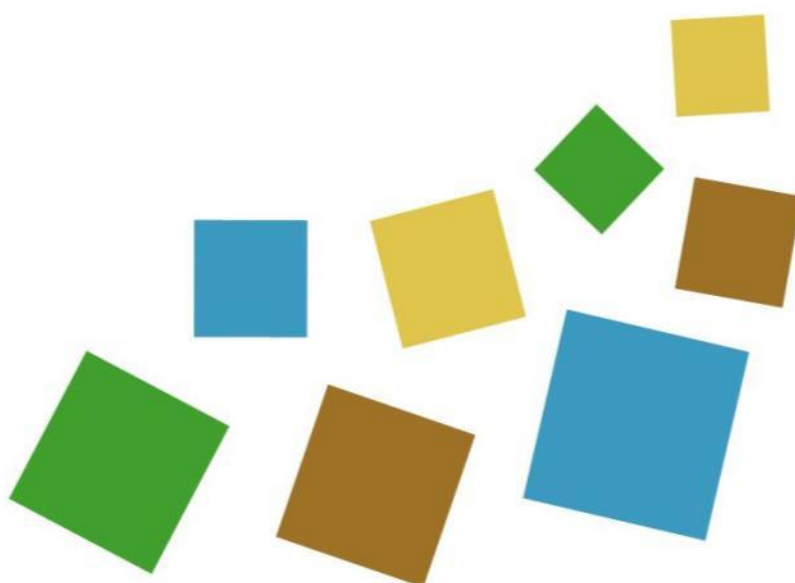




**INSPIRATION report
concluding 2nd project phase:
Enriched, updated and prioritised
overview of the transnational shared
state-of-the-art as input to develop a
Strategic Research Agenda
and for a matchmaking process**

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1. Introduction to INSPIRATION and this report

The aim of the EC H2020 co-funded coordination and support action INSPIRATION is to adopt a funder and end-user demand-driven approach to establish and promote the adoption of a Strategic Research Agenda (SRA) for land use, land-use changes and soil management in the light of current and future societal challenges. The main objectives are

- **formulating, consulting on and revising an end-user oriented SRA;**
- **scoping out models of implementing the SRA;**
- **preparing a network of public and private funding institutions willing to commonly fund the execution of the SRA.**

INSPIRATION's mission is to improve the supply and effectiveness of science/knowledge take-up by decision-makers in policy, administration and business. INSPIRATION's methodology is based on a multi-stakeholder, multi-national and interdisciplinary approach that covers the variety of stakeholders (public bodies, business, science, and society) and the variety of relevant funders.

The interface to engage with all relevant stakeholders across the 17 European countries involved in INSPIRATION is a National Focal Point (NFP) in each country. In the first year of the project in Working Package (WP) 2, which started in March 2015, the NFP's have organized interviews and workshops with more than 500 national key stakeholders (NKS), i.e. funders, end-users of research and researchers, across the various soil and land management disciplines to identify i.a. national research and innovation (R&I) needs (see INSPIRATION deliverable D2.5 – Brils et al. 2016)¹.



Picture 1: Participants at INSPIRATION WP3 – National-Key-Stakeholders workshop in Venice, September 2016

¹ Brils, J. et al. (2016): National reports with a review and synthesis of the collated information. Final version as of 01.03.2016 of deliverable 2.5 of the HORIZON 2020 project INSPIRATION. EC Grant agreement no: 642372, UBA: Dessau-Roßlau, Germany.

This report is available on the INSPIRATION website for download at: http://www.inspiration-h2020.eu/sites/default/files/upload/documents/20160301_inspiration_d2.5.pdf

In the second project phase, these national R&I needs were taken up by WP3 in order to cluster them and detect the trans-national and trans-boundary research needs. Following an intensive stakeholder engagement process, specific clustered themes topics as well as integrated research topics were identified giving an overview of transnational shared research demands on solutions for yet unmet societal challenges (cf. Makeschin et al. 2016)². **This report concludes the results of the second project phase.** It documents the outcomes of an INSPIRATION Core Group meeting devoted to concluding on the topics, priorities and potential coalitions that will enter the matchmaking process in WP 4 – thereby closing the second project phase.

Based on these results, a cross-country and cross-discipline dialogue will subsequently be organized among the relevant user communities, funding bodies and scientific communities in Europe in order to reach a transnational, prioritized SRA as well as a model for implementation of this SRA in WP4. Thus a SRA will be produced which will give national funders confidence that for each Euro they spend, they will get multiple Euro's worth of knowledge in return in order to address their national societal challenges.

Learn more about the INSPIRATION coordination and support action on the project's website: www.inspiration-h2020.eu and follow us on twitter: [@inspiration4eu](https://twitter.com/inspiration4eu) or subscribe to our newsletter with an email to inspiration@brgm.fr.



Picture 2: Participants at INSPIRATION WP3 – National-Key-Stakeholders workshop in Faro, June 2016

² Makeschin F, Schröter-Schlaack C, Glante F, Zeyer J, Gorgon J, Ferber U, Villeneuve J, Grimski D, Bartke S (2016): INSPIRATION - Enriched, updated and prioritised overview of the transnational shared state-of-the-art as input for WP4 to develop the SRA. Final version as of 30.09.2016 of deliverable D3.3 of the HORIZON 2020 project INSPIRATION. EC Grant agreement no: 642372, UBA: Dessau-Roßlau, Germany.

This report is available on the INSPIRATION website for download at: <http://www.inspiration-h2020.eu/sites/default/files/upload/documents/20160930-inspiration-d3.3-final.pdf>

2. Background to this report

2.1 Context of this report: Objectives of INSPIRATION Work Package 3

This report documents the outcomes of an INSPIRATION Core Group meeting devoted to concluding on the topics, priorities and potential coalitions that will enter the matchmaking process in WP 4. The meeting took place on 13 October 2016 in Berlin, Germany. Participating were all WP-Leaders, all Theme Leaders, the Coordinators, CG secretary and both WP4 key workers. The meeting was based on the Deliverable D3.3 report (Makeschin et al. 2016) and a preparatory online CG-call on 30 September 2016.

The D3.3 report presents the key results of WP3. Within the five WPs of INSPIRATION, WP3 is responsible for the collation, review and synthesis of national research demands delivered by WP2 in the 17 countries involved in INSPIRATION (see figure 1). This has been done via a desk study, several transnational multi-stakeholder workshops and working meetings with INSPIRATION consortium members.

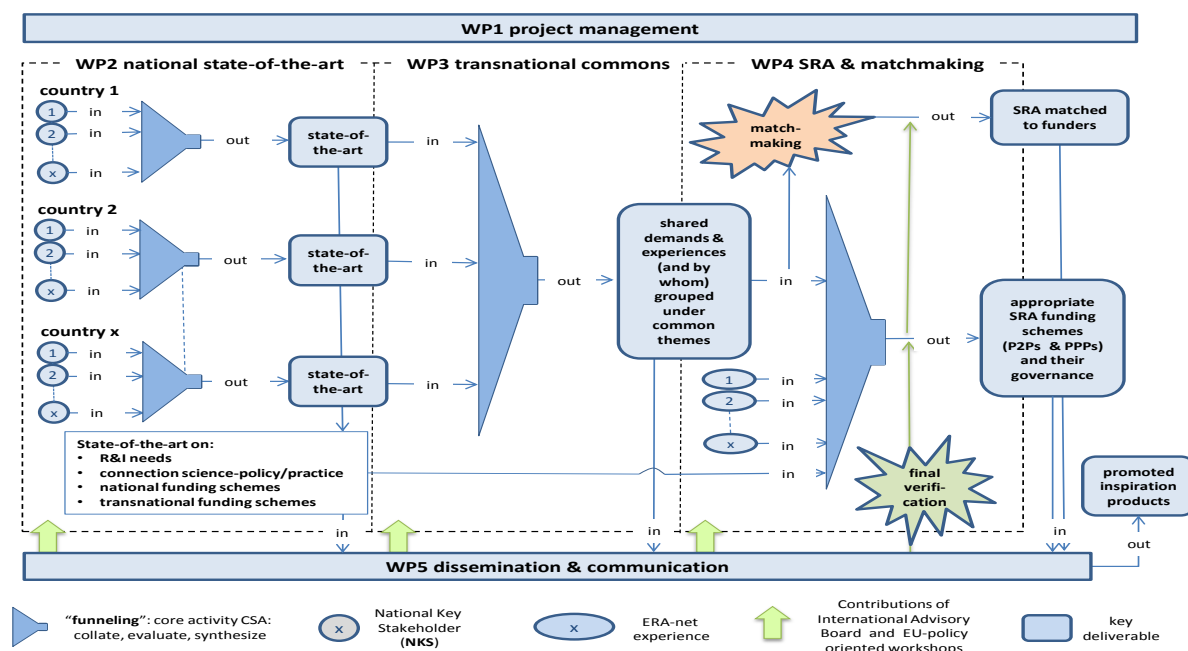


Fig. 1: Work plan and work packages in INSPIRATION

The main objectives of WP3 within INSPIRATION have been

- **to achieve an overview of the transnational shared demands and experiences grouped under common themes based on the national state-of-the-art reports as produced by WP2 – results presented in this report;**
- **to prioritise and elaborate the topics that could be included in the SRA (to be developed by WP4) under specific themes – based on a prioritization and analysis process in October 2016; and**
- to elucidate the opportunity to match (to be done under WP4) individual stakeholders (as funders) to specific SRA topics that could be shared trans-nationally – pursued in parallel to both objectives above.

WP3 consistently follows the key concept of INSPIRATION, which is a bottom-up approach which aims at basing the SRA on the demands of key stakeholders in the INSPIRATION partner countries. The National Focal Points (NFPs) have analysed the national inputs, have collated topics of national R&I needs and have gathered experiences regarding connecting science to policy/practice, the national and European funding schemes, and additionally other remarks and suggestions made by interviewees from more than 500 National Key Stakeholders (NKS) in the 17 INSPIRATION countries in WP2 (see D2.5 – footnote on p. 4). During the implementation of WP3, NFPs and NKS have been systematically involved in order to ensure that stakeholder demands to address their unmet societal challenges are taken thoroughly into account. The stakeholder engagement in WP3 was designed with the goal to ensure the following objectives:

1. Information check: Ensure that information provided in the national reports is correctly understood and considered in identification of the transnational research topics
2. Relevance check: Ensure that the transnational and -sectoral research issues reflect the most pressing and important national research demands of the stakeholders

At the end of WP3 by October 2016, the synthesized national R&I needs exit the funnel in the centre in Fig. 1 as 'output' of WP3 to be included in WP4 for writing-up the SRA and for the match-making process. The D3.3 report summarized the enriched, updated and (by the selection done) prioritised overview of the transnational shared state-of-the-art as input for WP4 to develop the SRA. It was at the same time a background document for the final work steps in WP3, which has been the prioritization and selection of topics for the SRA documented in this report.

2.2 Methodological background – Ensuring a bottom-up demand-driven SRA

Fig. 2 shows the workflow of WP3 between March and October 2016 including desk study, transnational multi-stakeholder workshops forming the transnational commons towards WP4. Find details in the subchapters below.

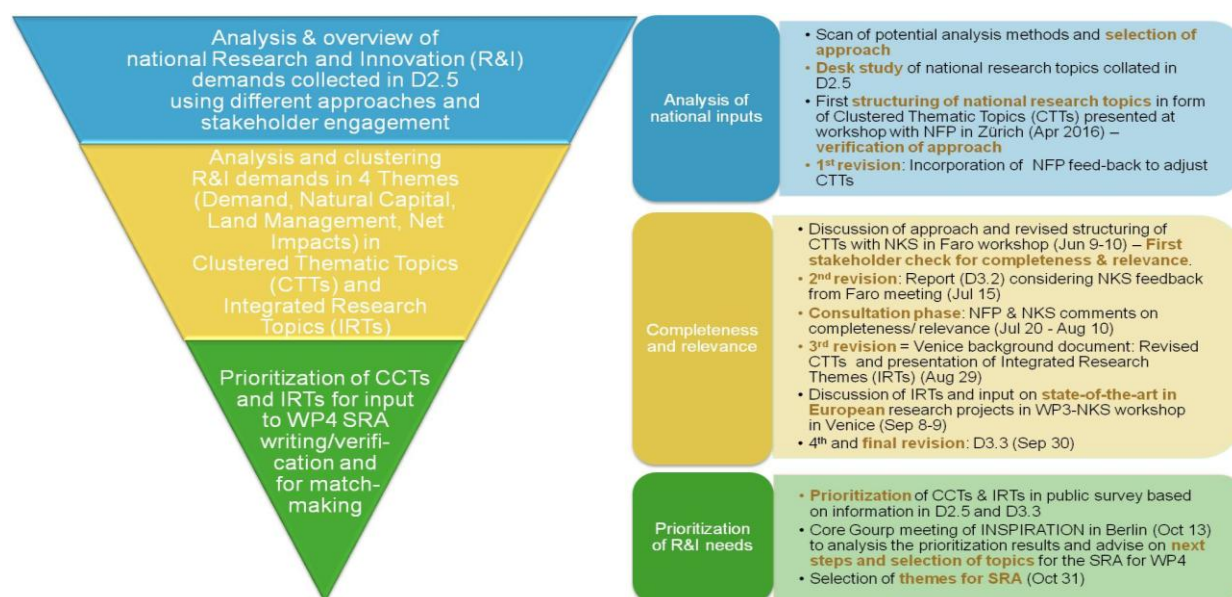


Fig. 2: Overview of workflow and summary of steps of WP3

2.2.1 Starting point: National reports collected in D2.5

The first step was to analyse the “National reports with a review and synthesis of the collated information” (see D2.5 – Footnote on p. 4) as bases of the WP3 work. In a Core Group (CG) meeting on 10-11 March 2016 in Berlin, WP3 discussed the potential approaches that could be applied and decided the subsequent tasks and work steps.

Analysing and synthesizing the national R&I needs was a challenging task given the scope and complexity of the research field – as is indicated to some degree in the extent of the report of national contributions (see D2.5), which comprises in total 965 pages. Among those, there are 567 pages of main text along with numerous detailed annexes (Fig. 3).

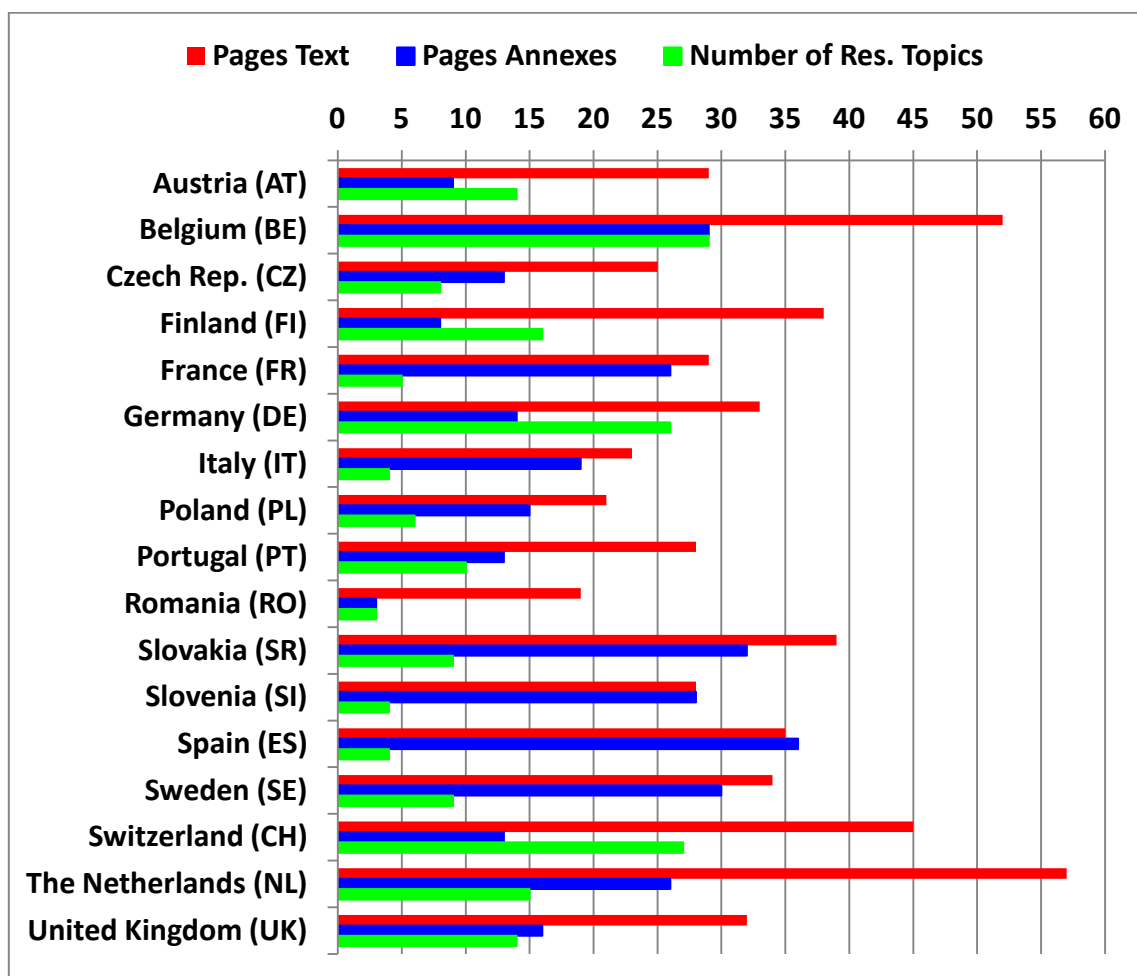


Fig. 3: Overview about the extent of country chapters in D2.5 (Brils et al. 2016)

The diversity illustrated in Fig. 3 regarding number of subjects of research and their presentation in different length as found between the countries in D2.5 warrants the following note: These significant differences in between the various countries seem mainly to correspond to various levels of aggregation and could be a result of an insufficient harmonization of the information collation guidelines and templates, which – reflecting the bottom up approach of INSPIRATION attempted to provide sufficient degrees of freedom for the partners to adapt the collation procedure and templates to their national environments.

In order to make the D2.5 report more accessible for analysis, WP3 leader extracted the following subchapters from the 17 countries in single documents:

- Executive summaries
- Research & Innovation needs
- Experiences regarding connecting science to policy/practice
- National and funding schemes
- Other remarks made by interviewees

The D2.5 section on national R&I needs comprises in total 203 research topics with more than 1,000 research questions.

The diversity illustrated in Fig. 3 regarding subjects of research and their presentation in different length as found between the countries in D2.5 warrants the following note: These significant differences in between the various countries seem mainly to correspond to various levels of aggregation and could be a result of an insufficient harmonization of the information collation guidelines and templates, which – reflecting the bottom up approach of INSPIRATION attempted to provide sufficient degrees of freedom for the partners to adapt the collation procedure and templates to their national environments.

2.2.2 Clustering research topics

In a first step in March 2016, WP3 revised different options in order to systematically structure the evaluation and synthesis procedure. These are outlined briefly in the following:

- A. Systematic text analysis,
- B. Superior research priorities recommended by NFPs,
- C. Collation to conceptual model approach in form of Clustered Thematic Topics (CTTs) and bridging Integrated Research Topics (IRTs).

2.2.2.1 Option A: Systematic text analysis

A systematic structural text and content analysis can be used for clustering the research & innovation contents. Usually, software is applied in a literary language analysis approach.

Advantages of this approach are: Support of key issues to group and assess the national research topics according to their cross-sectoral relevance.

Disadvantages are orienting the analysis through the use of prioritised semantic groups, which are to be developed by the Theme Leaders. This may somewhat contradict with the natural diversity of research topics / terms / priorities reflecting national specificities of INSPIRATION countries.

2.2.2.2 Option B: Superior research priorities recommended by NFPs

This approach starts from setting overall research topics. This approach makes use of the national research priorities developed by NKS and collected by NFPs in D2.5. As superior classification structures a) research fields (as done by e.g. Germany and Switzerland) and b) thematic areas (as proposed by Finland) were suggested in the respective national report sections to cluster research topics. Using this grouping approach in order to superordinate research demand (solution chain by following added values for research), could support identifying common cross-national research topics.

Advantage of this approach is its close connection to the scope and content of research priorities identified by the national stakeholders. As such, this approach may be easy for communicating results of WP3 work to NKS and NFPs.

Disadvantaging is that not all countries identified such thematic areas or research fields (only three did explicitly) or that some countries came up with a far larger number of topics than other countries, implying national differences in clustering and/or prioritising research questions. Hence, identified national topics may not be at the same level of detail and importance of some research need over another is not easy to grasp in the analysis. Moreover, there is a risk of developing sectoral isolated research priorities that may not be sufficient to address the content of the topic, such as the interplay between different drivers of losing natural capital.

2.2.2.3 Option C: Collating to conceptual model approach: Clustered Thematic Topics and Integrated Research Topics

This approach attempts collating the demands in clusters linked to the conceptual model, i.e. aggregated under 4 themes as well as across them.

Box 1: Conceptual model of INSPIRATION

Sustainable land management seeks to balance the demand and supply of resources and our natural capital, to cope with the effects of several driving forces putting pressure on the system and to decrease the global footprint of human made production and consumption activities. Thereby the main EU societal challenges, which are expressed in the Horizon 2020 work programmes, will be addressed. In order to identify cross-country and cross-sectoral knowledge gaps, research questions are structured along four overarching perspectives within INSPIRATION's conceptual model:

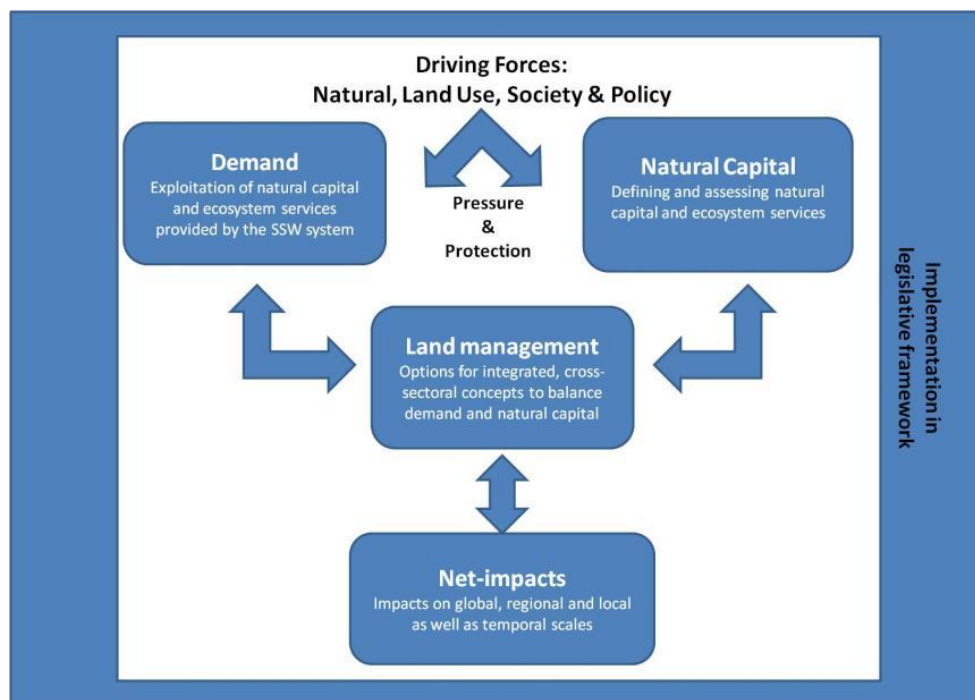


Fig. Box 1.: INSPIRATION's conceptual model

Box 1: Conceptual model of INSPIRATION – continued

Land and the SSW-system are goods and natural capital stocks that have to be used in a way that maximises the non-depleting use of ecosystem services. However, there are manifold drivers which affect natural resources, their potentials as well as their use, and which may eventually lead to a degradation of whole ecosystems. Intensive and unsustainable land use may have significant impacts to ecosystems and their ecological functions. Additionally, ecosystems are affected by natural drivers like extreme climate events in particular due to climate change (flooding, dry period, etc.).

