/nl/strategischeProjecten/ • Germany (Baden Württemberg): 13 model villages committed themselves to avoid new developments on green field sites. Available funding per municipality 0.6 – 1.5 mio. Euro. Æ focus on inner urban development potentials ; empty and underused buildings and sites, innovative conversion http://www.melap-bw.de/ identification and visualisation of underused and derelict sites in village centres Æ in many cases planned settlement enlargements were obsolete.			
Soil functions addressed in spatial planning**:**		SDGs addressed:	
Soil sealing and by that: • Water flows regulation (incl. water/ discharge storage) • Provision of food, fibre and biomass • Soil related cultural services (incl. cultural heritage, archaeology, landscape) • Climate regulation		11,13,15	
More information:			
presentation of Gundula Prokop (Federal Environment Agency Austria), GREEN WEEK, 2011, at http://ec.europa.eu/environment/archives/greenweek2011/sites/default/files/3.2_prokop.pdf sealing http://adsabs.harvard.edu/abs/2017EGUGA..19.8418L EC guidelines on best practice to limit, mitigate or compensate soil sealing			

[38] Case study / project name: Reducing Soil Sealing and Land Take Soil Compensation Account			
Type:	Presentation with case studies	Target group:	Policy makers / planners / experts
Countries:	Germany	level	Local / regional/ national
Project summary including key outputs and outcomes:			
Prokop (2011) presented some best practices to avoid and reduce Soil Sealing and Land Take within spatial planning. This best practice concerns the Soil Compensation Account (Dresden – Germany): Long term planning target built-up land for settlements and traffic shall be confined to 40% of the total urban land. New developments on undeveloped land require adequate desealing measures or “greening” measures somewhere else but within the city boundaries (exemption: inner urban developments). On average 4 ha urban derelict land are desealed.			
Soil functions addressed in spatial planning**:**		SDGs addressed:	
Soil sealing and by that:		11,13,15	

• Water flows regulation (incl. water/ discharge storage) • Provision of food, fibre and biomass • Soil related cultural services (incl. cultural heritage, archaeology, landscape) • Climate regulation	
More information:	
presentation of Gundula Prokop (Federal Environment Agency Austria), GREEN WEEK, 2011, at http://ec.europa.eu/environment/archives/greenweek2011/sites/default/files/3.2_prokop.pdf sealing http://adsabs.harvard.edu/abs/2017EGUGA..19.8418L EC guidelines on best practice to limit, mitigate or compensate soil sealing	

[39] Case study / project name: Brownfield Redevelopment / circular land use			
Type:	Case study / research project	Target group:	Policy makers / planners / experts / other
Countries:	CZ, PL FR, UK, BE, FI	level	Local /regional
Project summary including key outputs and outcomes:			
The 2011 Roadmap for Resource-Efficient Europe (part of Europe 2020 Strategy) is considering land as a finite and shrinking resource. The aim is “By 2020, EU policies take into account their direct and indirect impact on land use in the EU and globally, and the rate of land take is on track with an aim to achieve no net land take by 2050”. Re-use of land (e.g. “new” industrial land on brownfields) is therefore key to a solution instead of consuming new greenfields. Within re-use, soil challenges (e.g. considerable soil sealing, or soil contamination as a legacy of former activities) need to be considered, while soil qualities (soil related ESS, such as productivity, water storage capacity) can be capitalized within the new land use. Linking land use to soil quality is also a strategy to avoid land degradation. Brownfield Redevelopment- avoid new land take by reusing already developed land for new infrastructure projects. Brownfield organisations coordinate initial or supportive funding to encourage new infrastructure developments on brownfield sites • CZ & PL: Czech Invest and Invest in Silesia are in charge of developing major industrial brownfields for new industrial investors (focus on industrial investors). http://www.czechinvest.org/en http://www.invest-in-silesia.pl/ • FR: France disposes of a network of more than 20 public land development agencies (Etablissement Public Foncier), which among other activities develop brownfield land for social housing. http://www.epfl.fr/sites/internet/epffrance/Pages/default.aspx • UK: The Homes and Communities Agency (formerly English Partnerships) provides funding for social housing developments on derelict areas. http://www.homesandcommunities.co.uk/home • BE/Fl: Brownfield covenants are negotiated between the government and private investors to promote brownfield redevelopment.			
Soil functions addressed in spatial planning**:**		SDGs addressed:	
Multiple soil functions		11,15	
More information:			
Circuse project Preuß, T. & Verbücheln, M., (Eds.), 2013. Towards Circular Flow Land Use Management. The CircUse Compendium, Berlin. HOMBRE project: Zerobrownfields.eu TIMBRE project: http://www.timbre-project.eu/en/brownfield.html CABERNET: Ferber, U, Grimski, D, Millar K., Nathanail, P. (2006-II). Sustainable Brownfield Regeneration: CABERNET (The Concerted Action on Brownfield and Economic Regeneration Network) Network Report			