Principally, there are conflicting interests regarding land use among many relevant stakeholders in society, such as farmers, land planners, developers, industry, citizens, etc., for instance regarding the productivity of areas and/or protecting natural resources. As a rule, both are following mainstreams of a paradigm of 'Either-Or': expectations of land-users towards maximizing economic benefits on the one hand, and maximum requirements from environmentalists towards protective regulations on the other. Thus the sustainable management of agricultural, forest and urban land resources as well as the conservation of biological diversity or natural capital has to follow integrated, cross-sectoral concepts in order to address the different demands of all stakeholders. Moreover, the economic, societal, administrative and political impacts, which are steering and governing land use in the broad sense including stocks and goods of natural resources, have to be considered. Thus the net-impacts on a local, regional and global as well as temporal scale are significant back-coupling drivers and determinants of crucial importance.

These challenges must be tackled to benefit from the land and the soil-sediment-water system and to avoid depletion of our natural capital and resources. Better land use and land management are the means to that end. Multi-dimensional and intra-disciplinary approaches to research have been very successful in building our present understanding of ecosystems with their services and to protect natural resources. The challenges we face inherently straddle disciplinary boundaries and changes in one domain can have unwelcome and unforeseen consequences in another.

First, a spread sheet approach is used to structure the diverse national research topics, where the Theme Leaders first prioritise the national research topics according to their perceived major, minor or not given relevance for the specific theme. It can augment the systematic text analysis and the identification of overall research topics by looking at the national report from a theme-wise perspective, thereby interpreting results of WP2 in the light of INSPIRATION's conceptual model. Research collated under these four theme perspectives were to be clustered across the INSPIRATION countries in so-called "Clustered Thematic Topics (CTTs)" within each of the four themes, which are representing perspectives under which to analyse the national research needs collated in D2.5. These themes aim to cluster research gaps regarding sustainable land management stewardship along four questions targeted at revealing the strategic research demands. For each area, a Theme Leader is taking the responsibility for the execution of the evaluation and synthesis.

Box 2: The 4 INSPIRATION Clustered Themes

Demand: *What does society demand from natural capital and ecosystem services including the SSW-system? – Lead: J. Villeneuve BRGM*

Natural capital: *What has nature, including the SSW-system to offer and which determinants sustain the system? – Lead: J. Zeyer ETH*

Land management: *What are options for an integrated, cross-sectoral land management to balance societal demands and natural capital? – Lead: J. Gorgon IETU*

Net impacts: *What are the impacts of different options of managing natural capital, including the SSW-system on global, regional and local as well as temporal scales? – Lead: C. Schröter-Schlaack UFZ*

In a final step, to address and collate the cross-country topics that also crossing and bridging the four themes, “Integrated Research Topics (IRTs)” are identified.

The **advantage** of this approach is that it allows identifying cross-national and cross-sectoral research priorities in each of the themes of the conceptual model – and in the last step across them. It helps overcoming the risk of developing sectorally isolated research priorities, e.g. for agriculture, river management or soil science, while it seems imperative to acknowledge the interplay of these activities and of different disciplines in gauging a better understanding for future research needs.

A certain **disadvantage** but also chance, however, is that this approach could require more efforts in communicating the conceptual model and the content of each theme to be comprehensible to NKS / NFPs.

Figure 4 illustrates on the left the collation of national research topic under the four themes of the conceptual model. On the right, the identification of “Clustered Thematic Topics (CTTs)” and “Integrated Research Topics (IRTs)” is illustrated.

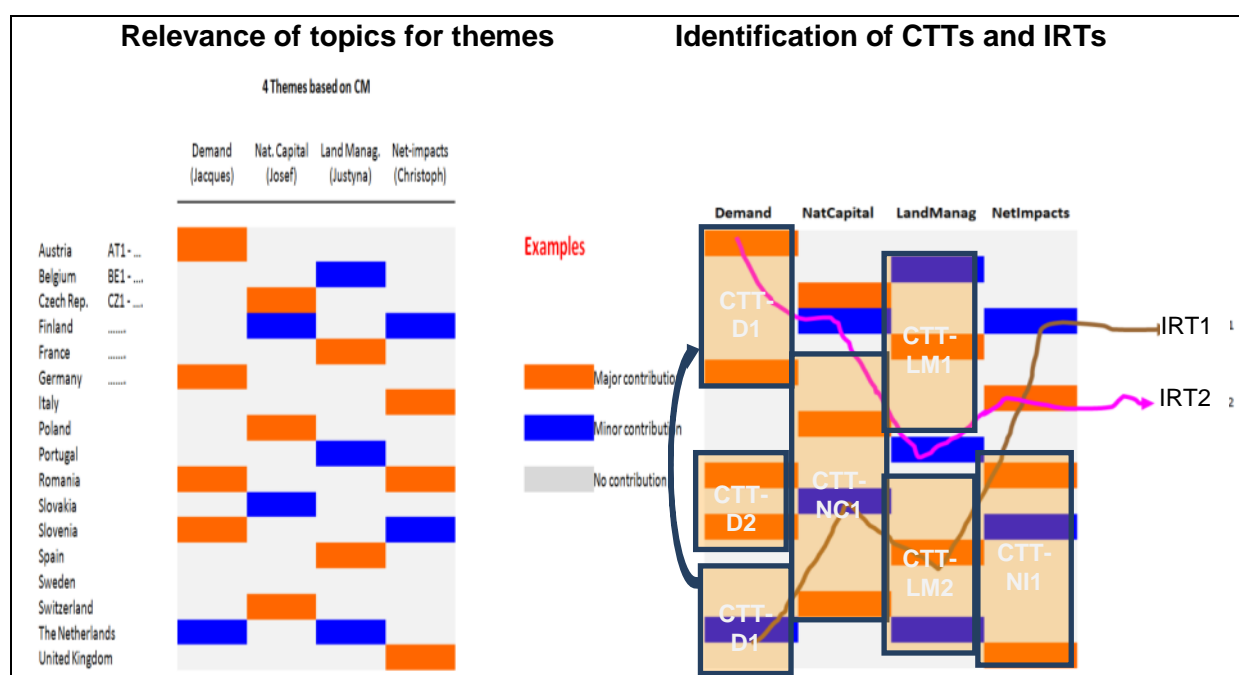


Fig. 4: Approach to assessing research topic relevance for aggregated themes (left) and for identifying Clustered Thematic Topics (CTTs) and Integrated Research Topics (IRTs) (right).



2.3 Course of action on which this report is based

Weighting the pros and cons of the different options, the INSPIRATION Core Group (CG) stated that no single approach is able to satisfy all demands to an effective analysis. In any way, the bottom-up imperative of the project was not to be questioned. This is why the options A and C were favoured. The following course of action was applied:

- Applying option A, a dictionary for text analysis with software “Tropes” was provided 10 March. A Tropes analysis was delivered 23 March 2016 and served a background.
- Applying option C, based on a preliminary list of 203 national topics, Theme Leaders (TLs) evaluated for each topic the relevance for their theme of interest (major, minor, no or don't know). WP3 lead summarized and synthesized the interim result in a matrix. WP3 discussed the NFP & NKS engagement in several online meetings.
- Approaches and interim findings were presented to and verified with NFPs in a workshop in Zurich on 28-29 April 2016 (see Box 3 below).
- Approach and interim findings were presented to and verified with NFPs and NKS in workshop sessions at a first WP3-NKS workshop in Faro 9 June 2016 (Box 3 below).
- Feedback based on Faro meeting and engagement was collated from NKS and sent to the project (via NFP). The project revised all materials in order to incorporate the feedback and presented an advanced and comprehensive report for consultation.
- 20 July – 10 Aug. 2016: Consultation phase: Preliminary report on transnational research needs sent to NKS, NFP and IAB for collection of comments and feedback: This document introduced the transnational CTTs and in Annexes the links to national research topics identified in the national information collection of WP2.
- During the consultation phase, WP3 identified Integrated Research Topics (IRTs) and revised the CTTs based on the consultation feedback. IRTs and revised CTTs were reviewed with the coordinator and the Venice workshop designed. On 31 Aug. 2016, the revised (CTTs) and enriched (IRTs) consultation report was sent as background document to Venice workshop participants, which took place on 8-9 Sept. 2016 (also Box 3 below). The WP3-NKS Venice workshop data was collected and all material, in particular the IRTs, revised according leading to the public report D3.3.
- The identified and finally revised CTTs and IRTs have been implemented for prioritization in an online survey <https://fr.surveymonkey.com/r/J9YWP87>. all NKS (not only NKS that participated in WP3 workshops, but all that were involved e.g. also on national interviewing or workshop level), NFPs and members of the IAB were invited to indicate their priorities for research topic regarding their relevant for meeting a) Societal Challenge 5, b) for their respective country and c) to meet their own knowledge needs as stakeholders of a SRA. In total 165 responses were received of which most completed the full survey (see Box 4).
- This significant feedback was discussed in the Core Group on 13 October 2016. Initiating the transfer of the prioritization of CTTs and IRTs, the TLs and responsible IRT-advocates presented their conclusions and explained for WP4 their view on the strategic importance of each topic respectively to be handed over from WP3 to WP4. As reported below in this report: The conclusion was drawn to transfer all topics – recognizing their inherent systematic links and equal prioritization by stakeholders.
- Box 5 summarizes the actions to initiate the match-making under WP3.

Box 3: Background on important WP3 meetings with national stakeholders

Background on Meeting of WP3 with NFP in Zurich

In order to serve the information check objective efficiently, the CG suggested preparing a follow-up workshop with the NFPs on 28-29 April 2016 at ETH in Zürich. The aim of the workshop was to give the TLs the opportunity to check with the NFPs unclear content of the D2.5 report. Moreover, understanding NFPs as catalysts of the stakeholders interviews during WP2, the meeting also served as a relevance check and continued bottom-up process. For this purpose, WP2 together with WP3 presented an overview about the national reports as they were perceived. Next, a presentation by WP3 followed on the first findings and on the proposed subsequent procedure for presentation the results of the intermediate evaluation and synthesis of the national inputs, collating and shaping the scopes to the conceptual model. The aim was to verify the correct use of the provided information in D2.5 and to achieve an agreement on continuing and/or elaboration of national inputs and demands towards the conceptual model and a fine-tuning of the approach.

The workshop was organized in presentations with discussions and a world café for detailed discussion of a preliminary collation of national R&I needs – the so called Clustered Thematic Topics (CTT) - under each of the four themes. Moreover, the meeting was used to discuss implications for the engagement with the selected NKS at the annual meeting of the INSPIRATION project. As a result of the Zurich workshop, Theme Leaders revised their preliminary CTTs and requested NFP to again review this analysis and link national R&I needs to the identified CTTs. The result of this review was used to prepare the input of WP3 for INSPIRATION's annual meeting (Faro, 9-10 June 2016) and the interaction with NKS.

NKS consultation at INSPIRATION's annual meeting in Faro

For each country involved in INSPIRATION, four National Key Stakeholders (NKS) were selected to collaborate with the TLs in the further development of the WP3 work and to participate in the annual meeting. The main role of the NKS invited to INSPIRATION was to ensure that INSPIRATION's results will meet actual and most relevant stakeholder needs and foster cross-European integration. In particular, the NKS were expected to:

- provide advice on / input for the identification of emerging strategic research needs,*
- support the orientation of the SRA towards real user needs,*
- ensure linkages to relevant national activities at scientific, policy and business levels,*
- provide feedback to their own organizations with regards to INSPIRATION achievements, and*
- support dissemination of INSPIRATION outcomes to relevant stakeholder communities in their countries and beyond.*

The NKS were selected in each country participating in INSPIRATION by the NFPs to engage with the remaining stages of the project. The selection has been based on the following criteria: 1) Representation: The four NKS from each country shall represent a) funders, b) knowledge producers, c) knowledge end-users and 4) policy-makers. 2) Motivation: People who are willing to actively engage with INSPIRATION and donate some of their time to support the project by participating in three face-to-face meetings and reviewing material. 3) Expertise: Persons with an acknowledged expertise in their field. 4) Multiplication: NKS who can share their experiences among their communities and who can act as ambassadors for implementing the INSPIRATION SRA. 4) Gender balance.

At the Faro meeting, Theme Leaders introduced their CTTs to the NKS in two extensive sessions. Giving room to the bottom-up approach, intensive discussions on the pros and cons of selected structuring approaches and selections were allowed for. Much information was derived from the discussions and a joint understanding on the goal of WP3 achieved.

Box 3 continued

WP3-NKS workshop in Venice

The Venice workshop aimed at i) a final quality check of the revised CTTs, ii) a revision of the IRTs, iii) a cross-checking with current research of relevant EU projects, iv) a first prioritization of research topics for the SRA, and v) further steps towards implementation of the SRA. Beside project partners of WP3 and the CoreGroup, 63 National Key Stakeholders and two members of the International Advisory Board as well as representatives of several EU projects participated in the meeting.

The workshop started with an overview of working steps in WP3 and explained how the NKS feedback was incorporated in the revised report. Next, the identified 17 Integrated Research Topics (IRTs) were intensively discussed in parallel working sessions with the advocates of the IRTs (those collated and wrote the proposed integrated research topics) organized in an expert hearing format. Each hearing was strictly organized and structured into timed sequences where participating NKS had the opportunity to ask questions and give comments and recommendations in discussions and in writing using different evaluation sheets, which were to inform the revision of IRTs.

The second day started with a presentation of relevant EU projects with corresponding interests in research for soil, land use and land management in Europe:

- RECARE: Preventing and Remediating Degradation of Soils through Land Care
- iSQAPER: Interactive Soil Quality assessment in Europe and China for Agricultural productivity and Environmental Resilience
- VOLANTE: Visions of Land Use Transitions in Europe
- SoilCare: Soil Care for Profitable and Sustainable Crop Production in Europe
- eLTER: The European Long-term Ecosystem Research Network

Beside the information received about aims, partner organizations and project steps, most valuable for INSPIRATION was that the EU project coordinators showed their links to INSPIRATION and identified research needs. As a key outcome of this exchange, INSPIRATION obtained important advice for the next steps of elaborating the SRA and the match-making process of WP4.

The morning of the second day ended with a review of updated IRTs in a poster session and an anonymous prioritization of the IRTs with a ranking between 0 (no relevance for the individual NKS) up to 5 (highly relevant). Their ranking averaged between 3 and 4 meaning medium or high relevance for the NKS. Concluding, the roadmap to prioritization of CTTs and IRTs towards the SRA was presented.

Based on the presentation to NKS on European research funding instruments in Faro, opportunities for an active match-making and identification of suitable funding schemes were elaborated in 3 parallel sessions focussing on topics in three clusters: 1) From information to implementation, 2) 4F (food, feed, fiber, fuel), and 3) Integrated urban management.

First, NKS identified topics (e.g. forest management as potential EraNet initiative, research in the context of the landscape convention, urban climate change). Innovative forms of funding have been proposed. Examples include

- 1) a new model of a stakeholder driven call,
- 2) the model of URBACT: if several countries have the same problem they can create a call and researchers can apply.

Proposals for the next steps have been collated. They include the creation of a platform, where problem owners could ask for a research solution and for funders that want to share money to solve a problem.

Box 4: Final prioritization of the CTTs and IRTs in an online survey

The online survey managed by WP3, WP5 and WP1 was organized in different sections:

In a first part, stakeholders were requested to provide some background information. This should enable to detect if certain priorities are linked to specific background characteristics – an information of importance for the identification of potential coalitions in the match-making. The following items were included:

- **Stakeholder type I:** - funder, - knowledge provider, -end user of research,
- **Stakeholder type II:** - national/regional regulator, - university/research, - SME/consultant, - business or industry, - NGO, - network, - other
- **Background type:** - soil, - sediment, - water, - land use management
- **Country** (in which the NKS is working).

*The second part focused on **scoring of each research topic** using a scale from 0 = “not relevant” to 5 “of key relevance / critical importance” divided into a) the 22 Clustered Thematic Topics, and b) the 17 Integrated Research Topics. The scoring was further divided to allow a specification from taking three different perspective: Addressing*

- 1) the knowledge needs as stakeholder from individual perspective
- 2) for the country in which one is working, and
- 3) for mastering the Societal Change 5 related to climate action, environment, resource efficiency and raw materials.

A final section provided the opportunity to give additional comments or feedback in free text format.

Box 5: Background on important WP3 meetings with national stakeholders

Matchmaking process initiated

The matchmaking process under WP4 was prepared in WP3 by devoted sessions during the NKS Consultation in Faro 6/2016 and Venice 9/2016.

Faro:

- Presentating European research funding instruments to NKS
- Stakeholder sessions "Funders", "Land Use in Urban areas", "Land use in rural areas and agriculture" with face to face exchange of NKS on their institutional background and current activities in the INSPIRATION context.

Venice:

3 workshops with the objective to identify potentials of match-making between stakeholders – See Box 3 above).



3. Transnational R&I needs

3.1 Demand

3.1.1 *Relevance of DEMAND perspective*

Sustainable handling and management of natural resources is indispensable for providing the needs of a growing and affluent population and coping with other societal challenges such as climate change. Sustainable handling and management is to safeguard the environment. The demand challenges to improve resource and energy efficiency. As underlined in the Resource Efficiency Flagship of the Europe 2020 Strategy, this addresses globally all resources, and particularly the management of land and geo-resources. It remains that most “efficiency” oriented policies do not consider the absolute intrinsic value of land as a territory of settlement. To that respect, the density of population and the legal organisation of land ownership in different countries lead to different status (and price) and heritage conditions of the land. Land use, as a constrained market, cannot be only considered under a productivity vision. Land as a resource can offer a lot of different services: for production of food, fibres or wood, but also as a carbon sink, water buffer and biodiversity archive. These last functions are contributing to societal challenges such as climate change mitigation and adaptation, food and security.

The demand for the goods and services provided by natural resources is driven by the total final consumption of our societies. All goods and services produced are consumed by households and institutions or exported. Unfortunately a high amount of goods gets lost during the production chain or is wasted instead of used. Nevertheless, their production requires continuous inter-sectoral exchanges within the economy. Even if very few sectors exploit natural resources (i.e. agriculture, forestry, fishing, organic and mineral geo-resources, chemistry, including the production of fertilizers), each sector in industry, construction, trade, services, buys to a certain degree products or services linked to the extraction of natural resources. Thus, the demand arises not only at the level of final consumption, but also at the level of intermediate consumption all along the supply chain.

This represents a strong connection and interrelationships between demand and supply (nature capital – see below).

The final demand is influencing the behaviour of first suppliers, who in turn, influence their own suppliers, and so-on until the ultimate suppliers of products directly made from natural resources. The demand of soil-sediment-water resources is also coming forth from societal challenges and these are not only consumption driven (though sometimes the result of over consumption) such as combating climate change, healthy urban living, recreation, cultural heritage. At the same time there are services that are not used at all or are under used, although they can contribute to welfare and wellbeing. For example city green to fight heat stress, canals and open spaces in cities to buffer and retain water, water management to grow peat instead of burn peat and thus building soil organic carbon, water management or avoid salinization, broadening riverbeds to avoid flooding. That finally means that there is a concurrence in different use types of the soil-sediment-water system. Different users



(stakeholder, supplier, owners, and investors) of different groups have their own demands which often influences the others but also the quality of the SSW-complex.

There are two very different aspects to distinguish between the demand for soil and water resources and the demand for occupied/sealed land: the former may be compensated on the markets, which means that the products can be imported if they are not produced locally in sufficient quantity, whereas the latter strictly depends on the geographic area available. These two components of the demand may both be qualified as a “direct demand”: there is a direct causal relation between the surface area required and the product delivered. There are new concepts for city farming that make farming less dependent on soil. But nevertheless they are also dependent on demands from land and soil (energy, clean water, fertilizer). Note that imported goods (food for example) need soils abroad for their production. “Direct demand” also means target oriented – Production of goods, products, like food, fodder, fuel, and fibre.

Nevertheless, the land and the SSW-system also provide “free” ecosystems services like water filtration, mitigation of the water cycle, air filtration, biodiversity, biogeochemical cycles of substances like carbon, nitrogen, phosphorus and on a longer term, metals. These services are systemic as they depend on the proper functioning of the SSW-system at different and interlinked geographical scales. They contribute to global livability like climate mitigation, air quality, but also more local environmental values like water quality, pleasant landscape, recreation areas, etc. The demand for these services may be qualified as “indirect”: it is expressed through social demands for quality of life, and rises from both urban areas where “green and blue infrastructure” are a major concern of urban development and redevelopment, and rural areas where the awareness of the long-term benefits of maintaining ecosystems services calls for new agricultural practices. Nevertheless they are real demands but they cannot be “owned”. But they might have interrelationship as well as concurrences in-between and to the so called “direct demands”. Different stakeholders like to have access / control to different categories of demand.

Notwithstanding, it is also clear that society needs specific resources to guarantee our ability to survive with clean, healthy and safely living. These are as well as food security, water security and energy security basic needs. Society demands resources of the SSW-system not only fulfils basic needs related to food and clean water consumption, energy and building materials, but also reflects the higher level satisfaction of human needs related for example to recreation with urban green spaces and valuing intrinsic cultural values related to SSW. These “products” are also different of character because they are exhaustible and we need to make a transition to turn to other sources, reuse land, reuse building materials, and use sustainable energy sources.

Hence, societal demand as such has many different components that are evolving with time. It cannot be equated with a fully dispensable pressure on the SSW system, but expresses our wishes that need to be balanced with the supply that can be provided through natural capital.

3.1.2 Overview on DEMAND-Clustered Thematic Topics

The theme Demand focuses on the thematic approach of research and innovation needs concerning the “demand” for the SSW system services. The research questions expressed in the national reports (D 2.5) are structured in seven clustered thematic topics (CTT). The first aim is to understand the links between consumption and the use of the SSW system services: the need is to quantify and map in time and space the systemic aspects of the nexus of SSW resources used for the final consumption of goods and services. A second issue is to adapt the consumption to mitigate the demand for the SSW system services: the need is to find more “resource-efficient” ways of consumption linked the direct demand of bio-sourced goods and area for the built environment and to save resources. And finally, to quantify and assess the indirect demand of SSW system services: how to assess the (long term) demand for ecosystems services used to preserve/improve the quality of life, the health.

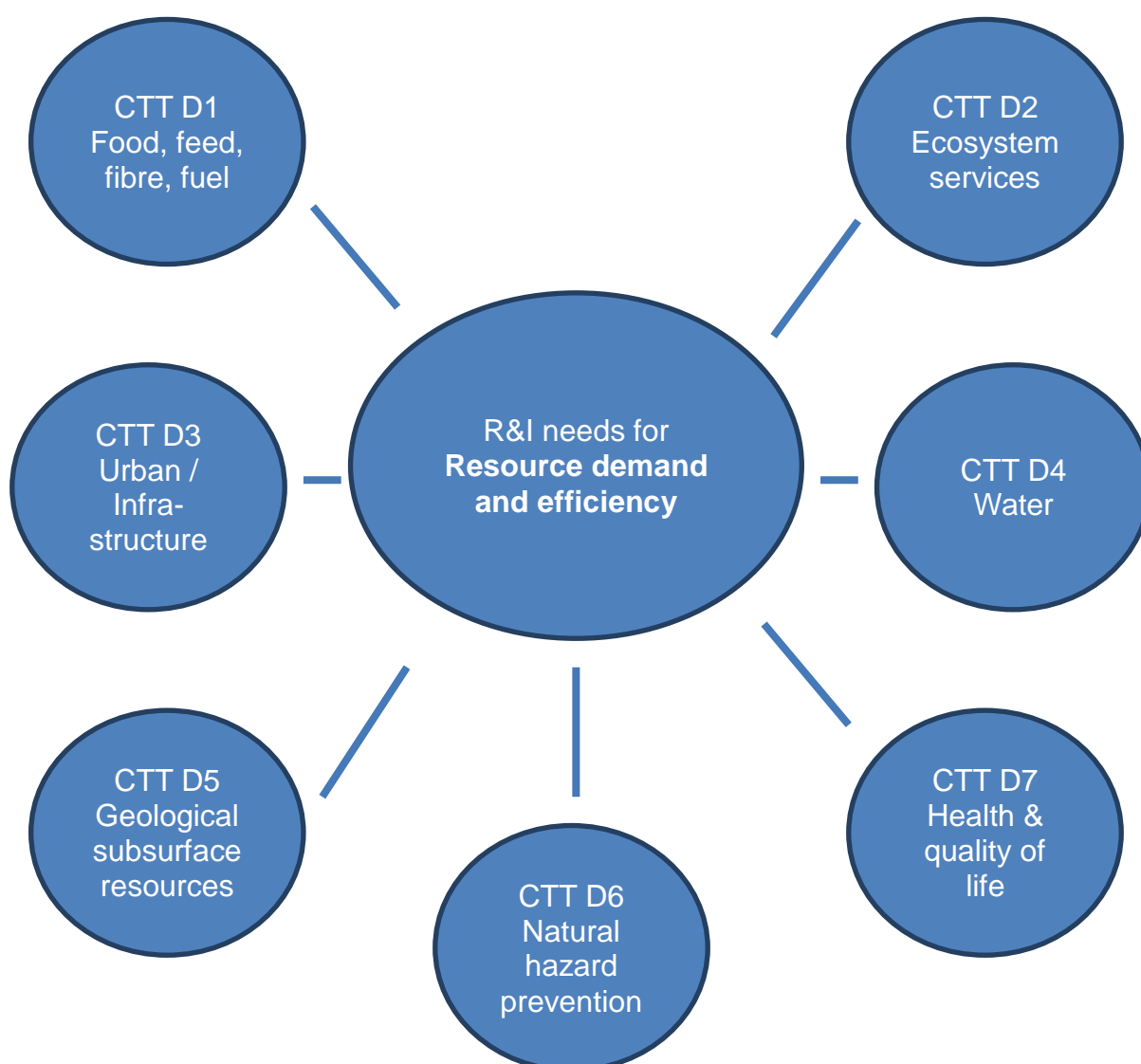


Figure D-1: Clustered Thematic Topics regarding DEMAND.

3.1.3 Research background per clustered thematic topic

CTT-D1: the 4 F's: Food, feed, fibre, (bio)fuel

DEMAND - Resource demand and efficiency;		AT	BE	CZ	FI	FR	DE	IT	PL	PT	RO	SR	SI	ES	SE	CH	NL	UK	No. of topics	No. of countries
CTT-D1	Food / Feed / Fibre / Fuel	AT-1; AT-3; A-13; AT-14	BE-1; BE-5; BE-10; BE-18; BE-21; BE-29	CZ-7	FI-7; FI-9	FR-1; FR-2; FR-4	DE-1.2; DE-3.5; DE-5.3; DE-5.5	IT-1	PL-2; PL-6	PT-1; PT-2; PT-4; PT-7	RO-1; RO-2; RO-3		SI-3	ES-3.8; ES-3.4	SE-1; SE-4; SE-5; SE-6	CH-2.10	NL-1; NL-2; NL-8; NL-9; NL-15	UK-1; UK-5; UK-9; UK-12	47	16

Soils are as production site the primary geo-resource for production of biomass and a key element in the bioeconomy (the so-called four F's). Biomass is used for production of agricultural goods for direct consumption or for conversion to diverse food products or chemical raw-material (like oils), for feed in animal husbandry, for various fibres and play especially with organic renewable in energy production as non-fossil fuels a growing role.

On the other hand, soils as production sites for biomass are increasingly threatened by land and soil consumption for infrastructure and because of land degradation, so the availability of fertile soils is shrinking, while demand for the 4 F's is growing. Furthermore, consumption behaviour towards higher meat diets and luxury food together with climate change and adaptation challenge soils and their role for water production and functional biodiversity. While soil assessment traditionally concentrates on biomass production, the provision of environmental services have to be taken into account and evaluated since they are increasingly demanded by society to contribute to human life and environmental quality such as flood protection areas or nature conservation (see CTT 4 and CTT 7).

Use of degraded soils for non-food purposes may be an option as a remediation method too and may avoid a conflict with food security. Remediation of degraded soils may also help in carbon management (sequestration) or improvement of local economy.

Integrated land assessment, land management and land use planning need reliable, actual and easily accessible data of land use, soil quality, and data knowledge. Basis for that is an integrated knowledge and management of data availability and security.

Key questions:

- How could an integrated spatial soil mapping make available?
- What Scenarios have taken into account for future demand of food, feed, fibre and regenerative fuels?
- How can degraded land be used for non-food purposes?
- If an increase of yield is needed could we meet this increase by production of organic products versus genetically modified crops? What are the impacts to the SSW-System?
- How could the potential for wood-based and cascade products meet the demand?

CTT-D2: Regulating Ecosystem services

DEMAND - Resource demand and efficiency:		AT	BE	CZ	FI	FR	DE	IT	PL	PT	RO	SR	SI	ES	SE	CH	NL	UK	No. of topics	No. of countries
CTT-D2	ESS	AT-7	BE-17; BE-18; BE-28	CZ-1; CZ-5	FI-8; FI-11	FR-2	DE-3.3; DE-3.5		PL-1; PL-5	PT-9; PT-10	RO-3		SI-4	ES-3.5; ES-3.15	SE-8	CH-2.7	NL-11; NL-15	UK-4; UK-6; UK-7; UK-8; UK-10	28	15

The topic of soil, sediment and water ecosystem functions includes research needs related to regulating and maintenance services. These are changes and interactions of biogeochemical cycles, soil carbon dynamics and climate change impacts on it, balancing bio-economic pressures with needs to adapt to climate change and protect biodiversity in forests and mires, identification of soil-related preconditions for sustainable intensification of food production, and assessment and mapping of soil ecosystem services.

Sustainability and sustainable management of natural resources require an optimization of soil functions including approaches, methods and instruments of the productive land against its transformation towards build-up areas. Other demands are intensive and ecologic acceptable productions in agricultural and forest country, the effect of land management due to ownership changes, and the harmonization of methods and structure of data.

Research needs are related to soil functions and services in general, the development of a specific methodology of evaluation of the demand and supply of soil functions and services associated with urban, industrial, natural and production (agricultural and forest) ecosystems. Challenges are also related to integrated modelling in order to optimize the management of landscapes linked with agro-systems. Special attention in different regions has to be given to re-valorisation of degraded sites according to their future urban, suburban or rural use (e.g. see “Evaluation of expenditure and jobs for addressing soil contamination in Member States” http://ec.europa.eu/environment/soil/pdf/Soil_contamination_expenditure_jobs.pdf). Attention has to be given also to potentials and dynamics of carbon sink and sequestration potential and GHG balance dependent from sites and land use. The restoration of soils is usually a way to improve ecological services - soil contamination often has detrimental affects. Even if sometimes ESS may be facilitated by contamination (e.g. biodiversity).

Key questions:

- What is the roadmap to reach the SDG target of a land degradation neutral world? What is the role of ecosystem services in this process? How can remediation technologies affect the process?
- How to understand, assess and optimize the soil functions and services in general, develop a specific methodology of evaluation of the demand and supply of soil functions and services associated to urban, industrial, natural and production (agricultural, forest) ecosystems?
- How optimized soil functions could support societal demands in urban areas?
- How to manage integrated models to optimize the management of the landscapes (agro-systems and urban structures)?
- How special attention in different regions could be given to re-valorisation of degraded sites according to their future (urban, suburban or rural) use?
- How can the potentials and dynamics of carbon sink, sequestration potential and GHG balance dependent from sites and land use be assessed and managed?

CTT-D3: Urban / infrastructure land

DEMAND - Resource demand and efficiency:		AT	BE	CZ	FI	FR	DE	IT	PL	PT	RO	SR	SI	ES	SE	CH	NL	UK	No. of topics	No. of countries
CTT-D3	Infrastructure / urban	AT-5; AT-10; A-13	BE-5; BE-6; BE-24	CZ-1; CZ-2; CZ-6	FI-11; FI-13		DE-2.1; DE-3.1	IT-2; IT-3	PL-4; PL-6;	PT-5; PT-6			SI-1	ES-3.1; ES-3.6	SE-4	CH-2.1	NL-3; NL-5; NL-6; NL-15	UK-3; IR-1	30	14

The demand on land for settlement areas, surface as well as subsurface infrastructure, as well as other uses such as landfill sites is constantly increasing. Land use in itself is in constant transition according to the needs of stakeholders (residential areas, industry, mobility/transport, recreation areas, housings etc). Urban expansion, population density and type of land use of the different regions - all affect the social, economic and environmental quality of cities and regions and have effects on the soil and city climate. The high demand leads to conflicting goals in regards to the use of land, for example, for settlement and infrastructure as well as green infrastructure in urban areas. Expanding areas with specific land uses are faced with the task of mobilizing land potentials despite the presence of a high level of competition for use. On the other hand, stagnant or shrinking regions have a surplus of land potentials which require concepts for deconstruction and the re-naturalisation of land. Brownfield remediation and recycling for urban use play a major role in saving soils for other purposes.

Main questions are

- How European cities can meet the challenge for inner development concepts in gaps in the built-up areas, brownfield regeneration, multifunctional and temporal uses, densification and the replacement of older constructions?
- How could stakeholders be involved new forms of cooperation such as that between planning and environmental administrations and public-private stakeholders? How could they contribute to solutions of the problems? What is required is the adaption of planning and administrative processes to current demands and at the same time the development of management strategies in cooperation with private land owners.

CTT-D4: Water

DEMAND - Resource demand and efficiency:		AT	BE	CZ	FI	FR	DE	IT	PL	PT	RO	SR	SI	ES	SE	CH	NL	UK	No. of topics	No. of countries
CTT-D4	Water	AT-4	BE-4		FI-1	FR-2		IT-4		PT-2		SR-3	SI-2	ES-3.3; ES-4	SE-2		NL-4; NL-7; NL-9	UK-2; IR-1	16	12

Clean and sufficient water is a key element for a healthy functioning SSW-system, the production of biomass, the provision of clean drinking water and groundwater sustainability. It is also a driving force for landslides and floods within the SSW-System (see CTT-.6) Special attention should be given to water resources affected by agricultural land use i.e. high density of livestock breeding, agriculture, irrigation, transfer of agricultural land to settlements and ongoing climate change.

The EU will increase the reuse of treated waste water to fight water scarcity (<http://ec.europa.eu/environment/water/reuse.htm>). Open questions are the contaminants in the water and the treatment for cleaning. This is also a major question for intact soil functions (filtering and buffer functions).

Within the landscape context key questions on water research are needed for assessment methods for spatial water potentials for agriculture in the context of different land use intensities and changes as well as water balance in meso-catchments. Other needs exist on (existing and) emerging pollutants for (drinking) water from surface and groundwater, for retention potentials for water in micro- and meso-catchment and reducing natural hazards, the quality and quantity of surface and groundwater, knowledge on water resources fluctuations within seasonal fluctuations and the demand from different sectors like agriculture, industry and homes. Finally manageable models have to be elaborated not only for water users itself, but also for planners and politicians.

Key questions include:

- How control and improve water quality in contaminated land management from both diffuse and point sources, including emergent contaminant classes?
- How to estimate the risks of emerging pollutants for drinking water production?
- Assessing the impacts of different land uses and climate change on the quality and quantity of surface waters and groundwater.
- What effects have to be mentioned by processes of water reuse?

CTT-D5: Geological (and fossil) subsurface resources

DEMAND - Resource demand and efficiency:	AT	BE	CZ	FI	FR	DE	IT	PL	PT	RO	SR	SI	ES	SE	CH	NL	UK	No. of topics	No. of countries
CTT-D5 geological sub-surface resources (minerals)		BE-5; BE-9		FI-9; FI-13		DE-2.3								SE-3; SE-7	CH-2.9	NL-8; NL-9		10	6

Geological subsurface resources like peat, gravel, sand, lignite and other materials are needed for economic development. The shallow extraction of resources (peat and brown coal more in the past, currently still sand, clay and gravel) influence landscapes strongly. Extractions (shallow and deep extraction such as salt) also leave space that can be reused or re-developed. Resource extractions highly influence the soil-sediment-water system and its ability to deliver ecosystem services.

Depletion of many non-renewable natural resources, such as minerals and nutrients, is an increasing problem. Sand and gravel has been used for decades in the construction of buildings and infrastructure. Some resources, such as gravel and good quality building material, have become scarce close to their consumption in cities and have to be transported considerable distances. Promoting the recycling of materials and alternative materials (biomass) can help to guarantee their availability and decrease environmental impacts, but methodology and procedures need to be further developed. As extraction activities are often only temporary, the re-use of land areas is an important issue and can provide new opportunities. Special attention should be given to re-use, re-built, and recycling to come not only to a circular economy but find examples for up-scaling of wasted materials.

Peat is known as a big source of energy and is also used in agriculture and horticulture. But peat is also a sink for CO₂ and thus a form of climate mitigation. When used it is a source of CO₂ and contributing to climate change. That is why alternative for peat have to be found and establish.



Lignite resources are great especially in the North of Europe but for instance Germany will bail out from the lignite mining. Because of remediation needs in shorter timer and on greater scale (mostly used as open pit mines) there will be a higher need development of effective remediation techniques than before.

Stones, gravel and sand are the most needed materials in the building industry. As far as we have activities in infrastructure development the materials are urgent needed. In some countries new sites to mine gravel and sand have to be developed because the known deposits are either depleted or blocked by conflicting uses.

On the other hand the underground itself is an important resource e.g. for Aquifer thermal energy storage (ATES) and geothermal energy. The relative amount of geothermal energy will develop from 2.2 to 13 per cent from 2010 to 2050 in Europe and the potential is referred to 300 TWh/y for Germany only. In the geological underground, instruments to weigh up underground land-use claims are missing with special attention to geothermal energy, fracking and building activities. Traditional uses of the underground like mining of fossil fuels and minerals and ore mining have to take into account their impacts to the SSW-Complex as well.

Therefore a competition in land use is remarkable between the different use of land and soil. Key questions include:

- Is there a need for more effective restoration measures of landscapes used for excavation of fossil fuels, minerals and ores? How could the energy demand be satisfied with traditional or new techniques by minimizing the impacts?
- How to manage the supply and demand of soil and aggregates in local and regional level through effective and appropriate (re-)use of various types of excavated soil, and organization of temporary storage for classified materials?
- How to advance the recycling of limited mineral and nutrient resources (e.g. through capturing phosphorous from wastewater or landfill mining)?
- What are the opportunities to recycle (C2C) excavated sand, clay, gravel? To what extend will this result in less excavating areas and contributes to circular economy (e.g. use as building material)?
- How to use the high amount of recycling material in a proper (safe and environmentally good) way?
- How to re-use sediments as secondary resource instead of primary resources?

CTT-D6: Areas where Natural hazards are prevented

DEMAND - Resource demand and efficiency:	AT	BE	CZ	FI	FR	DE	IT	PL	PT	RO	SR	SI	ES	SE	CH	NL	UK	No. of topics	No. of countries
CTT-D6 Natural hazard prevention	AT-4; AT-10	BE-26	CZ-4	FI-16					PT-4		SR-4		ES-4			NL-3		9	8

Due to the anthropogenic changes in the world – building up an efficient infrastructure for the economy – the risk for and vulnerability to natural hazards and disaster have increased. Firstly changes in nature (river straightening, deforestation and agricultural monoculture, non-proper land use, unconscious water management) cause land and soil instability. Secondly climate change increases this instability, especially in some sensitive areas in Europe like the Alps or in Southern Europe. River straightening and soil sealing increase the risk of floods.

Landslides occur in many different geological and environmental settings across Europe. For example, large rockfalls, rockslides, rock avalanches, mud slides and debris flows dominate in the Alps and steep slopes in other mountain ranges, but also in coastal areas of Great Britain, Bulgaria, Slovenia, Italy, France and others. Soil subsidence in lower countries and delta areas causes water problems in case of severe rains.

Approaches, methods and instruments of the lowering and elimination of natural hazards and risks incl. risk assessment on land use/soil use are needed. Examples for natural hazards are: floods, forest disasters, forest fires, geodynamic hazards and erosion. Risk assessment is necessary in relation the quality of water, in effects of drought and floods following climate change and anthropogenic changes in the landscape. Mitigation measures to lower abiotic and biotic damages on forest and agriculture have to be developed.

Societal awareness of the research on the protection of particular natural resources is low. There are available knowledge, methodologies and models focused on efficient and sustainable use of nature, natural resources, land-use, modelling the natural risks and hazards, scenario building, but their usability in the practice is low. Therefore stakeholders and the civil society should be more involved.

Key question:

- What is the area demand for flood protection areas, levees, residential areas, (water) transportation ways, retention areas, nature conservation areas and danger zones from the quantitative and qualitative perspective?
- What are effective approaches, methods and instruments for lowering and elimination and mitigation and risk assessment?
- How can building with nature be of help and instigated?
- How can stakeholders be involved?

CTT-D7: Health and quality of life (living environment)

DEMAND - Resource demand and efficiency:		AT	BE	CZ	FI	FR	DE	IT	PL	PT	RO	SR	SI	ES	SE	CH	NL	UK	No. of topics	No. of countries
CTT-D7	Health & Quality of Life	A-13; AT-14	BE-5; BE-18	CZ-6	FI-11	FR-1		IT-1		PT-3; PT-5	RO-2		SI-1	ES-3.1, ES-3.12	SE-3; SE-7	CH-2.1	NL-1; NL-2; NL-15	UK-8; UK-12	22	14

Environmental quality, standard of life and wellbeing are essential factors for healthy living. They need attention, especially in deprived urban areas as well as in rural areas characterized by intensive agricultural land use. Research and practice often focusses on single environmental mediums and the related sectoral political field or expert planning discipline. It concerns landscape planning, soil, groundwater and sediment contamination, emission protection, transportation, and noise protection; also the connection with the stakeholders.

There is a need for an integrated approach when dealing with the living environment. This requires data, indicators and related tools for analysis which are integrative, practical and able to be communicated to the public and can be used in spatial planning processes. It is in this context that holistic instruments for the development of a healthy (smart) city should be created and tested through their use in demonstration activities.

Similar to cities there is a need for a healthy rural area affected by industry from urban areas (emission of dust, noise) but also by own emission e.g. from agriculture or industry moved out of the cities into rural areas. This is often the case in densely populated regions.

Specific research questions are:

- How clean is clean? A number of chemicals do not have threshold values for soils but are accumulating in the nutrient chain. A derivation of these values is necessary to avoid contamination of food, fodder and humans.
- Food first? How prioritize soil and land use under various climate and economic conditions?
- How come to a comprehensive understanding of healthy living environment concept? There is a lack of comprehensive understanding what the healthy living environment is, how it is related to the spatial, social and other contexts and, what are the aspects and relationship between urban development and health/wellbeing.
- How the concept of the 4 R (reduce, reuse, recover, recycle) can be improved, e.g. by Up-scaling?
- What are trends in diets and what do they entail for soil and water use and health. How can people be convinced to change to a diet with less animal proteins?; Who are the winners and losers in the food chain in the transition to a more healthy (for people and the environment) diet and agriculture? How to take care of the losers? What can be the role of the common agricultural policy (CAP) in this transition?
- How can we improve the quality of life in rural areas by making the best use of the soil-sediment-water system and land management, taking into account natural and cultural values and economic and social factors that determine the location of businesses and individuals also under attention of the demographic factor?

3.2 Natural Capital

Natural capital is an economic metaphor for the limited stocks of physical, chemical and biological resources found on earth, and the capacity of ecosystems to provide goods and services. The expression is related to the classical economic notion of capital, in which capital enables the production of goods and services. Natural capital includes all kind of natural resources such as the subsurface, the landscape, the groundwater and surface water, the atmosphere as well as all living organisms. Natural capital provides the society with a wide range of goods and services, which are often considered to be free of charge (e.g. crop irrigation by rainfall, pollination by insects, pollutant degradation by microorganisms). A steady supply of all these services is only guaranteed if the environment is healthy and if ecological structures and functions are preserved.

Natural capital is of paramount importance for the functioning of our society and therefore a number of studies dealt with a systematic categorization of the resources. The detailed categories may depend on the viewpoint, i.e. agriculture will have other priorities than industry. However, a global perspective was presented in 2005 by the UNEP (United Nations Environment Programme) in the Millennium Ecosystem Assessment Report (MEA). This report was assembled by hundreds of experts and it includes a number of volumes covering methodologies, scenarios, policy responses, stakeholders' views, geographical patterns, etc. The report presents a global inventory and a scientific assessment of the ecosystems and the services they provide. The basic conceptual model of the report is shown in figure NC-1.