5.6 Research questions considering spatial planning from the INSPIRATION SRA

The research questions of the INSPIRATION strategic research agenda[45] on spatial planning considering soil quality are summed up underneath.

Recognizing the value of ecosystem services in land use decisions T2 / IRT-2
Assessing magnitude and societal distribution of costs and benefits of land use options (e.g. through cost-benefit analysis, cost-effectiveness analysis or multi-criteria analysis) can help mainstream the value of ecosystem services into decision-making.
Integrated scenarios for the Land-Soil-Water-Food nexus under societal pressures and challenges T5 / IRT-5
Identification of land use scenarios that deliver benefits to society AND to the environment and lead to changes in soil management and spatial planning. Growing populations increase soil and land degradation thereby rendering the remaining scarce fertile soils vulnerable to overuse and further degradation. Scenarios modelling will help assess major impacts and decrease further degradation, secure food and identify ways of achieving land degradation neutrality. Changes in the economy and the society should estimate like growing / shrinking areas and their impact to the land-soil-sediment-water system.
Indicators for assessing the efficiency of the Soil-Sediment-Water-Energy nexus of resources T6 / IRT-6
National, regional, local authorities would benefit from a more global and informed vision of the utility (private and public) of their decisions if they were supplied with indicators helping to measure the consequences of their decisions on the natural resources. This “footprint” type of indicators will permit a statistical scoreboard to be used to analyse environmental impacts through the whole global economic cycle and thus better balance societal benefits and ecological effects of different resource-use options.
Circular land management T8 / IRT-8
Research is required to understand the patterns of behaviour and interdependencies of actors, especially land owners, active in land-related policy areas on a theoretical and practical level. It is important to combine the strategies and instruments by circular land management through applied research and pilot case studies and in the sense of modular “tool boxes” to qualify a sustainable land management.
Policies to effectively reduce land consumption for settlement development T9 / IRT-9
Knowledge on how to design effective policies given the institutional constraints of their implementation and enforcement will be necessary to realize the benefits of reduced land consumption in rural and urban areas.
Stakeholder participation to facilitate the development of liveable cities T10 / IRT-10
Understanding the potential of stakeholder participation will help to ensure the liveability of urban development and enhance transparency and legitimacy of decision-making.
Integrated management of soils in urban areas T11 / IRT-11
Better understanding the role of urban soils in improving quality of urban space and consequently on health and living quality.
Environmentally friendly and socially sensitive urban development T12 / IRT-12
Solutions that bridge the goals of urban environmental protection and social concerns of urban development are crucial to realize sustainable cities. Knowledge on environmental issues in urban planning as well as on social concerns is partly available but has to be deeper, up to date and better integrated.