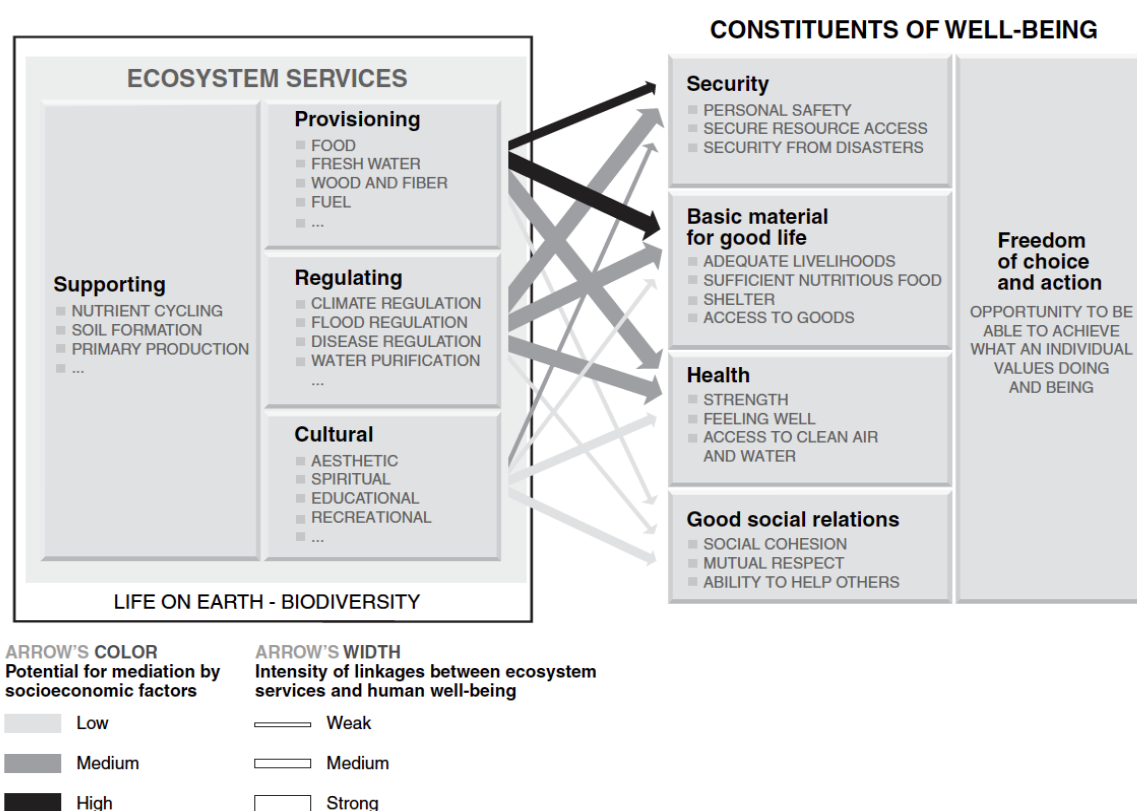


Figure NC-1: Categories of ecosystem services and links to the human well-being (copied from UNEP Millennium Ecosystem Assessment Report (MEA), 2005)



The services include 4 major categories: (i) Supporting services which form the basis for all other ecosystem services (ii) Provisioning services, which include all products generated by ecosystems (iii) Regulating services include the benefits from the proper regulation of processes and (iv) Cultural services which are the nonmaterial benefits people get through recreation, aesthetic perception, spiritual cognition, etc. Figure NC-1 also stresses the linkages between the ecosystem services and the human well-being. The width of the arrows depicts the intensity of the linkages. The shadow-colour of the arrows depicts the potential for mediation by socioeconomic factors.

The MEA did trigger a world-wide debate on ecosystem services and a number of modifications and alternatives were suggested soon after its publication. An international committee called “The Economics of Ecosystems and Biodiversity” (TEEB) suggested a number of alterations. For example TEEB proposed to replace the category “supporting services” by “Habitat services” and “Ecosystem functions”.

Over the last few years an attempt to categorize the natural capital was put forward by the “European Environmental Agency” (EEA). This scheme was designated as “Common International Classification of Ecosystem Services” (CICES) and it relies on 3 main categories: (i) provisioning, (ii) regulating/maintenance, (iii) cultural. These 3 main categories are subdivided into a total of 9 subcategories. CICES mentioned on the homepage: *“CICES provides a hierarchical system, building on the MEA and TEEB classifications but tailored to accounting”*

A number of goods and services provided by natural capital can hardly be quantified, leave alone monetized. As a consequence, a decrease of the quantity and quality of the natural capital is often ignored. There are very few economic models which fully appraise the value of natural capital. Particularly in the domains of agriculture and land management there is a tendency to overlook the decline of natural capital, even if the decline is irreversible. Unfortunately, with regard to agriculture and land management there are very few “flag ship studies” which could serve a paradigm of how to quantify and monetize the decline of natural capital.

In a TEEB interim report (2008) the problem of valuing ecosystem services was represented in a simple but illustrative figure (Fig. NC-2). The pyramid diagram shows that our ability to assess ecosystem services is limited by a lack of information. In Fig. NC-2 the non-specified fraction of the ecosystem services is depicted in grey. Even a qualitative assessment is not complete because some benefits are probably not even known. A quantitative and a monetary assessment is even more demanding. The latter would require reliable quantitative data plus meaningful economic tools and models. Consequently, it will be most challenging to assess the full range of soil related ecosystem services.

In contrast, in the domain of greenhouse gases and global warming the British economist Nicholas Stern published the so called “Stern Review”. This review was released in 2006 and provides an in depth analysis of the costs and risks of climate change. Stern concludes that costs of early and rigorous actions to reduce the emissions of greenhouse gases will be by far lower than the long term costs (societal and financial) of a no action policy

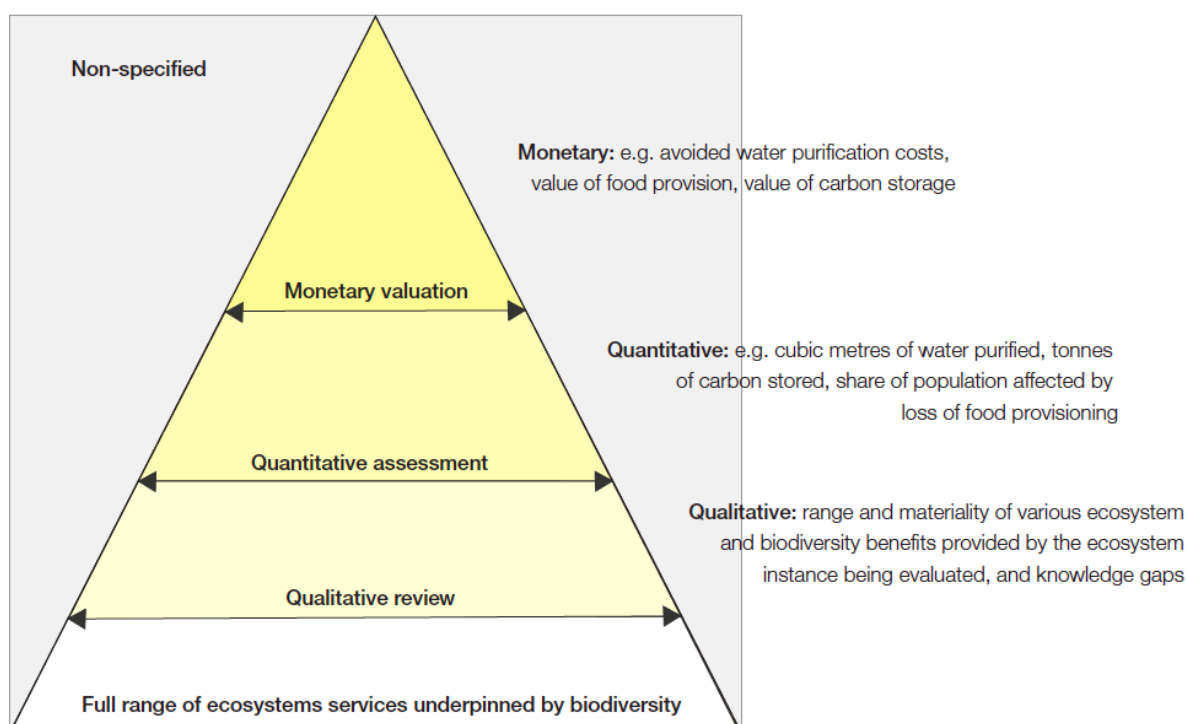


Figure NC-2: Valuing ecosystem services (copied from “The Economics of Ecosystems and Biodiversity” (TEEB), Interim Report 2009)

3.2.1 Relevance of the NATURAL CAPITAL perspective

The concept of natural capital is of great importance within the INSPIRATION research project. The conceptual model forms the basis of INSPIRATION and it includes the four themes (i) demand, (ii) natural capital, (ii) land management, (iv) net-impacts). Although the conceptual model is depicted as a flow chart the themes should interact with a number of cause-effect relationships, non-linear functions and feed-back loops. A few examples may serve as illustrations: The theme demand can be considered as an antagonist of natural capital, i.e. a well equilibrated balance between demand and supply is essential for a sustainable development. The theme land management has to consider the potential and the limits of what natural capital can offer. The management options may also include trade-offs between different categories within natural capital. Last but not least the theme net-impact has to develop a sensorium for beneficial or damaging long term effects on the natural capital and on environmental structures and functions (e.g. effect of high yield monocultures on soil fertility, effect of irrigation in semi-arid zones on groundwater table).

The goal of INSPIRATION is to define research questions within the four themes. From the viewpoint of natural capital there are number of crucial questions and a detailed list can be found in chapter 3.2.3. However, most of these questions share some common ground:

- There seems to be little awareness on the importance of the natural capital and the ecosystem services. How can we highlight the positive and fundamental role in order to protect and/or restore these services?



- There is no doubt that natural capital has to be preserved. However, quite often the rate limiting step in preservation endeavours is not lacking scientific knowledge and legislation but the implementation of existing knowledge, i.e. the transfer of knowhow into societal action.
- Research on natural capital should not be limited to phenomenological descriptions but reveal the underlying and systemrelated mechanisms.
- Research should not only focus on an extensive gathering of data and correlations but try to develop models with predictive power. Such models will be essential, particularly for the themes land management and net-impact.
- Research on natural capital should not only be sectorial but also consider the interaction of disciplines (physics, chemistry, biology, etc.) and systems (soil, water, atmosphere, etc.). Reliable predictions within the theme net-impact will partially rely on a holistic understanding of the processes within natural capital.
- For obvious reasons field research often relies on point measurements (e.g. soil carbon and microbial biomass at a given sampling spot at a given time). It will be a challenge to extrapolate these data in space and time at the landscape level. Issues such as geostatistics and spatial and temporal variability will play a major role.
- All climate change scenarios predict an increasing risk of extremes with regard to rain, draught, temperature, etc. Research in the field of natural capital can no longer afford to study exclusively “normal” steady state conditions but will also have to consider highly dynamic systems under stress (considering resistance and resilience, new equilibrium states).

Literature for chapters 3.2. and 3.2.1:

- Interim Report on The Economics of Ecosystems and Biodiversity, TEEB”, 2008, ISBN-13 978-92-79-08960-2
- Proceedings of the National Academy of Sciences, PNAS, 2015, Vol. 112 (24), 7390-7395
- Proceedings of the National Academy of Sciences, PNAS, 2015, Vol. 112 (24), 7396-7401
- Ecological Economics, 2015, Vol. 115, 11-21
- Ecological Indicators, 2016, Vol. 61, 90-99
- Frontiers in Environmental Sciences, 2016, Vol. 4, 1-49
- The Stern Review on the Economics of Climate Change, 2006
- Millenium Ecosystem Assessment, Report United Nations, 2
- Common International Classification of Ecosystem Services (CICES), <http://cices.eu/supporting-functions/>
- Economics of Ecosystems and Biodiversity (TEEB), <http://www.teebweb.org/>
- Mapping and Assessment of Ecosystems and their Services (MAES), <http://biodiversity.europa.eu/maes>



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The goal of INSPIRATION is to define research questions within the four themes. From the viewpoint of natural capital there are number of crucial questions and a detailed list can be found in chapter 3.2.3. However, most of these questions share some common ground:

- There seems to be little awareness on the importance of the natural capital and the ecosystem services within the SSW-system. How can we highlight the positive and fundamental role in order to protect and/or restore these services?
- There is no doubt that natural capital has to be preserved. However, quite often the rate limiting step in preservation endeavours is not lacking scientific knowledge and legislation but the implementation of existing knowledge, i.e. the transfer of knowhow into societal action.
- Research on natural capital should not be limited to phenomenological descriptions but reveal the underlying mechanisms relevant for the SSW-system.
- Research should not only focus on an extensive gathering of data and correlations but try to develop models with predictive power. Such models will be essential, particularly for the themes land management and net-impact.
- Research on natural capital should not only be sectorial but also consider the interaction of disciplines (physics, chemistry, biology, etc.) and systems (soil, water, atmosphere, etc.). Reliable predictions within the theme net-impact will partially rely on a holistic understanding of the processes within natural capital.
- For obvious reasons field research often relies on point measurements (e.g. soil carbon and microbial biomass at a given sampling spot at a given time). It will be a challenge to extrapolate these data in space and time at the landscape level. Issues such as geostatistics and spatial and temporal variability will play a major role.
- All climate change scenarios predict an increasing risk of extremes with regard to rain, draught, temperature, etc. Research in the field of natural capital can no longer afford to study exclusively “normal” steady state conditions but will also have to consider highly dynamic systems under stress (considering resistance and resilience, new equilibrium states).

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- Mapping and Assessment of Ecosystems and their Services (MAES), <http://biodiversity.europa.eu/maes>

3.2.2 Overview on NATURAL-CAPITAL - Clustered Thematic Topics

Based on a careful study of “D2.5, National reports with a review and synthesis of the collated information” (Jos Brils et al.) it was decided to highlight 10 CTT as being important within the theme “natural capital”. This selection strictly relied on a bottom up approach and it was extensively discussed with the NFP at the workshop in Zürich (April 28-29, 2016). The overall concept was approved but the NFP suggested to add another CTT, namely “Geological resources”. At the workshop the NFP’s also suggested to expand on the CTT “Intrinsic values of soils and landscapes”. All these suggestions were considered and the modified version of the text was discussed with the NKS’s at the workshop in Faro (June 8-11, 2016). The feedback by the NKS’s included the following major points:

- Quantity of soils, quality of soils, health of soils, carbon and green house gases are highly linked issues and should not be listed as independent CTT but merged into one CTT. This suggestion was considered in the present version of the text.
- Water is of paramount importance for most soil functions within the SSW-system and this should be stressed in the text. This was now done all the way through.
- It will be a major challenge to quantify and valuate ecosystem services. A qualitative description of these services alone is a poor basis for soil management decisions. This suggestion was taken up and the Stern review is now mentioned as an illustration.
- There are a number of categorization concepts for ecosystem services, which the NKS suggested to mention. This was done and for illustrative purposes the categorization used by the UNEP is shown in this version of the text.

-
- Several NKS stressed that soil management decisions are often very challenging because there is a legal conflict between private goods (e.g. land property, agricultural crops, real estate) and social goods (e.g. water quality, air quality, biodiversity).
- Last but not least a number of NKS mentioned that a splitting of the theme natural capital into CTT is inevitable but eventually somewhat artificial. Management decisions have to adopt an integrated view of all services within the SSW-system.

In summary, after the workshop in Faro the text was modified and the theme natural capital now includes a total of 7 major CTT (see Figure NC-3)

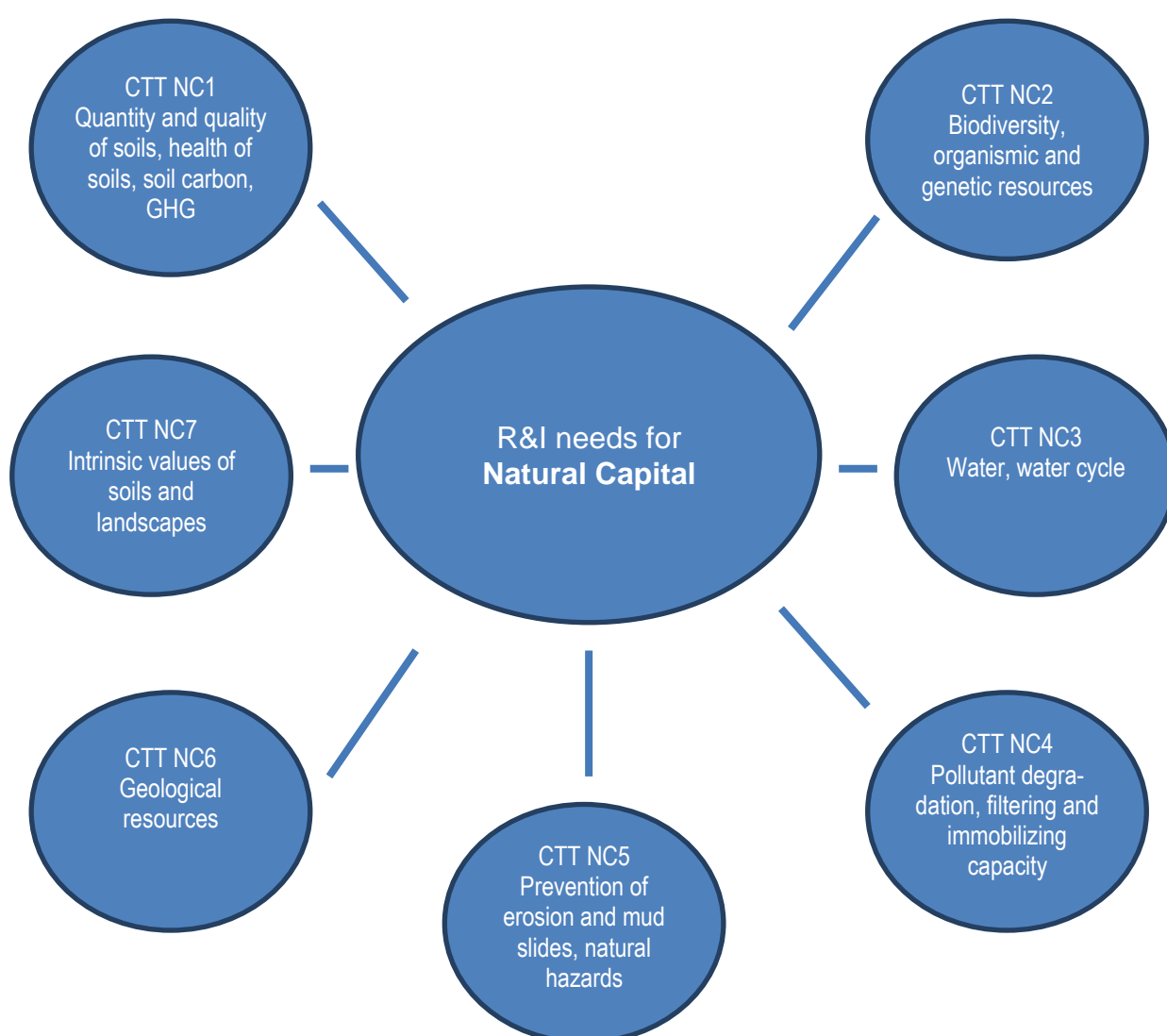


Figure NC-3: CTT identified as being important within the theme Natural Capital.

3.2.3 Research background per clustered thematic topic

CTT-NC1: Quantity and quality of soils, health of soils, soil carbon, greenhouse gases

NATURAL CAPITAL: Cluster Thematic Topics		AT	BE	CZ	FI	FR	DE	IT	PL	PT	RO	SR	SI	ES	SE	CH	NL	UK	No. of topics	No. of countries
CTT-NC1	Quantity and quality of soils, healthy of soils, soil carbon, greenhouse gases	AT-7	BE-10; BE-15		FI-4; FI-5; FI-6; FI-7	FR-1; FR-2; FR-3; FR-4	DE-4.1; DE-4.2		PL-3	PT-1; PT-2; PT-3; PT-4	RO-2; RO-3	SR-7		ES-3.13; ES-3.15	SE-5; SE-6; SE-8	CH-3.2; CH-3.3; CH-4.1; CH-4.4	NL-1; NL-3; NL-13		33	13

Soil quantity (in terms of m²) is an essential factor in agriculture and forestry as well as in housing and infrastructure. Scarcity of land with an adequate geotechnical quality triggers land use conflicts. Sustainable land use concepts are of paramount importance. However, for agriculture and forestry not only soil quantity but also soil quality is a crucial factor. A fertile unspoiled soil provides important structures (e.g. habitat for organisms) and functions (e.g. ability to catalyse biogeochemical cycles). A network of factors (e.g. compaction, exploitation, fertilization, etc.) can reduce fertility and the soil functions. The assessment of "soil health" is rather challenging. Soil carbon is a key factor for a fertile soil. Soil carbon has to be preserved.

Soils and particularly soil carbon play an important role in the cycling of greenhouse gases (GHG). Soils can produce or consume GHG. A few examples: Carbon sequestration by forests, selected crops or in wetlands is a major mitigation strategy for carbon dioxide. Over-fertilized and poorly drained soils can produce nitrous oxide. Well aerated soils can act as sinks for methane.

Last but not least it has to be stressed that water is a key factor for all major soil functions. Water is of paramount importance for physical (e.g. water as a transport vehicle), chemical (water as major solvent) and biological (e.g. water as basis for any life) processes.

CTT-NC2: Biodiversity, organismic and genetic resources

NATURAL CAPITAL: Cluster Thematic Topics		AT	BE	CZ	FI	FR	DE	IT	PL	PT	RO	SR	SI	ES	SE	CH	NL	UK	No. of topics	No. of countries
CTT-NC2	Biodiversity, organismic and genetic resources		BE-16; BE-17; BE-18	CZ-5	FI-8	FR-5	DE-3.5				RO-2			ES-3.2	SE-3; SE-8	CH-3.1			12	9

Soil is the major habitat for organisms (flora and fauna as well as microorganisms). A broad diversity is essential for the stability and resilience of an ecosystem. This is particularly important with regard to climatic extremes which may put a soil under pressure. The so-called "carrying capacity" is linked to diversity. The diversity is important on different levels: (i) Diversity of ecosystems, i.e. different habitats, (ii) diversity of organisms, (iii) diversity of genes (from an agricultural point of view important for future plant breeding), (iv) diversity of functions (e.g. functions can substitute each other which enhances the stability of the ecosystem).

CTT-NC3: Water, water cycle

NATURAL CAPITAL: Cluster Thematic Topics		AT	BE	CZ	FI	FR	DE	IT	PL	PT	RO	SR	SI	ES	SE	CH	NL	UK	No. of topics	No. of countries
CTT-NC3	Water, water cycle			CZ-4	FI-6		DE-4.2						SI-2	ES-3.3; ES-3.4	SE-2		NL-4; NL-12		9	7

The hydrological cycle between soil, surface water, groundwater and atmosphere largely relies on an undisturbed landscape. Sealing of soil surfaces, limited river bank infiltration, soil compaction, etc. can interrupt the water cycle and impede the water quality. As a consequence of climatic change parts of Europe may be subject to severe water shortages or surpluses. Both will affect agricultural productivity. In coastal zones a lowering of the groundwater table might enhance the salt water intrusion into the groundwater. In inland areas, an enhanced irrigation and evaporation may lead to a salinization of the agricultural soils.

CTT-NC4: Pollutant degradation, filtering and immobilization capacity

NATURAL CAPITAL: Cluster Thematic Topics		AT	BE	CZ	FI	FR	DE	IT	PL	PT	RO	SR	SI	ES	SE	CH	NL	UK	No. of topics	No. of countries
CTT-NC4	Pollutant degradation, filtering and immobilization capacity				FI-1; FI-4	FR-2		IT-1; IT-2				SR-7			SE-7	CH-3.3	NL-7		9	7

Soils, aquifers and rivers play important roles in pollutant degradation. Organic pollutants (e.g. pesticides) can be degraded by microorganisms, metals can be chemically and biologically converted (e.g. redox reactions). The biological degradation of pesticides was extensively studied by the agrochemical industry. The potential of soils to degrade and detoxify organic pollutants is an outstanding ecosystem service. Metals cannot be degraded but a number of redox reactions in soils may lead to an enhanced mobility (i.e. metals will be washed out) or an enhanced immobility (i.e. metals will be adsorbed to surfaces and thus lower their bioavailability).

CTT-NC5: Prevention of erosion and mud slides, natural hazards

NATURAL CAPITAL: Cluster Thematic Topics		AT	BE	CZ	FI	FR	DE	IT	PL	PT	RO	SR	SI	ES	SE	CH	NL	UK	No. of topics	No. of countries
CTT-NC5	Prevention of erosion and mud slides, natural hazards	AT-7		CZ-4				IT-3.4	PL-2	PT-4	RO-1		SI-2		SE-1	CH-4.2			9	9

A healthy soil with an adequate plant and tree cover is an important stability factor with regard to erosion, landslides and avalanches. These factors can hardly be matched by technical means. For example, a healthy forest in alpine zones provides a solid avalanche protection. On the other hand, an alpine meadow which is not cultivated any more or which is covered with alder provides a poor avalanche protection. For the sake of completeness it has to be noted that "normal" processes of erosion followed by sediment transport can also be beneficial for low lands.

CTT-NC6: Geological resources

NATURAL CAPITAL: Cluster Thematic Topics		AT	BE	CZ	FI	FR	DE	IT	PL	PT	RO	SR	SI	ES	SE	CH	NL	UK	No. of topics	No. of countries
CTT-NC6	Geological resources														SE-3		NL-8; NL-9		3	2

The surface and subsurface, respectively, can offer deposits of minerals (e.g. metals) and building materials (e.g. rocks, gravel, sand). Moreover, it can be a source of energy (e.g. wood, fossil fuels, and geothermal energy). Peat may serve as an example: For centuries in many parts of Europe peat was excavated and used as fuel. As a consequence the ecosystem services associated with peat were reduced (carbon sequestration, intact water cycle, high biodiversity, etc.).

CTT-NC7: Intrinsic values of soils and landscapes

NATURAL CAPITAL: Cluster Thematic Topics		AT	BE	CZ	FI	FR	DE	IT	PL	PT	RO	SR	SI	ES	SE	CH	NL	UK	No. of topics	No. of countries
CTT-NC7	Intrinsic values of soils and landscapes									PT-10					SE-8	CH-2.7	NL-2		4	4

Soils, flora and landscapes have intrinsic values (e.g. aesthetic, cultural and social values) which can hardly be valued. These values can be a basis for tourism and recreation. "Cultural landscapes", or man-made landscapes (in German "*Kulturlandschaft*", in Dutch "*Cultuurlandschap*") can be unique from a cultural, social and historical point of view. One has to be aware of the fact that these intrinsic values are often public goods (e.g. esthetical value of a landscape, biodiversity on an alpine meadow) whereas the challenges from the demand side are often private interests (e.g. infrastructure for tourism, real estate).



3.3 Land Management

Land management is the process of managing the use and development (in urban and rural settings) of land resources. It covers all activities concerned with the management of land from an environmental, economic and societal perspective. Land is a finite resource. How it is used constitutes one of the principal reasons for environmental change, with significant impacts on quality of life and ecosystems. According to the EEA, Europe is one of the most intensively used continents on the globe, with the highest share of land (up to 80%) used for settlement, production systems (including agriculture and forestry) and infrastructure. Conflicting land-use demands often arise, requiring decisions that will involve hard trade-offs. (<http://www.eea.europa.eu/themes/landuse/intro>).

Due to its specific features, land is perceived as a stock of natural resources including soils, water, sediments and vegetation, as well as like resource itself. Land management defined as process of organizing land planning, land use and development is related to the variety of environmental and socio- economic aspects. Important role of land management is to balance the demand for and supply of resources and natural capital in urban and rural areas. Land management includes the institutional capacity of local, regional and national governments to identify and protect vulnerable areas, ensure long-term productive potential of agricultural land (cropland, rangeland, forests), enhance adaptation to the climate change and to provide strategies to reduce the urban sprawl, (which is related to the land sealing and land degradation), as well as to minimize urban structure fragmentation and reuse of degraded, derelict or abandoned sites into new function. Therefore, land management covers competition among various land use options and could create or deal with land use conflicts.

3.3.1 *Relevance of LAND MANAGEMENT perspective*

State of art: The main aim of INSPIRATION is to develop a Strategic Research Agenda (SRA) to inform environmentally friendly, socially acceptable and economically affordable soil and land use management that meets societal needs and challenges.

From the INSPIRATION perspective land management needs to ensure efficient use and protection of resources and natural capital including its services and thereby contribute to solving existing problems and future challenges. Of major concern is the pace at which land, is being consumed by development activities. The fundamental challenge related to land management is to achieve integration between different policy levels and various stakeholders involved in this process and to ensure sustainable land use management by introducing appropriate instruments for solving land-use conflicts. With the increasing demand on natural resources, conflict on uses became an important element, which needs to be carefully assessed in order to allow evidence-based policy formulation and decision making.

Land management is strong related to spatial planning and should include the institutional capacity of local, regional and national governments to provide integrated strategies for better land use and land management. Spatial planning considers the way in which countries manage both strategic and land-use planning for a particular territory, which may be national, regional or local and in urban, rural and natural area. This is carried out in a variety of ways across Europe, depending upon legal and administrative frameworks, as well constitutional



law and historical traditions. (The direct and indirect impacts of EU policies on land, EEA Report 8/2016, p.23).

All EU countries have spatial planning systems which seek to regulate the use of land in the public interest, although the scope and methods of operation of each system differs. Spatial planning systems generally comprise two main functions:

- elaboration of plans (providing frameworks through development strategies and plans at different spatial scale from local to national),
- monitoring and development control (administrative and legal procedure operating at the local level to control the location of new functions or change of land-use).

Efficient spatial planning is one of the priorities on the EU countries³. The ambitious challenge of planning procedures is to deal with conflicts on different scales, in particular to balance the strong economic interests of private land owners on local scale versus public social and environmental implication on regional or international scale.

All efforts improving the methodologies in spatial planning and land-use management, exploring the potentialities of new technologies, innovative approaches, methods and instruments associated to development as well as to the land protection, could strengthen the relation between spatial planning and land management.

Gaps in research needs: Referring to the INSPIRATION aim and objectives, several gaps related to the research needs have been identified within the framework of the land management theme.

The most important is the lack of integration among different policy levels and various stakeholders involved in the process of land management. Especially weak presence of social science in the context of the land management, as well as economic aspects like role of property, ownership regarding duties and rights are mentioned as problematic. Research on land management and a better more connection between EU and national levels is needed. Recommendation is therefore to approach the research on soil and land use in a more integrated and systemic focused way and to bridge the boundaries of the own expertise or policy domain.

Need for innovations: Social science, partnership, involvement of end-users within the process of identification of research needs- connection between researchers and end-users for better matchmaking etc.

³ Resource Efficiency Road Map (2011): *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*

3.3.2 Overview on LAND MANAGEMENT Clustered Thematic Topics

Land consumption, land use and land availability are most important topics from the perspective of land management. Clustering process of identifying the transnational commons related to land management has been organized as follows:

Based on a content analysis of the national reports a first collation of clustered thematic topics (CTT) was revised following a review by INSPIRATIONs National Focal Points during the workshop in Zurich. Afterwards, research and innovation needs with regard to “land management” have been clustered in seven main CTT. This set of topics has been presented to the group of NKS for comments and suggestions during the workshop in Faro.

The main objective of the land management workshop in Faro was discussion on relevance of clustered topics to the national research and innovations needs, perceived from EU perspective. Common understanding of the theme has been based on commonalities and gaps regarding “Land management” with reference to the EU research context.

The workshop confirmed the important role of land management as a key mechanism keeping balance between demand of and supply for resources and natural capital in urban and rural areas. Land management operates across multiple scales, with many connections between the dynamics at different scales. That’s why it has been crucial to distinguish the multiple objectives and spatial scales of various interactions. The links between (new) knowledge and its implementation has been discussed. Simplifying the structure of CTTs by combining their content has been recommended during the workshop. Based on discussion during this workshop and after analysis of comments and suggestion made by NKS, as well as taking into consideration outcomes from interactive Common Forum meeting, the new structure of clustered thematic topics on Land Management is proposed below:

CTT-LM 1: Governance, management mechanisms, instruments and policy on Land Management, comprises former CTTs content of problems and challenges:

- CTT1- *Land as a resource- “Circular land use approach”*
- CTT3- *Conflicts on land use management;*
- CTT5- *Institutional aspects of land management ;*
- CTT7- *Urban-rural relationships*

CTT-LM 2: Climate Changes challenges for Land Management, comprises former CTTs content of problems and challenges:

- CTT2- *Climate change adaptation and mitigation;*
- CTT3- *Conflicts on land use management;*
- CTT4- *Development of Green Infrastructure and nature based solution,*

CTT-LM 3: Land as a resources in urban areas - (Sustainable urban land management)-

comprises former CTTs content of problems and challenges:

- CTT1- *Land as a resource- “Circular land use approach”;*
- CTT6- *Landscape protection and regeneration*
- CTT3- *Conflicts on land use management*

CTT-LM 4: Land as a resources in rural areas - (Multifunctionality of rural areas)-

comprises former CTTs content of problems and challenges :

- CTT3- Conflicts on land use management;
- CTT6- Landscape protection and regeneration;
- CTT-7- Urban-rural relationships,

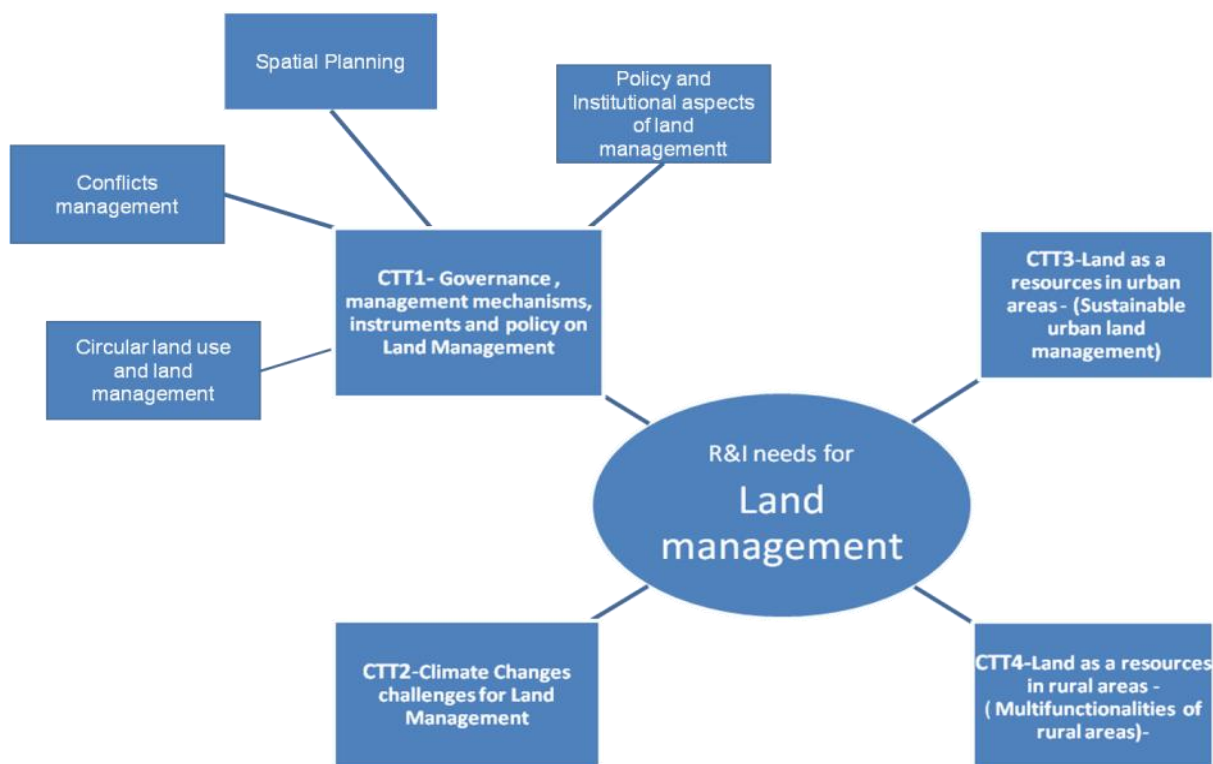


Fig. LM1. Clustered thematic topics with regard to “Land management”.

3.3.3 Research background per clustered thematic topic

The CTTs structure has been created on the basis of national reports, especially their part presenting research needs and questions.

CTT-LM 1: Governance, management mechanisms, instruments and policy on Land Management

LAND MANAGEMENT: Cluster Thematic Topics		AT	BE	CZ	FI	FR	DE	IT	PL	PT	RO	SR	SI	ES	SE	CH	NL	UK	No. of topics	No. of countries
CTT-LM1: Governance, management mechanisms, instruments and policy on Land Management																			75	43
1.1	Policy and Institutional aspects of land management	AT-13	BE-26; BE-24; BE-21	CZ-6	FI-13; FI-14; FI-15	FR-1	DE-1.1; DE-3.4	IT-3; IT-4	PL-4	PT-10		SR-2; SR-4; SR-5	SI-4	ES-2; ES-3.6; ES-3.8	SE-8; SE-2; SE-3	CH-1.2; CH-1.3; CH-1.12	NL-10; NL-14; NL-15	UK-2	32	16
1.2	Spatial Planning		BE-24; BE-21; BE-12		FI-8		DE-2.2; DE-3.2		PL-5				SI-1			CH-2.1; CH-2.4; CH-2.5; CH-2.8; CH-5.2	NL-8		14	7
1.3	Conflicts management	AT-4; AT-14	BE-22		FI-15; FI-10		DE-1.2; DE-2.2			PT-8				ES-1; ES-2	SE-9	CH-2.10; CH-5.1	NL-4		14	9
1.4	Circular land use and land management		BE-13; BE-26		FI-9; FI-11	FR-5	DE-2.1; DE-2.3	IT-3	PL-3; PL-4	PT-6		SR-1		ES-3.1			NL-7	UK-2	15	11

Governance in the context of land management is defined by the policies, using appropriate instruments and mechanism and the institutional, administrative framework. Making better use of existing instruments as well as introduction of new innovative mechanisms, based on a circular land use approach, will help keep more of Europe's land in beneficial use. The main challenge related to land management governance in Europe is the diversity of administrative and planning systems in EU members' countries as well as dynamic private sector initiatives e.g. in urban development and agriculture. Different countries have taken different approaches to land management and have different planning culture including: law and regulations, fiscal and economic system, complexity of investment's procedure and public information and communication. Content of this topic includes a common focus of many innovative approaches are being defined by the partner s' countries as a research needs.

These research needs have been further subdivided in four subtopics: 1) Policy and institutional aspects of land management, 2) Spatial planning, 3) Conflict management and 4) Circular land use and land management.

CTT-LM 1.1: Policy and Institutional aspects of land management

Policy and institutional aspects of land management are related to a broad scope of "land management" issues like: political regulations and public involvement, social and environmental needs, right of ownership, financing of land purchase, establishing and enforcing development controls, instruments mechanisms, which are focused on land management. The proposed research topics can be related to the efficiency of administrative procedures, management of land uses and spatial policy coordination. Identifying innovative solutions as well as institutional capacities required to carry out all of these tasks seek to introduce a new, holistic and systemic approach to land management, including urban-rural interaction. The integrated approach to land management reflects importance of co-ordination within broader as well as specific local context. Many research questions which are included in the national reports refer to these aspects of land management.



CTT-LM 1.2: Spatial Planning

Spatial planning goes beyond traditional land-use planning to bring together and integrate policies for development and use of land with other policies and programmes. Spatial planning plays an important role in achieving the spatial relationships between societal needs, economic activities and natural capital stewardship and is designated to regulate use of land balancing private and public interests.

In Europe, the relationship between spatial planning and measures to protect and enhance the soil and land varies from system to system. Due to the growing complexity and speed of the changing processes related to the particular context of land, it is more and more important to be able to have a real-time and flexible response to problems and opportunities. A general requirement for better and effective spatial planning is that environmental and societal objectives should be identified at an early stage of the planning process. It is crucial to develop support measures and guidelines that serve this purpose. There is a need to define multi-purpose guidelines which should respect various spatial planning scales (from global to local) and which should strengthen the ability of “land management” to deal with spatial, temporal and sectoral interdependencies among economic activities and with interrelationships between environmental and socio- economic objectives. Operational elements of spatial planning, e.g. new agencies and revolving funding instruments are required to coordinate different aspects of land management and improving soil land management quality.

CTT-LM 1.3: Conflict management among different land use options

Conflicts are an inherent part of land management. Competition among various land use options could create land use conflicts. Conflicting objectives exist in all types of spaces, on all scales and they reach beyond the set of instruments of spatial planning as “mutual spatial management process”. These conflicts exist, and to deal with them in an adequate way require the scientific basis for the adequate balancing of decisions and proposed solutions. Spatial vision systems are not compatible enough with one another. Also the interdependence of the different actors of land use decisions has been only partially understood up until now and a strong demand exists for empirical research. Better land management and integration of different land use targets could support reconciliation of potential conflicts on different scales and minimize negative impact on society, ecosystem services and quality of space. All topics related to the land management have been also related to the conflict management. From this perspective, conflict management seems to be an important and widespread issue across many countries. Management of conflicts is needed in the context of land ownerships versus public interests, local and worldwide effects (like climate change adaptation, urban- rural interdependencies etc.). There is a need to establish an integrated approach to conflict management, which should be coherent with all aspects of land management. There are research needs expressed by INSPIRATION's National Key Stakeholders to identify stronger involvement of wide range of stakeholders especially end- users into the process of land conflict management on to address societal challenges.

CTT-LM 1.4: Circular land use and land management

Land is a finite resource. That is why better land use and management should present a strategic approach for sustainable development of settlement structures as well as efficient use of land as a resource. Land-use from the perspective of circular economy refers to circular land use and management. Circular land management also offers a starting point for the achievement of the EU goal "no net land take by 2050" and the international goals related to a no-net-land degradation. This concept can be described with the slogan "reduce - recycle - avoid", and is focused on new, innovative ways to minimize the consumption of land by reusing and redevelopment of, derelict and under-used land sites as well as on de-sealing abandoned brownfields as a compensation measure for newly urbanised areas in order to achieve a zero land take balance. In this context, the circular land management concept presents a comprehensive strategic approach for steering the development of settlement structures. Circular land management also offers a starting point for the achievement of the EU goal "no net land take by 2050" and the international goals related to a no-net-land degradation. Furthermore, circular land management can contribute to the implementation of strategies for climate adaption and "healthy" cities. Research is required to understand the patterns of behaviour and interdependencies of actors active in land-related policy areas. It is important to combine the strategies and instruments of circular land management through applied research and pilot case studies and in the sense of modular "tool boxes" to qualify a sustainable land management. As a part of sustainable land use the circular material management should be included. Since many European standards are affected by this, this action should take place on the European level.

CTT-LM 2: Climate changes challenges for land management

LAND MANAGEMENT: Cluster Thematic Topics		AT	BE	CZ	FI	FR	DE	IT	PL	PT	RO	SR	SI	ES	SE	CH	NL	UK	No. of topics	No. of countries	
CTT-LM2: Climate Changes challenges for Land Management																					
2	Climate Changes challenges for Land Management	AT-4	BE-21	CZ-4	FI-12: FI-16		DE-2.5		PL-1	PT-4; PT-5; PT-10		SR-4; SR-7		ES-3.11; ES-3.12; ES-3.14; ES-4	SE-1; SE-4; SE-6; SE-5	CH-2.8	NL-3; NL-13		23	12	

Climate change affects all European countries. It is seen as a serious challenge for the urban areas as well as for rural areas on different scales. Climate changes all over Europe are increasing the danger of droughts, floods, landslides and other hazards, affecting both the quality of life of people and economy/businesses development. The comprehensive understanding about the processes resulting from climate change should be deepened, and better knowledge is needed for more effective and suitable land use management. Due to global aspects climate change should be regarded differently than the other societal challenges. The main focus should be on the protection of environment and the support of sustainability within the changing conditions as a result of climate change. Nevertheless, climate change is seen to be the number one threat as it is a very complex problem, therefore needing integrated, cross-sectoral solutions. Extreme weather events, flooding, drought and environmental stresses impose new demand on spatial planning and land management. Spatial planning is an instrument for coping with effects of climate change and land management can be a strong instrument supporting development and implementation of counteracting negative climate phenomena. There is awareness on climate change as a

societal challenge, that's why decision makers need to better integrate strategies for dealing with climate change into their development plans, rather than leaving them isolated as stand-alone policies and projects.

There is a need to work out land management instruments supporting climate change adaptation in the context of improving preparation for unexpected climate conditions in natural, semi-natural and built-up areas (rural and urban), through strengthening their resilience. Development of green infrastructure and nature-based solutions could enhance role of ecosystems services in the processes of strengthening this resilience.

CTT-LM 3: Land as a resources in urban areas (Sustainable urban land management)

LAND MANAGEMENT: Cluster Thematic Topics		AT	BE	CZ	FI	FR	DE	IT	PL	PT	RO	SR	SI	ES	SE	CH	NL	UK	No. of topics	No. of countries	
CTT-LM3: Land as a resources in urban areas - (Sustainable urban land management)																					
3	Land as a resources in urban areas - (Sustainable urban land management)	AT-6; AT-10; AT-7	BE-5; BE-6; BE-7; BE-12; BE-13	CZ-1; CZ-2; CZ-6	FI-10; FI-11		DE-2.2	IT-3	PL-3; PL-5; PL-6	PT-6		SR-7		ES-3.9	SE-4	CH-2.2; CH-2.3	NL-5; NL-6; NL-7	UK-2	28	14	

Sustainable urban land management is referring to SDG Goal 11: Make cities inclusive, safe, resilient and sustainable. Cities build diversified and dynamic economies, and become the key engines of development (by 2030, almost 60% European population lives in cities, towns and suburbs⁴). It is widely recognized that cities play a vital role in social and economic development of all European countries. However many growing and shrinking cities have difficulties related to economic, environmental and societal problems closely related to the transition of land. Sustainable urban land management is essential for innovative and effective approach of urban policy (e.g. compact cities, smart cities, healthy cities...). Increasing urban density reduces the effectiveness of urban solutions to hazards management and increases the need for costly engineering solutions. That's why one of most important questions is: How to improve the cross-sectoral implication of urban development? The other important part of urban land management is referring to the necessity of efficient (re)use of land resources: such as water, energy, and reuse of derelict, degraded and post- industrial urban sites. That's why is important to establish integrated solutions related to the multiple reused urban land, including those areas which recognised as a city's brownfield's.

Main challenge for sustainable urban management is to find ways of balancing the needs and pressures of urban growth with the opportunities and constraints of the environment. Once a solution was found and agreed, implementation structures are required to avoid deadlocks. In this context further research-fields are: impacts of demographic change, economical effects of urban sprawl, nature protection in urban space role of urban green infrastructure and nature – based solution, brownfield revitalisation, improvement of quality and efficiency of urban infrastructure, (multifunctional use and flexibility of buildings and infrastructure), governance of urban structure such as, urban agglomeration, polycentric conurbation and functional urban areas.

⁴ <http://www.un.org/sustainabledevelopment/cities/> and <http://www.eea.europa.eu>

CTT-LM 4: Land as a resources in rural areas (Multifunctionality of rural areas)

LAND MANAGEMENT:		AT	BE	CZ	FI	FR	DE	IT	PL	PT	RO	SR	SI	ES	SE	CH	NL	UK	No. of topics	No. of countries
Cluster Thematic Topics																				
CTT-LM4: Land as a resources in rural areas - (Multifunctionalities of rural areas)																				
4	Land as a resources in rural areas - (Multifunctionalities of rural areas)	AT-8	BE-18; BE-11; BE-12; BE-14; BE-15; BE-19; BE-20	CZ-3; CZ-8		FR-5	DE-3; DE-3.2	IT-1	PL-2	PT-2	RO-1	SR-8; SR-9	SI-3	ES-3.1	SE-5	CH-3.4; CH-1.1; CH-2.2; CH-2.5	NL-1; NL-7	UK-3	29	16

Sustainable urban land management is referring to a SDG Goal 15: Sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss. Land-use transition through agricultural production and the development of the countryside settlement structure are closely related to one another and the rural ecosystem services. There are a number of factors related to the transition of agriculture to the urban land. Most important is the pressure on high quality soils by new settlements, which lead to urban sprawl and high level of soil sealing. Also demographic change and migration from rural to urban areas play important role in this process. However transition process also offers chances for experiments, new users and uses. Limited natural resources such as water and soil should be used and managed following the principle of sustainability, in order to preserve them for the next generations.