[45] http://www.inspiration-agenda.eu/

Urban Metabolism – Enhance efficiency of using soil-sediment-water resources through closing of urban material loops T13 / IRT-13
Without further development of the methodological concept of urban metabolism, it will be not possible to identify comprehensive measures to enhance urban resource efficiency, consistency and sufficiency. Practically useable urban metabolism instruments and tools are needed at different scales (local, regional, national and supranational) to address indirect impacts, such as rebound effects or indirect land consumption. Such new instruments and tools will help manage our common resource basis, minimize negative ecological effects, foster the local economy through a circular urban economy and support a long term, high level of urban quality of life.
Sustainable management to restore the ecological and socio-economic values of degraded land T15 / IRT-15
Dedicated research will elaborate degradation-type and region-specific restoration and rehabilitation approaches for valorisation of degraded areas.
Innovative technologies and eco-engineering 4.0: Challenges for a sustainable use of agricultural, forest and urban landscapes and the SSW system T16 / IRT-16
Improved rural and urban land use through appropriate sustainable technologies, exploitation of comprehensive data collected by high-quality on- and off-site sensors, and purposeful communication. Eco-engineering for the design, monitoring and management of rural and urban ecosystems can integrate human society into the natural and man-made environment. Identifying what is a sustainable intensification via industrial or organic agriculture and forestry will help planning and permitting.
Climate change challenges - improving preparedness and response for climate conditions and related hazards T17 / IRT-17
Spatial planning could be an instrument to deal with effects of climate change, but only if we have a better understanding of climate change mitigation, adaptation and counteracting negative climate phenomena. Integrated strategies on soil protection and land management should help reduce direct and indirect impacts from climate change. New technical and operational solutions can be developed using low cost, widely available data science.
Quantity and quality of soils, health of soils, soil carbon, greenhouse gases T18 / NC-1
Land use conflicts may be resolved by sustainable land management concepts based on natural capital and multiple ecosystem services provided by the soil-sediment-water system.
The 4 F´s: Food, feed, fibre, (bio)fuel T25 / D1
This research will strengthen the transition towards a circular and biobased economy, by quantifying the societal demand of this transition for soil functions.
Urban / infrastructure land T27 / D3
This research will contribute to land use conflict resolution, the liveability of shrinking regions and villages, increased brownfield regeneration and land re-use, which will help save soils for other purposes.
Water T28 / D4
Current and future water demand scenarios will enable more futureproof land use decision making to ensure the delivery of sufficient and clean water for future generations.
Areas where Natural hazards are prevented T30 / D6
This research will reduce occurrence, duration and severity of natural hazards, by developing alternative land use management strategies that will increase the natural resilience to floods, fires, land subsidence, erosion and landslides.
Health and quality of life (living environment) T31 / D7
Research on the contribution of nature to health and well-being will allow for better spatial design to optimize these health benefits, especially with respect to vulnerable groups in deprived areas.
Governance, management mechanisms, instruments and policy T32 / LM1
Improved policies, governance structures and institutions to promote sustainable land management throughout Europe.

Climate changes challenges for land management T33 / LM2
This will enable the design of effective spatial planning and land use management systems to deal with extreme weather events, (e.g. flooding, droughts) and other environmental stresses.

Land as a resources in rural areas (Multifunctionality of rural areas) T35 / LM4
This research will contribute to maintaining and improving soil fertility, and nutrient and pesticide management. It will support nature conservation and provide options to deal with urban sprawl and rural depopulation.

Developing impact assessment methodology T36 / NI1
Developing monitoring and impact assessment methodology will enable us to detect and assess emerging threats from global environmental change (such as climate change), land management and pollution to human health and well-being, biodiversity conservation and ecosystem service provision as well as the prosperity of our economies.

Understanding and assessing impacts of drivers and management T37 / NI2
This research will provide us with an understanding of the magnitude of the ecological, economic and social impacts of climate change, land management decisions, emerging and/or mixed pollutants, socio-economic drivers of land management and land use change, and policies, planning and regulation.

Trade-off analysis & decision support T38 / NI3
Research on comparative assessment of land management options will support realizing synergies and trading off conflicts between different societal demands with regard to land use and land management.

Science-Policy-Society Interface T39 / NI4
Strengthening the science-policy-society interface will facilitate knowledge-based development and implementation of land use policies by awareness raising, stakeholder involvement and policy integration.