Due to high levels of urbanization in Europe, keeping balance between urban and rural areas became a crucial issue especially in the context of soil protection and land management in peri-urban and rural areas. Effects of loss of high quality agricultural land due to other land uses, e.g. energy production became a challenge for development of the rural areas. It should avoid extensive use of land, ensure soil protection, limit soil-sealing. Improvement of management measures for the cultivation of agricultural land is a very urgent topic because it addresses people worldwide. Implementable solutions with regard to the regional adaptation are necessary. An international implementation of improved management measures will have a tremendous impact for small- and large-scale farmers. Sustainable use of the soil and multifunctional rural development could contribute to tackle societal challenges without losing soil quality. Environmental issues in rural areas are almost always related to environmental-development relationships like productivity and sensitivity of natural systems, as well as environmental hazards risk. Research in the field of "Rural Areas, Landscape Transition and Ecosystem Services" is needed on management and steering mechanisms, the development of the land/real estate market and environmental compensation measures linked to ecosystem services. Other important field of research related to the management of rural, areas are: innovative management of agricultural land. respecting their multi-functionality, pressure on high quality soils by settlement and species conservation, public awareness, on the economical, ecological and social value of landscape, biodiversity versus fertility of soils, role of soil-sediment-water-systems in planning procedures, long-term safeguarding of food security.



3.4 Net Impact on global, EU and local scale

3.4.1 Relevance of NET-IMPACT perspective

The European Union's economic prosperity and the well-being of its people is underpinned by natural capital; i.e. its biodiversity, including ecosystems that provide essential goods and services, from fertile soil and multi-functional forests to productive land and seas, from good quality fresh water and clean air to pollination and climate regulation and protection against natural disasters. In order to meet the growing (and changing) societal demand, land management decisions alter land use to more effectively exploit ecosystem goods and services, such as intensifying agriculture to increase provisioning services to produce food, fibre or energy. However, as the provision of many ecosystem services is interlinked with each other and/or linked to biodiversity, land use and land use change to increase the productivity of ecosystems is inevitable coupled with ecological, economic and societal impacts on global, EU and local scale as well as on different temporal scales. Moreover, climate change influences the array of ecosystem services provided by natural capital as well as societal demand for certain regulating ecosystem services, such as carbon sequestration, flood protection or soil erosion control. Against this background, INSPIRATION's net impact perspective is about assessing benefits and costs of land management options and providing guidance for decisions (land management) characterized by trade-offs between different societal goals (demand) and different ecosystem services (natural capital) given climate change and other global megatrends, such as demographic and social change, urbanisation, different pace of economic development in the world's regions and technological breakthroughs.

Notwithstanding remarkable increases in productivity and efficiency in the use of natural capital and its ecosystem goods and services, e.g. in agriculture, 10 million ha of arable land gets lost each year due to soil erosion, pollution, as well as land use change and desertification⁵. Even more dramatic is the situation in densely populated regions of Africa and Asia. It is estimated that by 2050 global agriculture production will need to increase by at least 70% and will be more impacted by climate change⁶. At the same time, taking into account global food consumption patterns in relation to health and disease such as rising rates of obesity and chronic diseases such as cardiovascular disease and cancer, recent publications raise awareness on future mortality risks⁷. In Europe, the challenge is to simultaneously address the often conflicting demands for land for the production of food and biomass, extraction of raw materials, water and energy provision, housing and infrastructure development but also for biodiversity conservation, recreation and protection of cultural

⁵ UBA – German Environmental Agency, 2015: Joint press release by German Environment Agency and Federal Ministry for Economic Cooperation and Development Ten million hectares of arable land worldwide are 'lost' every year. URL: <https://www.umweltbundesamt.de/en/press/pressinformation/ten-million-hectares-of-arable-land-worldwide-are>

⁶ IPCC – Intergovernmental Panel on Climate Change, 2014: Climate Change 2014: Impacts, Adaptation and Vulnerability, Summary for Policymakers; *ibid*: WGII AR5 Summary for Policymakers.

⁷ Kearney, J., 2010. Food consumption trends and drivers. *Philosophical Transactions of the Royal Society B: Biological Sciences* 365, 2793-2807; FAO, IFAD and WFP. 2015. The State of Food Insecurity in the World 2015. Meeting the 2015 international hunger targets: taking stock of uneven progress. Rome, FAO.

heritage. A substantial body of European Union legislation seeks to protect, conserve, and enhance natural capital. However, recent assessments, in particular the mid-term review of the Biodiversity Strategy, show that biodiversity in the Union is still being lost and that most ecosystems are seriously degraded as a result of various pressures, undermining their ability to sustain the essential services that they deliver and the associated benefits to our economy and society. To this end it is of utmost importance to understand the net impact of alternative land management practices and land use change on the soil-water-sediment-system – and ultimately – human well-being and economic prosperity.

3.4.2 Overview on NET IMPACT-clustered thematic topics

Under this theme, research and innovation needs as expressed in the national reports prepared by INSPIRATION WP2 are elaborated with special emphasis on the perspective of net impact on global, EU, national and local scale as well as on different temporal scales. Based on a content analysis of the national reports earlier drafts of a collation of national research and innovation needs under so called clustered thematic topics (CTT) were revised following a review by INSPIRATIONs National Focal Points (see Annex NI-3 in D3.3 report) and discussions with INSPIRATIONs National Key Stakeholders at the project's annual meeting in Faro, Portugal.

R&I needs with regard to “net impact” can be clustered in four main CTT (see figure NI-1). While CTT-NI 1 deals with knowledge gaps in the wide array of impact assessment methodologies and tools, CTT-NI 2 is concerned with gaps in understanding the impacts of alternative land management strategies, the effects of policies and regulations affecting land use and the impact of global change, such as climate change, consumption and life style patterns or market developments. CTT-NI 3 encompass all research and innovation needs regarding trade-off analysis and decision support, e.g. knowledge needed to sensibly address conflicting societal goals with regard to the spatially explicit optimal use of land or the development of cost-effective land management solutions for societal challenges. Finally, CTT-NI 4 deals with questions related to how the effectiveness of research and policy-making can be enhanced through strengthen science-policy interfaces, raising awareness, advancing knowledge transfer and facilitating participation in research and decision-making. In the following, these four clustered thematic topics are elaborated in more detail. The distribution of national R&I needs across the CTT and their subtopics can be found in annex NI-1 in D3.3 report; specific national research questions clustered under the subtopics in annex NI-2 in D3.3 report.

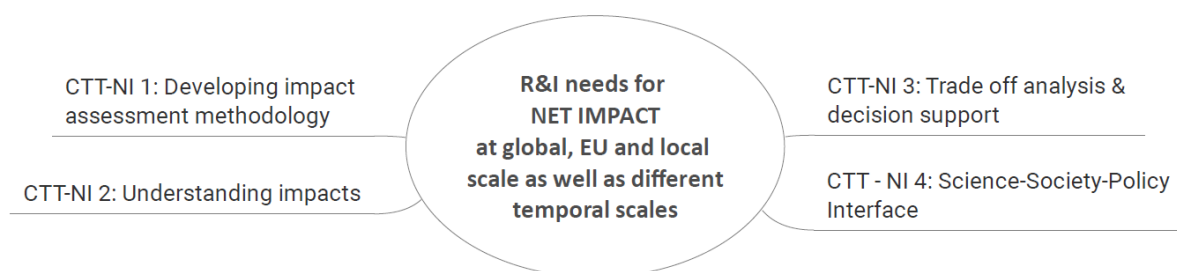


Figure NI-1: Clustered thematic topics with regard to “Net impact”.

3.4.3 Research questions per clustered thematic topic

CTT-NI 1: Developing impact assessment methodology

This topic clusters R&I needs regarding methodological development of impact assessment approaches. The research needs can be further subdivided in six subtopics (see figure NI-2):

- 1) the development of monitoring methods and indicators to assess changes in SSW-systems and related impacts;
- 2) R&I needs regarding data needs, data collection, harmonization across different geographical and temporal scales as well as governance levels, and data accessibility;
- 3) the further development of risk assessment methods, e.g. to deal with uncertainty of data input or the probability of outcomes as well as to assess health related risks;
- 4) the development of methodologies to analyse the net impact of governance settings, regulation and policies;
- 5) the development of integrated valuation methods that consider ecological, economic, and social impacts; and
- 6) the development of innovative impact metrics that are able to grasp yet uncovered impacts or that help to demonstrate impacts in a format accessible to stakeholders and/or decision-makers.

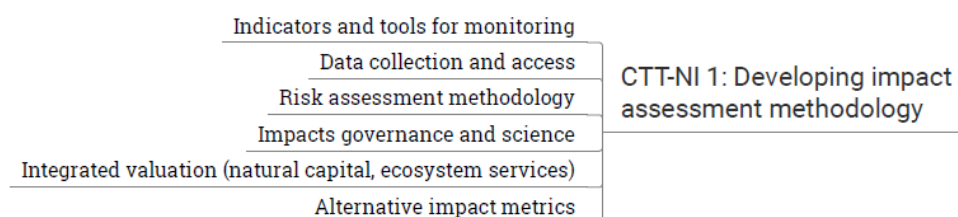


Figure NI-2: Clustered Thematic Topic NI-1 “Developing impact assessment methodology” and its subtopics.

Table NI-1 provides the distribution of national R&I needs for CTT-NI 1 at a glance. For more detail see annex NI-1 and NI-2 in D3.3 report. In the following, a rationale for the subtopic and exemplifying research questions are presented.

NET IMPACT: Clustered thematic topics and subtopics	AT	BE	CZ	FI	FR	DE	IT	PL	PT	RO	SR	SI	ES	SW	CH	NL	UK	No. of Topics	No. of countries
CTT - NI 1: Developing methodology to assess net impact																		117	17
1.1 Indicators and tools for monitoring	AT-5			FI-2; FI-3	FR-5	DE-3.5; DE-8.1	IT-2	PL-4		RO-1			ES-3.1; ES-3.8; ES-3.14; ES-4	SW-7; SW-8	CH-2.7; CH-2.12	NL-3; NL-7; NL-12; NL-13	UK-4	22	12
1.2 Data collection and access		BE-1; BE-4		FI-2; FI-3	FR-3	DE-8.1; DE-8.2	IT-2; IT-3		PT-9		SR-1; SR-7	SI-4		SW-1; SW-3	CH-4.1; CH-4.4	NL-14		18	11
1.3 Risk assessment methodology		BE-2; BE-3; BE-4; BE-27		FI-5; FI-10		DE-3.3; DE-4.2; DE-6.2	IT-1; IT-2	PL-6			SR-4; SR-5; SR-8	SI-3	ES-3.1; ES-3.5; ES-3.13	SW-1; SW-2; SW-7		NL-2; NL-7	IR-1; IR-2	26	11
1.4 Impacts governance and science	AT-11; AT-12; AT-13		CZ-2; CZ-4; CZ-5			DE-6.2	IT-3	PL-4	PT-7				ES-3.14	SW-3	CH-2.5; CH-2.12	NL-10		15	10
1.5 Integrated valuation (natural capital, ecosystem services)	AT-9	BE-16; BE-22; BE-23	CZ-1	FI-8; FI-13; FI-14		DE-3.5; DE-6.2; DE-9	IT-4	PL-3	PT-7		SR-6	SI-1	ES-3.14	SW-3; SW-8	CH-2.5	NL-2	UK-4	22	15
1.6 Alternative impact metrics	AT-12	BE-26		FI-5; FI-11; FI-12; FI-13		DE-2.3; DE-6.2; DE-6.3							ES-3.1; ES-3.2; ES-3.4; ES-3.14				UK-5	14	6

Table NI-1: Distribution of national R&I needs per subtopic of CTT-NI 1 “Developing impact assessment methodology”



CTT-NI 1.1: Development of methods and indicators to assess and monitor changes in SSW and net impact on human well-being and economic prosperity

Despite a basic understanding of the connection between drivers of change and impacts on biodiversity, ecosystem integrity, human well-being or economic development, there is often a lack of appropriate indicators, monitoring systems and tools to assess magnitude of drivers and their impact on the SSW. A better monitoring of indicative indicators would help to inform decision making, e.g. via the monitoring of threshold values or the development of early warning systems, thereby reducing unintended or unforeseen environmental degradation and enhancing the net impact of land management to address societal challenges.

In general, there is a need to develop an implementable set of indicators to monitor and evaluate the impact of e.g. use of natural resources, annual land consumption for housing and traffic or the vulnerability and risks due to impacts of climate change, floods, fire, landslides, summer tourism peaks, and depopulation etc. Depending on risk parameters, there is a need for short, medium and long term indicators that may respond to regional specificities.

In particular, what are suitable indicators that help to monitor **landscape change** and the drivers of **land consumption and urban sprawl**? Which indicators can improve the evaluation of qualitative and quantitative aspects of the consumption of land and study land use transition in urban and rural areas and may serve as a basis for long-term strategic vision of urban development?

How can (efforts and) results of **soil quality** care be monitored and by the use of which indicators? How could it be used for communication and monitoring (e.g. a threshold value)? What indicators should be used to quantify soil degradation?

Moreover, what indicators could be developed, that reflect the importance of **ecosystem services** in their relations to one another, so that bundle of services could be considered together?

In the case of **coastal areas and estuaries**: what set of common / harmonized indicators could be developed that would entail the development of methods for evaluating the effects of global change (climate change, invasive species, air pollution) on these ecosystems and their services? The regional specifics of certain **water bodies** and systems may require the development of specific indicators, e.g. to enhance the implementation of the European Water Framework Directive.

There is a need to define indicators and descriptors of effects of **contaminants** on organisms and on ecosystem services: What are essential parameters that describe the harmful short- and long-term effects and combined effects of such substances? How to develop and harmonize models and tools for **contaminated sites management** that would enable life cycle thinking in the field of brownfield and contaminated land regeneration?



CTT-NI 1.2: *Harmonization and standardisation in data collection and access*

A huge challenge for assessing net impact of land management is to identify (monitor) data needs, harmonize and standardise data formats and make available data better accessible for different stakeholders. In this regard, a range of research needs were expressed by INSPIRATION's National Key Stakeholders: There is a need for harmonized methods for comparability, reproducibility and transparency of data collection and management and to link data across different scales, e.g. from global to local scale in climate change modelling. There were questions on how increasing availability of data due to better measuring and monitoring (big data) impact land management and respective policies. Moreover, what are challenges for data requirements, sampling and handling under rapid changes in economic development, e.g. industry 4.0? It is expected, that optimized and harmonized delivery and utility of (monitoring) data will be more cost-effective and beneficial for innovative research, support in land management and policy formulation, while also promoting public awareness.

In particular, there is a call for the development of cheap, efficient, quick, validated and reliable **innovative screening methods** for data sampling and analysis for all monitoring parameters? How to organize joint production of field data, where samples are taken, observations are made or automated monitoring is used for multiple needs (soils, waters, land use, biodiversity)? How to integrate different detection and collection methods? How could legal instruments to support the collection of information through private means and to secure access of this information for stakeholders, incl. science be designed? There is also a need to develop new and **improved interpolation and modelling methods** to obtain area information from point data.

How to find new ways to produce, use and manage **big data** resources concerning soils, land use, groundwater and surface water interactions for various needs of the society? How to get a better match between / unambiguous information within national portals? How to process and use real time data on environmental conditions for different operational purposes in forestry, agricultural and other sectors?

How to promote **harmonisation of classifications** and gather comparable attribute data on different environmental compartments? How to maintain and combine different time series data to detect long-term changes? There is a need to harmonize data on contaminated sites, on national as well as on EU-level. How can we standards and protocols for data in support of vulnerability and risk assessments, and decision-support systems be established?

Develop tools, like online platforms to **share existing and future monitoring data**. How can data of the soil-sediment-water system be translated into information that helps in the decision making process? What is the scale of information needed for proper land management? How can we improve recording, exchange and use of data of the soil-sediment-water system on a national and European level? How could a flood risk management system look like, that links local data at national level and provide the basis for cost-effective risk mitigation measures?



CTT-NI 1.3: *Developing risk / impact assessments methods*

For certain activities, drivers of environmental change and associated risks there is a need to develop new assessment methods or to enhance existing tools and methods. A better understanding of cause-effect relationships would enable decision makers to manage land with more security on short, medium, and long term. A low uncertainty, e.g. on health impacts would favour swift decisions and flexibility in delivering permits for specific uses on land and (if necessary) under specific servitudes.

There is a need to establish **integrated risk / impact assessments**: How to make the assessment more systematic and comprehensive to deal with different kinds of (ecological, technological and economic) risks? How can analysis and evaluation methods be dynamically organized and monitoring systems and statistics be adapted to this to enable a continual process of sustainability evaluation? How can various timescales (long-term, short-term) be integrated into the sustainability effects of land use decisions? How can various spatial scales (landscape, region, nation, Europe, etc.) be integrated into the sustainability effects of land use decisions? How can we integrate risk assessment of soil and groundwater contamination or soil and land use aspects in risk and impact assessment? How can we integrate individual and / or societal level views assessments?

There is a need for updated and harmonized **models for human and eco-toxicological risk evaluation** for contaminated land, water and sediments, including updated and refined toxicological and dispersion parameters. What is the role of soil, sediment, water in the spread of antibiotic resistance and risk of (new) contaminants such as medicines and nanoparticles? How to survey (and remediate) groundwater contamination (e.g. VOC, pesticides in limestone aquifers)? How to estimate the risks of new or emerging pollutants for drinking water production?

There is yet not much knowledge about the understanding and evaluation of effects of **multiple stressors or sources** of perturbation, their interactions and interdependencies and their overall impact on biodiversity, functions of ecosystems and the resilience of these. How to take into account toxicity of mixed contamination? How to fingerprint (e.g. determination of age) sources of contamination in mixed plumes? How to refine the modelling of interaction and dispersion in the groundwater-sediment-surface water interface? How to create a transparent basis for the development of pollution-related measures for the various sources of these elements?

How can we assess **climate related risks** and “geotechnical risks”, e.g. contaminated sites at locations vulnerable to flooding or land-slides? How can we do a risk assessment on drought and floods as the effects of climate change and anthropic changes in the landscape? What is needed for long term monitoring and evaluation of climate change adaptation actions in order to prioritize measures? How to improve the **soil carbon assessment** methods that e.g. Intergovernmental Panel on Climate Change (IPCC) is using?

There is a need for a **strategic assessment of an efficient use of landscape**, environmental loads, potentials, and limits. In this respect, assessment methods, incl. risks of degradation processes need to be developed. Furthermore, such assessment could be used to establish comprehensive revitalization programs for degraded areas or mitigation measures on agricultural land? In order to prevent damage caused by land subsidence and to propose possible remedies to this phenomenon risk areas should be adequately



monitored. However, current measuring methods aren't still able to take to fully describe this complex phenomenon.

CTT-NI 1.4: Methodologies to analyse net impact of governance models and science

There is a call for adaptive governance models that enhance stakeholder participation in all and already at very early stages of decision-making or co-designing research (see also CTT-NI 4). By now, however, it is not clear, how the success of such new approaches in terms of increased effectiveness / efficiency of policy / planning solutions or usefulness and applicability of research results can be assessed. In this regard, several countries are calling for the development of methodology to better understand the roles of actors in decision-making and explore the net impact of innovative governance models, increased stakeholder participation in decision-making and setting research priorities and to guide the development of related infrastructures.

There is a need to better **understand the political and economic interests** that shape spatial planning and land management decisions and the roles of the different bodies of public administration in SSW system.

How can the **effects of policies and planning** be analysed? There is a need to better understand policies' impacts for resources, ecosystem service provision and society to get insights whether to further develop or promote policies and regulations. What methods should be developed for analysis of social, natural and economic consequences of plan implementation? How can policy pilots be used to avoid mismatches between policy and practice? There should also be a standard for assessing the effectiveness of protection-projects.

How can the **impact of research projects** be assessed regarding the improvement of public awareness? How can public reactions to science projects and their implementation be assessed? How can a political impact factor for scientific research look like?

CTT-NI 1.5: Integrated evaluation of impacts on ecosystem services

Currently, high expectations are placed on initiatives that aim at making nature's economic values visible and mainstreamed into decision-making at all levels. A structured approach to valuation can help decision-makers to recognize the wide range of benefits provided by ecosystems and biodiversity and capturing nature's economic values in decision-making can contribute to sustainable development and to optimize decision making processes. However, economic valuation is contested: Is a monetisation of ecosystem services necessary to achieve cost transparency and global equality? Is the decoupling of economy and environmental effects a sustainable solution for the value assessment of soil? Against this background, a range of research needs are articulated in national reports.

What kind of **cost-benefit analysis** is needed to value different kind of land use solutions (e.g. community development/water supply)? How to increase the importance of health and environment parameters over economic parameters in CBA? How can less evident/visible ecosystem services be accounted for, such as soil processes and certain cultural ecosystem services?



There is a need to further develop **multi-criteria analysis**, i.e. develop models incorporating the environmental, social and economic aspects to guide policy-making process: How can ecological, social (including cultural) and economic evaluation methods be integrated and what potentials are offered by the concept of ecosystem services and where are the gaps? What are the differences in valuations of stakeholder, individual and collective values? How is precision in the valuation of different types of ecosystem services best achieved? How to deal with different values and objectives in decision-making in multi criteria-analysis? How to strengthen ethical considerations in valuation frameworks? How to assess the intrinsic value of the environment?

How can **bundles of ecosystem services** evaluated? There is a need for approaches, methods and instruments of multifunctional assessment and an assessment of threats between particular ecosystem services (e.g. production versus protection).

CTT-NI 1.6: Development of alternative impact metrics

Besides established impact metrics, such as biophysical, economic or health effects that are often looked in separation, there is a call for developing systemic or holistic evaluation approaches that are able to link impacts at different scales in space and time as well as between different types of impacts. There is also a call for metrics that allow the evaluation of intangibles, and enhance qualitative assessments. In this way, it is expected that decision-making could be better informed and the complex interlinkage between action and impacts could be better communicated.

How can concepts such as resilience, irreversibility, sufficiency, and vulnerability be integrated into **sustainability evaluation** to guide policy design and for consumer information (e.g. certification and labelling)? How to develop assessment tools that consider the sustainability impacts of alternative land use solutions? What are the appropriate methods, models and tools to assess sustainability of urban development?

There is a call for a better understanding of the whole **life cycle** of food production, transport, consumption and waste to identify and minimize negative impacts. How to develop a life-cycle analysis (LCA) based model of soil carbon for minerogenic soil and peat or for soil remediation and regeneration? Can life cycle analyses be developed for construction materials and with this understanding new instruments be developed for the requirement of the reuse of construction materials?

There is a need to develop a framework for linking **footprint analysis** and biodiversity, i.e. footprints as a mean to measure externalities of biodiversity. Moreover, there are calls to (further) develop footprint analysis: **urban footprint** unbound to population growth; **water footprint** to inform decisions about implications of agricultural management; **carbon footprint** to assess climate effects of material consumption of infrastructure development and maintenance, e.g. in the transport sector.

CTT-NI 2: Understanding and assessing impacts of drivers and management

This topic clusters research and innovation needs regarding the identification (why and where are there impacts?) and the assessment (what is the impact?) of (yet unknown) impacts of different drivers of environmental change. In this regard, there is a need to better understand the impacts of (see also figure NI-3):

- 1) climate change;
- 2) land management decisions;
- 3) new and / or mixed pollutants;
- 4) socioeconomic drivers of land use and land use change, such as market trends, lifestyle and consumption patterns; and
- 5) policies, planning and regulation.

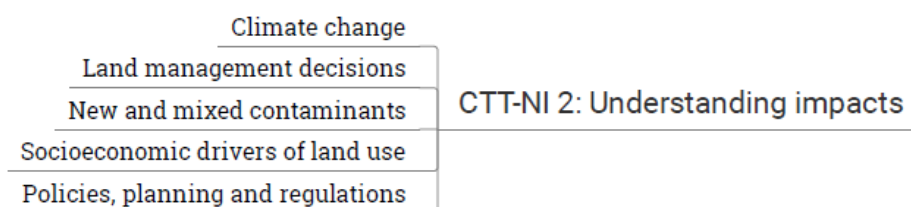


Figure NI-3: Clustered Thematic Topic NI-2 “Understanding and assessing impacts” and its subtopics.

Table NI-2 provides the distribution of national R&I needs for CTT-NI 2 at a glance. For more detail see annex NI-1 and NI-2 in D3.3 report. In the following, a rationale for the subtopic and exemplifying research questions are presented.

NET IMPACT: Clustered thematic topics and subtopics		AT	BE	CZ	FI	FR	DE	IT	PL	PT	RO	SR	SI	ES	SW	CH	NL	UK	No. of Topics	No. of countries
CTT - NI 2: Understanding and assessing impacts																			125	17
2.1	Climate change	AT-2			FI-1; FI-4; FI-6; FI-16		DE-2.5; DE-4.2; DE-9		PL-2	PT-4; PT-7	RO-3	SR-3; SR-8		ES-3.11; ES-3.12	SW-1; SW-2; SW-4; SW-6	CH-3.3	NL-3; NL-5; NL-12		24	11
2.2	Land management decisions	AT-9	BE-10; BE-18	CZ-1	FI-1; FI-4; FI-6; FI-7	FR-2; FR-5	DE-3.5; DE-5.1; DE-5.3; DE-5.5; DE-9	IT-3	PL-2; PL-6	PT-1; PT-2	RO-2	SR-4; SR-9	SI-1; SI-3	ES-3.6; SW-3; ES-3.7; ES-4	SW-2; SW-3; SW-5; SW-6		NL-1; NL-6; NL-8; NL-9; NL-12	UK-4; IR-2	40	16
2.3	New and mixed contaminants					FR-3		IT-2		PT-3					SW-2; SW-7	CH-3.3	NL-7		7	6
2.4	Socioeconomic drivers of land use	AT-10	BE-21				DE-2.1; DE-2.2; DE-3.1; DE-5.3			PT-4		SR-3; SR-8			SW-3; SW-5; SW-8	CH-2.11	NL-1; NL-5	UK-1; UK-5; UK-11	18	9
2.5	Policies, planning and regulations	AT-6; AT-7; AT-8; AT-10; AT-13	BE-10; BE-17	CZ-2; CZ-4; CZ-5	FI-1; FI-3; FI-9; FI-10	FR-1	DE-1.1; DE-2.2; DE-3.3; DE-3.4; DE-5.4			PT-3; PT-7; PT-10		SR-2	SI-1; SI-4	ES-3.14	SW-2; SW-3; SW-5; SW-7; SW-8	CH-2.12	NL-1; NL-3; NL-10	UK-7	36	14

Table NI-2: Distribution of national R&I needs per subtopic of CTT-NI 2 “Understanding and assessing impacts”



CTT-NI 2.1: *Understanding impacts of climate change*

There is a need to better assess impacts of climate change to prevent long-term consequences that might grow to an extent and magnitude unable to be controlled. Proper land use management systems have to be design in order to mitigate climate change impact with regard to carbon sequestration in agricultural and forestry lands, reducing agricultural land CH₄ and NO₂ emissions, or providing biomass for biofuels as well as to support the design of adequate land management strategies to adapt to climate change impacts.

Therefore, **integrated modelling of climate change effects** is to improve capacities for assessing vulnerability of specific systems, i.e. water resources, coastal zones, marine resources and ecosystems, terrestrial ecosystems and urban areas to climate change in relation with climate scenarios and to support decision making for their adaptation.

In particular, what is the effect of climate change on **soil quality**, soil characteristics, soil biodiversity, soil processes, soil subsidence and ecosystem services? What are the consequences of decreasing ground frost to soil quality, geotechnical properties, nutrient leaching and pests? What are the impacts of climate change on desertification and what are the impacts in economic, environmental and social terms? What are impacts on **agricultural productivity**? What are the effects of climate change on agricultural greenhouse gas emissions? In what ways will **forests** and mires change along with climate change, what are the consequences of the changes and how to prepare for them?

What are the **impacts of climate change related hazards**, such as storm water drainage on water bodies, increasing runoff waters during wintertime, more frequent and severe flood events? What are the effects of a changing climate on ground stability and landslide risks for transport infrastructure and buildings?

How sea level rise due to climate change and affects **coastal erosion** and what is required in terms of adaptation (beach defences, adaptation in residential areas)? How can urban chains of reaction (thermal/hydro) be better understood?

Lastly, there is a need for an assessment of climatic factors influencing the **water** balance in a territory. How do extreme weather events affect the sufficiency of groundwater in relatively shallow aquifers and groundwater depending ecosystems? How does climate change affect provision of drinking water?

CTT-NI 2.2: *Understanding the net impact of land management decisions*

There is a call to improve the knowledge about socio-economic and environmental benefits and costs resulting from different land management strategies in order to raise social awareness and to support decision-makers in land management and policy. There is a range of research questions asking for the impact of land use and land use changes on ecosystem provision and (changes in) organic carbon, soil fertility, soil erosion or water quality. What are the 4D (x,y,z and t) effects of land use and interferences in the natural system? What are the long term impacts of management practices on different soils under various climate conditions? What are comparative (dis-)advantages of different land use intensities or practices, e.g. in agriculture or forestry? What is the impact of urbanisation on the SSW-system but also on human health and vulnerability to climate change? It is expected, that such knowledge will improve competitiveness and sustainability of land management.



How to observe **land use impacts on water** ecosystems and groundwater depending ecosystems? What are short and long term impacts of land management and land use changes on the quality, quantity and temperature of surface and groundwater as well as on the quantity and quality of drinking water provision? What are the impacts of interventions in the water system result for other areas such as agriculture and spatial planning?

How do **agricultural production** systems constitute threats for ecosystem resilience as well as soil biodiversity, and affect risks of ecosystem and environmental collapse, and climate-induced catastrophes? What are the environmental and climate impacts of structural changes in agriculture, i.e. specialization versus integration, small scale versus large scale, and geographic localisation? There is a need to understand nitrogen impacts under various agricultural forms in order to quantify involved processes and spatial interactions implied in the nitrogen cascade. What are effects of agricultural practice for eutrophication of coastal zones, groundwater quantity and quality and climate on a global scale? What contribution can **organic agriculture** offer to increase yields, reduce negative environmental impacts and granting food security? There is a call to establish long term trials/demo fields (in plain and hilly side, respectively) for organic vs. conventional farming. How can **integrated agricultural systems at different scales**, for crop, livestock and energy production be designed and evaluated? What are the gains in terms of biodiversity preservation, efficiency, soil compaction of innovative soil tillage technologies? What are the potential advantages and disadvantages of using more land for different types of agricultural production? How much will productivity improve with soil management and crop rotation and what would be the alternative methods and measurements? Study and assess impacts of innovative and sustainable agricultural technologies, e.g. what are perspectives for agricultural factories (hydroponic) and what effects do they have upon land use?

What are the impacts of **forest management**, such as forest cutting, forest renewal and ditch network maintenance on runoff waters from drained mires? What are positive externalities of agroforestry? What is the contribution of forest cover to water quantity and quality, and how do different types of silvicultural systems affect the overall health of surface waters? How does forest management affect nutrient dynamics in soils, leakage to surface waters, and eventual export to the Baltic Sea? What are the effects of recreation on human health and economic aspects of multiple uses of forests under the influence of climate change? How is carbon sequestration in forests soils affected by different forest management strategies?

What are the social costs and benefits of **urban development**, in particular on greenfields? There is a need to better understand the relationship between built environment and health since research based on empirical data is still missing. Which (new) threats to the quality of the urban soil-sediment-water system can be expected in the coming decades and what costs do they involve? What are the (measurable) effects of ecological and building-with-nature concepts, spatial planning based on green-blue structures and the use of ecosystem services to the societal challenges in urban areas? How to estimate level of ecosystem services of urban areas achieved after implementation of scenarios including recycling of degraded areas?



Do interventions for the purpose of **mobility and transport** disturb the balance between the potential of the soil-sediment-water system and societal needs? What are positive and negative interactions between **subsurface infrastructure** and the soil-sediment-water system, and what can we learn for future infrastructural developments?

There is a lack of information about **cross boarder-supply of ecosystem services**, the number of such services and the number of their users. Such knowledge would be useful in spatial and regional planning, transport planning (especially public transport) and social care services.

CTT-NI 2.3: Understanding impacts of (new) contaminants

There is a lack of information about the impact of 'new' or 'emerging' contaminants on soils and surface water bodies as well as groundwater (see also CTT NI-1). There is a serious lack of knowledge about contaminants properties and distribution in the different environmental matrices and their interaction with health. Moreover, there is a need to better understand the impact of mixed pollutants coming from a range of different sources. Research could help to close gaps in law dealing with (emerging) pollutants and their consequences on the environment and people's health.

In particular, there is a need to **characterize and evaluate new pollutants** (emerging / persistent), their bio-accumulation and bio-dispersion. What are the impacts on natural resources and how do they affect the provision of ecosystem services? What entails the presence of substances alien to the system for the quality and resilience of the soil-sediment-water system? There is a need for research on toxicity, bioavailability, physicochemical properties, fate and transport, analytical methods (low detection limits), especially for PFAS-substances, fertilizers, pharmaceuticals, and "unknowns"). How do such contaminants affect raw water quality, treatment processes, mixture toxicity and human health? What materials in contact with water affect water quality and to what extent?

What are the effects from **diffuse contaminant sources**, the sum of contribution from many "small" sources, from **contaminant mixtures** and what is the impact of contaminant sinks (such as sediments, fibre banks etc.) on ecosystem services in the light of land uprising and climate change? There is a need for on line monitoring, in situ metrology, integrative/passive sampling and study of mixtures and procedures to estimate the hazard of the emerging pollutants on the basis of the most relevant exposure pathways. Which are the health effects from exposures of several contaminants (mixture/mixture toxicity)? How do diffuse sources/sum of contribution from many 'small' contaminant sources affect the quality/contamination levels in ground and surface water?

CTT-NI 2.4: Assessing the net impact of socioeconomic drivers of land use change

Besides climate change, market developments fuelled by accelerating international trade, globalization of product chains, consumption and lifestyle patterns play an important role for shaping land management. Yet there is a lack in detailed understanding of the importance of these socioeconomic drivers for land use and land use change decision and resulting impacts on natural capital, ecosystem service provision and human well-being. Research questions clustered here are concerned with the identification and assessment of these



drivers, thereby providing guidance for the design of corrective actions to minimize negative impacts.

In particular, which causes are responsible for the **consumption of land** (for example private investments, city development or investment-oriented assistance programs)? How to predict and lower the effects of global urbanization on landscape, its structure, character, visual parameters? Integrated research on the effects of the transformation from industrial to post-industrial knowledge based society is needed and the impact of that on land, soil, water and landscape transformation.

Land prices (e.g. for nature conservation, agriculture or public recreation areas) are rising due to private landowners buying big parcels of land. What is the impact of this process? Can we assess and calculate this impact? How can the pressure be minimized upon (organic) agriculture and/or the small scale agricultural production? What are the effects of increased competition for land based resources on producer prices and the economy in the agricultural sector, e.g. more large-scale and specialized production, or integration of production in new kinds of ownership and collaboration? How does improving supply chain efficiency affect the pressure on land use?

What impacts have **demographic trends** on the use and management of the soil-water-sediment system? What effects does demographic change have on spatial development, like housing and residential district development? How are rural spaces affected by the current migration movements (in the context of demographic change, but also refugees) and how do they affect land use?

What is the connection between **life style and consumption** of ecosystem services and the consumers' dependence of and effect on ecosystem services including issues related to consumer awareness and responsibility? What are the effects and development trajectories of different consumption models in regard to their environmental footprints? What are the effects of social trends and lifestyle on space, e.g. the demand for larger living space? What are trends in diets and what do they entail for soil and water use and health. How to achieve changes in human behaviour? Is policy needed?

CTT-NI 2.5: Understanding the net impact of policies, planning and regulations

Policies, planning and regulation shape the decision-making space for land users, producers and consumers as well as citizens and may thereby steer land management towards meeting the societal challenges. There is, however, a lack of understanding of the real impact of policies, planning and regulations and what makes a policy impetus effective or not. Also, there is a need to better understand the role of different administrative bodies in decision-making on setting up policies and planning.

How can the **impact of policies** intended to protect natural capital and foster ecosystem services be reliably predicted over medium- and long-term timescales? How do different land use policies, such as agricultural policy and city planning policy, contribute to the environmental impacts of land use? How do political sustainability goals (for example the UN Sustainable Development Goals⁸) and state/regional/municipal as well as sectoral expert

⁸ <https://sustainabledevelopment.un.org/?menu=1300>



planning (transportation, agricultural systems, nature protection...) influence the practical land use decisions of actors? What is the impact of locational policy, site competition and tax policy on spatial development? What are the impacts of environmental requirements in public procurement? How have legislative measures prevented "new" substances from affecting drinking water or sources for drinking water? What impacts can be achieved through instruments of loss prevention? What effects could be expected from the expansion of these instruments?

There are research questions regarding **policy choice & design**: Which level of planning is the most effective for the strategic application of planning instruments for the purposes of steering land use? What political incentives and sanctions could drive sustainable land use? What new policy instruments are needed and how the existing instruments should be developed to support sustainable risk management? What policy instruments can be used for stimulating the introduction of products on the market that are easily reused, repaired and recycled? How do different instruments affect each other and which are the effects of different levels and ambitions in the instruments? How is the knowledge about effectiveness of policies and planning used in policy formation?

There is a need to analyse the main driving forces and environmental, social and economic aspects influenced by **agricultural policies**. What is the impact of the manure policies and legislation (limitation of manure use on land) on organic carbon, N- and P-balances? How do political processes related to climate, the environment, biodiversity, trade, rural development, animal health and welfare etc. lead to international, regional and national agreements, policy instruments and laws supporting or restricting agricultural land use and production? What can be the role of the common agricultural policy (CAP) in the transition to a more healthy (for people and the environment) diet and sustainable agriculture?

What are the costs and benefits of **climate adaptation and mitigation policy** for the soil-sediment-water system? Which steering instruments are suitable for influencing the form of the landscape within the context of the "energy transition" in rural areas?

What are the **effects of policy change**, for example financial compensation and agricultural policy of the EU and the ERDF funding, beyond individual sectors? What happens to the rural areas when one choses to withdraw from sectoral funding sources?

Finally, there is a knowledge gap regarding the **coordination of policy and planning**, e.g. when and how to actually set up efficient coordination between different levels and the reasons that determine if the process is successful or not? There is a need to improve the process understanding – especially on the roles of the different public administration.

CTT-NI 3: Trade-off analysis & decision support

Research needs under this topic are concerned with analysing synergies and trade-offs between different (societal) goals with regard to land use as well as research needs regarding the comparative assessment of management options to balance conflicting demands. Such analysis is demanded as an input for transparent and evidence-based policy-making.

The following sub-topics can be distinguished (see also figure NI-4 below):

- 1) Conflicting societal goals, e.g. food security, supply of renewable energies, nature conservation etc.;
- 2) Cost-effective solutions in land management, i.e. how to select land management approaches with the most favourable impacts; and
- 3) Spatially optimized land uses; how to most efficiently use natural capital in space to address societal challenges.

CTT-NI 3: Trade off analysis & decision support

Conflicting societal goals

Cost-effective solutions in land management

Spatially optimized land uses

Figure NI-4: Clustered Thematic Topic NI-3 “Trade-off analysis & decision support” and its subtopics.

Table NI-3 provides the distribution of national R&I needs for CTT-NI 3 at a glance. For more detail see annex NI-1 and NI-2 in D3.3 report. In the following, a rationale for the subtopic and exemplifying research questions are presented.

NET IMPACT: Clustered thematic topics and subtopics		AT	BE	CZ	FI	FR	DE	IT	PL	PT	RO	SR	SI	ES	SW	CH	NL	UK	No. of Topics	No. of countries
CTT - NI 3: Trade-off analysis & decision support																			100	17
3.1	Conflicting societal goals		BE-3; BE-10; BE-28	CZ-3	FI-6; FI-15		DE-2.2; DE-5.2; DE-6.1; DE-9		PL-1	PT-8	RO-1				SW-1; SW-4	CH2.8; CH2.9; CH-5.1	NL-3; NL-5; NL-6; NL-10; NL-15	UK-6	24	11
3.2	Cost-effective solutions in land management		BE-5		FI-1; FI-10; FI-11; FI-16	FR-1; FR-5		IT-2	PL-1; PL-3; PL-4; PL-6	PT-1; PT-3; PT-4; PT-5	RO-1	SR-6; SR-7	SI-3	ES-3.8; ES-3.11; ES-4	SW-1; SW-2; SW-3; SW-5; SW-6; SW-7	CH-2.2; CH-2.3; CH-2.10; CH-3.4	NL-1; NL-2; NL-3; NL-4; NL-5; NL-7; NL-8	UK-3; UK-9; UK-10; UK-12	44	14
3.3	Spatially optimized land uses	AT-11	BE-1; BE-17; BE-22; BE-24	CZ-7	FI-7; FI-8; FI-12; FI-14	FR-1; FR-5	DE-4.1; DE-9		PL-4	PT-6		SR-5	SI-2	ES-3.9	SW-5	CH-2.1; CH-2.3; CH-2.7; CH2.10	NL-1; NL-2; NL-4; NL-7; NL-9; NL-15	UK-6; UK-8; UK-12	32	14

Table NI-3: Distribution of national R&I needs per subtopic of CTT-NI 1 “Trade-off analysis & decision support”



CTT-NI 3.1: Dealing with conflicts and promoting synergies of societal goals

Given the scarcity of resources and the overall limits of natural capital, conflicts and trade-offs between the realizations of different societal goals regarding land use and land management will be inevitably. Research questions clustered under this subtopic aim at identifying trade-offs as well as synergies and by assessing the relative importance of conflicting goals provide guidance for policy-making on how to go about these trade-offs or to realize synergies.

What are **methods for weighing up different societal interests** and goals? How can an effective stakeholder dialogue be conducted (see also CTT-NI 4)?

What conflicts arise from the **various goals of sustainable development**? How to map the “trade off” between money or economic growth and ecosystem in a better way?

Food security and energy need: Agricultural production for food is significantly crowded out by other non-food production (energy crops), which significantly influences future food (in-)security of the country. In this regard, what risks are associated with the creation of renewable energy sources in view of land use competition and a changing agricultural practice (example of consequences for the plant yield with high corn content)? Which quantity of biomass can be exploited keeping the soil quality? How can intensified use of forest biomass be balanced with objectives related to biodiversity, carbon sinks, site productivity and environmental sustainability?

What scales and standards are to be used in the evaluation/weighting of **spatial/urban development** processes and conflicts? How can collaboration be improved and conflicts of interests avoided in urbanization processes? How can soil and subsurface be balanced against other (environmental) topics (such as: water, safety, air, noise, ecology, economy, finance, spatial quality and societal challenges) in the development and management of urban areas? How can the requirements of nature protection, especially species protection, be weighted and integrated in inner urban areas? What instruments are needed to avoid / minimise impacts?

There is a call to develop criteria, tools and instruments to weigh up conflicting **underground land-use claims** and to revise the legal framework so that society can gain the maximum possible benefit from the use of the geological underground.

CTT-NI 3.2: Identifying cost-effective solutions for land management

There are research needs expressed by INSPIRATION's National Key Stakeholders to identify cost-effective solutions to address societal challenges. For example, how to identify most cost-effective remediation measures for contamination / brownfield revitalization? How can we deal with temporal distortions, e.g. some measures can be more expensive than business as usual but on long term save cost (or give high societal benefits)? How can costs and effectiveness of climate change mitigation and adaption measures be assessed and compared? How to deal with different benefits (social, health, economic, ecological) in cost-effectiveness considerations? What is the contribution of public green space / green infrastructure for human well-being / in climate change adaptation? How to adapt land management in agriculture and forestry to fully deploy the multifunctionality of these land uses? Research will help to develop land management strategies with the lowest negative



impacts. It will also guide policy-makers in designing regulations and support scheme to promote such cost-effective management strategies.

In particular, there is a call to develop evaluation methodology to compare the efficiency of **treatment and remediation techniques**: How to make remediation of contaminated soil, groundwater, sediment more sustainable and cost-effective (e.g. lower energy consumption, cleaning of soil, ...)? How to organize remediation activities in a cost-efficient way minimising the use of natural resources and environmental impacts and learning from failed projects? How to define sufficient level of purification for contaminated areas?

There is a call to develop comprehensive approaches for **restoring ecosystems** (peatlands, estuaries, coastal); this would entail the development of methods for evaluating the effects of global change (climate change, invasive species, air pollution).

Challenges in **urban development**: How to prevent urban sprawl, minimise land take and support sustainable use of built-up areas? How to use green infrastructure, technical solutions (above ground and subsurface) to tackle problems with noise, and poor air quality and create pleasant environments for everyday life? What are cost and benefits of alternative infrastructure solutions (water supply, sewage networks, energy supply etc.) in remote settlements?

Delineate and assess **climate change mitigation and adaptation** strategies for land management, using pilot projects to better understand the role of ecosystem services both for mitigation (i.e. carbon uptake and storage) as well as adaptation (i.e. nature based solutions as measures for storm and flood regulation, impacts on water supply and food production). What measures in the soil-sediment-water system are most effective to comply with the commitments to reduce greenhouse gas emissions (mitigation)?

How to detect the most effective ways to **improve water quantity and quality** e.g. through modelling and systemic approaches? How soils can be managed with regard to an intelligent use of continuously decreasing water resources?

How can we achieve a sustainable food production by **agricultural practices** in terms of quantity, quality, and minor environmental impact? How can resource use efficiency and production be increased on agricultural land while maintaining ecosystem services, biodiversity and animal welfare? What could be the contribution of precision agriculture coupled with higher resolution understanding of how natural systems vary?

How is **forest** biomass grown and utilized as efficiently as possible from an economical as well as environmental viewpoint and how can forest residues, for example stumps, be used in bioenergy production (in a lifecycle perspective)?

How can choices be made between different types of **energy production** (necessity, sustainability, costs and benefits, risk impact and acceptance)? Which assessment method is suitable and widely applicable? How can energy be stored and transported efficiently and sustainably using the subsurface and which technological knowledge is needed?



CTT-NI 3.3: Towards spatially optimized land use / land management

In order to best address the societal challenges of a resource-efficient development, land uses have to be spatially optimized to reduce negative impacts while realising synergies. In this regard a range of research questions were raised by INSPIRATION's National Key Stakeholders: Which type of land should be used for specific functions? What is the best use of land and what are the good uses of land; and in contrast, where should certain land uses be not allowed? The aim is to develop visions for spatial planning and policy-making of how land is to be used in future, how cities and municipalities are to be planned, how the landscape to be developed.

In particular, how can **multiple land uses** be managed in ways that optimise their value and reduce their adverse impact? How can reliable predictive models be developed to inform decision making? How to develop decision supporting tools to optimize land use and spatial planning, taking into account different societal needs at system level (e.g. mobility, water management, agriculture, residential areas, energy production, industry, nature, recreation ...)? There is a call for an assessment of the quality and efficient use of landscape and the (further) development of mapping approaches. Can such models, tools and maps be used at different scales – from field scale to national character area? How to target policy instruments to different areas taking into consideration the differences between growing urban regions and sparsely populated rural areas? How to define best locations for new developments and infrastructure in order to consolidate the existing of urban form?

Land sharing/land sparing strategies: how can a division of functions between natural conservation and agricultural production be considered at different spatial levels? How to identify in different areas the most important ecosystem services to be secured and what are necessary measures to maintain and increase them? Where and how sustainable intensification of food production is possible? Should high impact economical activities (e.g. cattle breeding) be equally distributed over Europe? How to develop decision making tools to determine which land should be used for specific functions, e.g. biomass production, food production...? Define quality and development goals for landscapes and determine where the subjects of landscape protection are located.

Which are proper **target or threshold values** for different soil types and for the different land use and vegetation types? What are the optimal P-levels in different soil types and for different land uses? When will system boundaries of soil quality be exceeded, e.g. intensive uses (system understanding) and can we quantify these (tipping points)? This is also relevant in an urban context: A task is to define criteria to decide where compact building is and where it is not to take place. Show how to decide fairly which residential areas have to limit themselves to inner development in the future.

CTT-NI 4: Science-Society-Policy Interface

This topic clusters research needs on how to enhance knowledge uptake and acceptability of policy measures to alter land-use decision with the ultimate goal to improve the net impacts of land management. The following sub-topics can be distinguished (see also figure NI-5 below):

- 1) approaches for awareness-raising among and behavioral change of policy-makers, land users and society;
- 2) participation of stakeholders in planning and decision-making;
- 3) transfer of knowledge to policy-makers and land managers; and
- 4) measures to facilitate policy integration, i.e. connect policy sectors to realize synergies or avoid conflicts in land management.

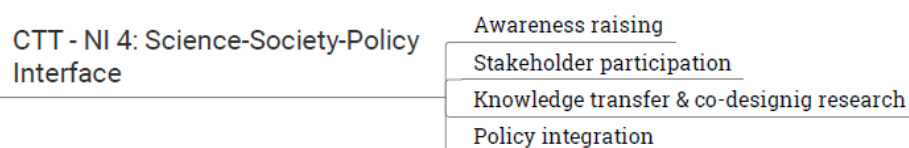


Figure NI-5: Clustered Thematic Topic NI-4 “Science-Society-Policy Interface” and its subtopics.

Table NI-4 provides the distribution of national R&I needs for CTT-NI 4 at a glance. For more detail see annex NI-1 and NI-2 in D3.3 report. In the following, a rationale for the subtopic and exemplifying research questions are presented.

NET IMPACT: Clustered thematic topics and subtopics	AT	BE	CZ	FI	FR	DE	IT	PL	PT	RO	SR	SI	ES	SW	CH	NL	UK	No. of Topics	No. of countries
CTT - NI 4: Science-Society-Policy Interface																		67	17
4.1 Awareness raising	AT-11	BE-2; BE-4; BE-13; BE-14	CZ-8	FI-10; FI-15		DE-1.2	IT-4	PL-5	PT-1	RO-2		SI-3; SI-4	ES-1	SW-2; SW-9	CH-2.5; CH-4.4; CH-5.4	NL-1; NL-5; NL-11		24	15
4.2 Stakeholder participation	AT-11			FI-15					PT-5			SI-4	ES-1; ES-2; ES-3.14		CH-5.1	NL-2		9	7
4.3 Knowledge transfer & Co-designig research	AT-2; AT-4; AT-11	BE-21; BE-24; BE-29	CZ-1; CZ-5	FI-3	FR-3	DE-4.2			PT-4; PT-10	RO-2	SR-2; SR-7		ES-1	SW-9	CH-2.3; CH-3.4; CH-5.3	NL-1; NL-11	UK-2; IR-1; IR-2	26	14
4.4 Policy integration	AT-13			FI-13; FI-14		DE-1.1; DE-5.3								SW-1; SW-4; SW-9				8	4

Table NI-4: Distribution of national R&I needs per subtopic of CTT-NI 4 “Science-Society-Policy Interface”

CTT-NI 4.1: Awareness Raising to facilitate communication, stimulate behavioral change and increase acceptance

Awareness Raising is seen as a critical factor to enhance people’s willingness to be actively engaged in decision-making via participation procedures, to facilitate uptake of knowledge in policy-making and land management, as well as acceptance of policies and planning to reduce negative impacts of land use decisions – all of this contributing to the ultimate goal of improving land management. Against this background, research needs were expressed on what factors facilitate communication and raise awareness among decision-makers as well as the broader public? And what infrastructure is needed to support awareness raising and to promote a change in behavior?



In particular, what **communication approaches** are effective and efficient in practice? Against this background, there is both a need for basic research as well as applied research. On the first, what is the social, cultural, anthropological and psychological background knowledge necessary for effective awareness raising and change in behavior? On the latter, a lot of questions were raised: Through what kind of measures and processes can social acceptance be addressed and achieved? How to reconcile potential conflicts through negotiations and consensus-building methods? How can concepts of ecological and social resilience (i.e. thresholds and target values) be operationalized and used as communication tools? How to improve relation of population to soil and landscape to avoid further pressure on landscape? What innovative evaluation instruments can support this, e.g. sustainable shopping cart, ecological footprint “land” for food production, etc.? What could be the role and suitable approaches for **environmental education** already starting in primary school?

How to raise awareness for the possible risks due to **soil contamination** (e.g. in vegetable gardens)? How to communicate about risks openly, transparently and interactively paying attention to the availability of data and privacy protection? Providing meaningful, relevant and accurate information, in clear and understandable terms targeted to specific audience, can lead to more widely understood and accepted **risk management** decisions.

Develop strategies on how to convince farmers to produce more ecologically sound and cause less damage to the soil (e.g. smaller tractors). Develop approaches that motivate farmers to apply and implement new knowledge. Improve the level of awareness regarding the environmental benefits of **organic farming** in agricultural schools and universities and among farmers by advisory and training. How become stakeholders aware of the importance of good soil quality for **food safety and quality** and their role in this matter?

CTT-NI 4.2: *Enhancing stakeholder participation*

Stakeholder participation may facilitate acceptance, effectiveness and efficiency of planning and policy-making, e.g. by ensuring the development of more easily utilized solutions as well as building public understanding and trust through informal and formal communication processes. There is also a trend towards bottom up activities in decision-making but a lack of knowledge and understanding about the reasons for the development of such initiatives and about their long term consequences and impacts. Against this background a range of research questions were identified and answers to these questions are deemed to be crucial to advance the positive effects of stakeholder participation for better managing land use conflicts.

In particular, there is a need for research on **inclusive decision-making and social empowerment**, exploring new or improved ways to achieve real participation of society in the decision including (academia, general public, NGO, experts, practitioners and whatever other actor with interest in land use and resource management). How to design new **participatory tools** to promote the active role of citizens and stakeholders in planning and decision-making processes and to increase common understanding of solutions (e.g. interactive panels, conflict-resolution 'laboratories')? How to include society in monitoring land uses and the state of soil/water? How can the users of land and groundwater in an area be involved in realizing clean groundwater and healthy soil for agriculture and nature?



CTT-NI 4.3: *Sharing knowledge effectively*

A common statement of INSPIRATION's National Key Stakeholder is that there is a lot of knowledge on how to enhance net impact of land management available; however, it is not disseminated to relevant stakeholder (from science to policy and administration on to end-users as well as the other way round) nor implemented in practice. An essential key to improve the situation is to facilitate knowledge transfer. In this regard it is necessary to understand how knowledge transfer works and what necessary infrastructures and support measures are, what kind of legal constraints (e.g. intellectual property rights) on knowledge exchange have to be considered and the market uptake of innovative solutions can be accelerated.

In particular, how does knowledge transfer works? Where are **barriers for transfer** of know-how into policies and management strategies? Which measures can reduce these barriers and enhance bi-directional knowledge transfer? How to gather evidence base for decision making and summarise diverse research findings in a comprehensive way, e.g. in a common research portal? How to **stimulate mutual learning** from positive and negative impacts of alternative land management experiences and policy-making?

How can knowledge transfer be enhanced by **transdisciplinary research and knowledge exchange** processes? How can research questions be formulated from and adapted to specific stakeholder needs? How can research results interpreted and translated, so they are in context and understood by decision makers, resource users and people focused on economic development? E.g.: How can we translate existing knowledge of soil biodiversity to actions for farmers to improve soil biodiversity? How to support good practices and pioneers in transition behaviour or mind shift? What can be the role of knowledge brokers, (digitally) exchanging experience platforms or learning networks?

What contributions to a knowledge transfer can experimental approaches, **demonstration projects** or pilots make? Improve research focused on best practises and demonstration projects supporting both productive and environmental function of landscape to facilitate interdisciplinary science approaches and promote exchanges among authorities. Establish long term trials/demo fields for organic vs. conventional farming. Show how bio control methods in agriculture can be applied cost-efficiently.

CTT-NI 4.4: *Facilitating policy integration*

Land use and land use change is influenced by many different policy sectors aiming at different, sometimes conflicting goals, e.g. housing & traffic, agriculture & forestry, climate mitigation & adaptation, water management, or nature conservation (see CTT-NI 3). As a result, there are many side-effects of sectoral policies, some of them intended, others occurring unintended. In order to facilitate the realisation of synergies and avoid / minimize conflicts of policies, there is a call for policy integration, to consider all relevant effects. It is unclear however, what tools and infrastructures are necessary to facilitate such policy integration and R&I needs are formulated in many national reports.

In particular, what effects do sectoral expert planning (transportation, agricultural systems, nature protection...) have on land use decisions and how can they be integrated into spatial planning and development? How can communicative feedback-loops support **cooperation**



between departments? What communication tools can be implemented? How to achieve integration of approaches, solutions and policies in the nexus between the use of water, energy and food to support an efficient and sustainable utilization of natural resources? How to learn from best practices of cross-sectoral integration of targets and creation of common understanding with the help of shared knowledge?

How to enhance ***spatial integration of governance***, e.g. among urban regions, rural regions and between these groups? What policy instruments have a trans-border effect and how can these get incorporated into existing/new European initiatives and departmental politics? How can the non-uniform administrative practices, e.g. within federal organized countries be altered to support large scale and integrated analysis?

3.5 Integrated Research Topics (IRTs)

3.5.1 Background to the integrated perspective

Research questions of National Key Stakeholders of the 16 (17) INSPIRATION case countries have been compiled by WP2 (see Brils et al., 2016). These national research questions have been structured according to the four perspectives of INSPIRATION's conceptual model (so called themes) to derive trans-nationally shared research needs, called clustered-thematic topics (CTTs). As a next step, crossing and bridging issues between these themes were identified and respective research needs assembled in so-called Integrated Research Topics (IRTs) (Fig. IRT-1).

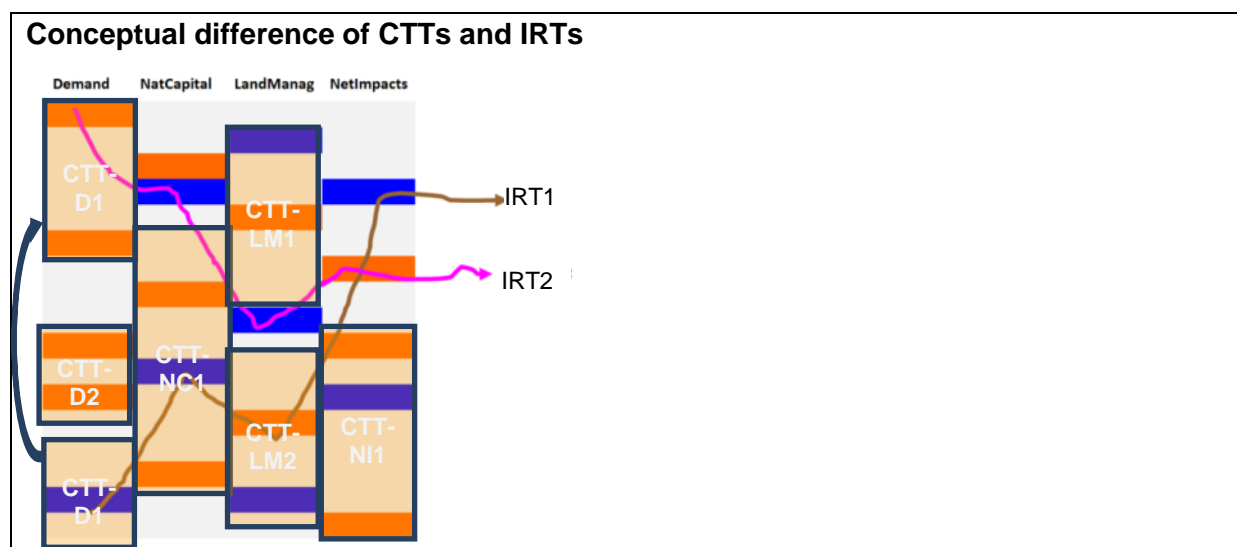


Fig. IRT-1: Clustered Thematic Topics (CTTs) and Integrated Research Topics (IRTs).

Whereas the CTTs were meant to systematically find clusters of research interests within the themes of the conceptual model (demand, natural capital stewardship, land management and net impact), the IRTs integrate research topics that are bridging different CTTs: Examples are the application of stakeholder engagement, questions related to the collection, harmonization and improved accessibility of data and monitoring methodology, integration of valuation methods and so forth. In other words, the IRTs do not replace the CTTs, but they rather complement them. While elaborating the IRTs, lessons learned from the construction of CTTs were reflected. Here an often heard feedback was that the topics are too general, broad, or abstract. The approach for IRTs was to elaborate them in a way that includes exemplary research questions and that applies the fundamental research need to a particularly important/relevant domain. By “particularly important/relevant”, we refer to the societal challenges identified in the national reports (e.g. sustainable agriculture and food security) and linked it with overarching topics such as monitoring and data collection (IRT1) or with the general demand for improved valuation techniques for ecosystem services (IRT2) and so forth. Often, IRTs are also relevant in other fields of application, e.g. data and valuation could have also been put forward in an urban or forestry context, but we identified a stronger call for it from the agricultural field. This assessment has been discussed with NKS in Venice and was revised according to the feedback given there.



3.5.2 Overview on Integrated Research Topics

The identification of IRTs compiling topics crossing or bridging the four perspectives has been based on 1) the input for overarching research issues in the country reports collated in D2.5, 2) feedback from stakeholders received in the engagement and consultation phases as well as 3) linking the CTTs identified in the four themes (see above). The identified IRTs were introduced to NKS in a background paper and revised in the Venice workshop (see chapter 2.2).

As for the CTTs, the IRTs thereby were elaborated following strongly the bottom-up approach of INSPIRATION. These IRTs consider trans-national and cross-thematic topics towards thematic programme packages and are for a better overview preliminarily sub-clustered into five groups.

- Group **“From information to implementation”** merges research needs from integrated monitoring; assessing, valuing to transferring complex knowledge to manageable tools;
- Group **“FFFF: demand, potentials and risks”** embraces dimensions’ potentials and management options for the 4F-context (Food-Feed- Fibre-[bio-]Fuel) under consideration of local, regional and global transdisciplinary and strategic approaches;
- Background of group **“Challenge: Integrated urban Management”** are the questions on how research can contribute to solving problems in and of urban and periphery regions with their interdependencies;
- the group **“Disturbed landscapes”** contains elaborated research issues on how to secure, manage and valorize degraded sites, landscapes and regions in Europe;
- and finally, in **“Climate change challenges”** the preparedness and response for climate conditions and related hazards are summarized.

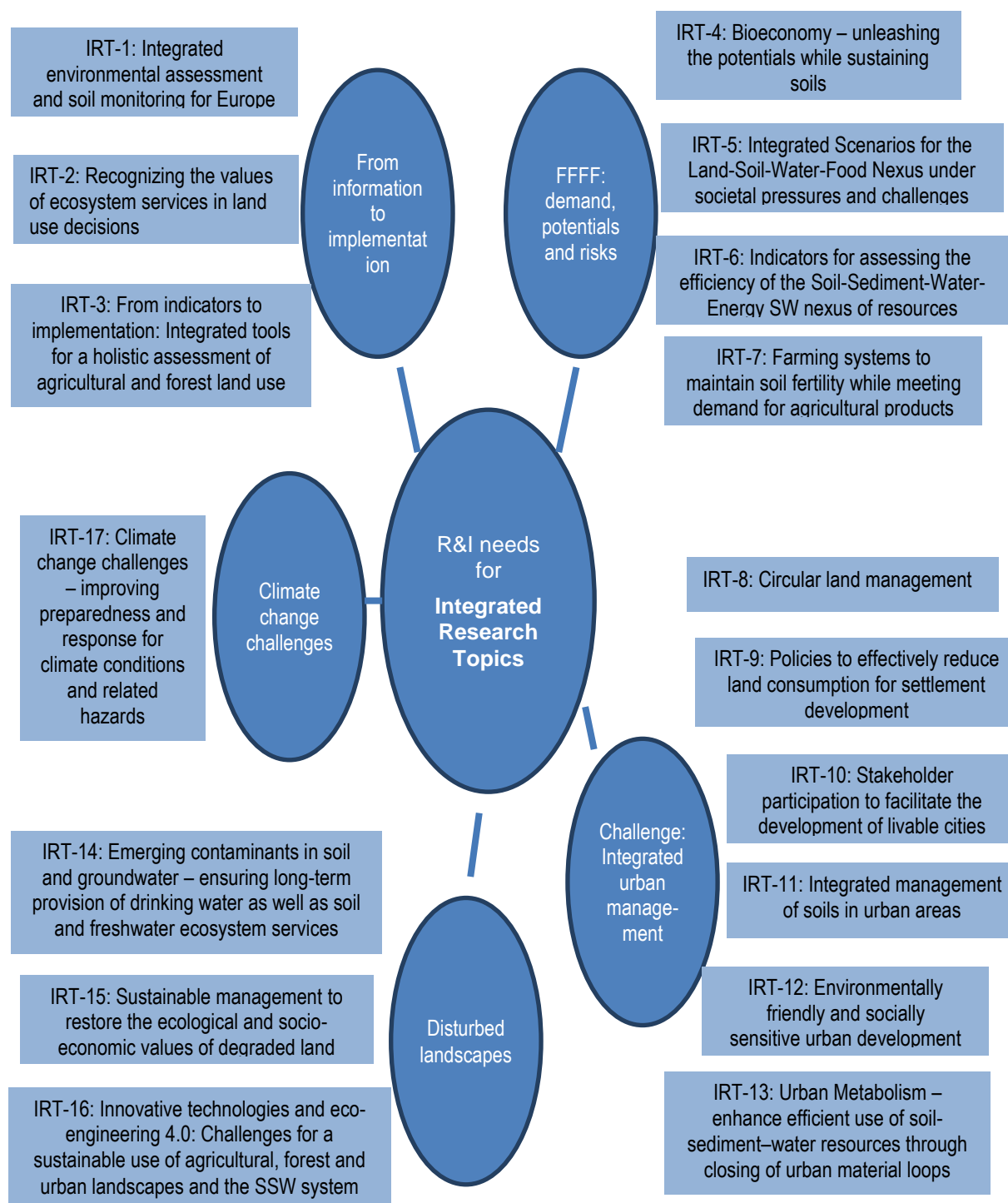


Fig. IRT 2: Workflow of WP3 towards CTTs and IRTs

These IRT groups thematically coincide well with overarching topics suggested and outlined in the executive summaries in the synthesis report of national research demands report D 2.5 (see footnote p. 4). It was crucial to show the consequent links of the IRTs to the formulated CTTs hierarchically summarizing the cross-sectoral and theme-bridging collation process. These are indicated in the respective descriptions below.



3.5.3 Integrated Research Topics

From information to implementation

IRT-1: Integrated Environmental Assessment and Soil Monitoring for Europe

Theme proposed by F. Glante, S. Bartke (UBA)

Background: The ENVironmental ASsessment of Soil for mOnitoring (ENVASSO) Project was funded as Scientific Support to Policy (SSP) under the European Commission 6th Framework Programme (Contract 022713, 2006- 8). The main task was to document existing soil monitoring schemes in 25 EU member states and to give an outline for a European-wide monitoring network to assess the state of European soils and trends of soil properties. ENVASSO also proposed a number of new monitoring sites to complete the network for overall Europe. (<http://esdac.jrc.ec.europa.eu/projects/envasso>). – So far, soil monitoring networks have focused on assessing the trends of hazardous compounds in soil, soil biology, erosion, and in some intensive monitoring sites also fluxes of compounds between soil and groundwater. But meanwhile, a number of questions arose that cannot be answered by “classical” monitoring. These are related to e.g. topics of climate change, food security, SDG implementation and accounting, and challenges in land-use changes. How can we achieve the connection of established networks and the integration of new networks in a way that ensures broad data availability (open data)? Are new statistical methods needed given the new demand for data and reporting? – Although ENVASSO proposed a European wide cooperation, and although on the EEA/JRC-level the European Data Center was established, a network of monitoring systems is still waiting to come to power. There are some surveys done in Europe like geochemical mapping of agricultural and grazing land soil (GEMAS), the forest soil survey or LUCAS-soil run by JRC but the future / replication of these activities is not sure and cannot replace a true monitoring. Nevertheless the harmonized methods should be taken into account in future harmonization activities, – New regulation (like INSPIRE) for data exchange has to take into force, but still research is needed to answer to knowledge gaps (parameters, indicators, scale). The remote sensing techniques, like the COPERNICUS program, might bring new data and information needed as background data for the monitoring.

Goal: Give an actual proposal for a European wide soil monitoring network to provide an information and data tool for scientists and decision makers. How to meet the land degradation neutrality target? Define Status of the soils in Europe and the trends of changes – either in soil / land use but also in impacts to the soils (chemical, biological and physical changes of soil functions). There is a definition needed: What is good soil quality – for which purposes? So soil quality targets should be elaborated.

Rationale from the themes: Demand: Without information on soil properties and the trends of changes in soil quality and soil use, we are not able to assess the links between demand and natural capital (ecological services). New challenges, new types of land use influence the soil quality, e.g. biomass production for energy, monoculture, agroforestry – which on the other hand are needed to satisfy our societal demands for sufficient energy, food and fibre. From a monitoring perspective new action is needed, because these land use types have not been covered in the monitoring schemes so far. There is nearly no monitoring



of soils in urban areas but changes and loss of soil functions caused by land use changes are very quick. So a monitoring not only of quantity of soil loss / and take but also of quality changes is urgent.

Natural Capital: Data availability is a necessary precondition to deriving models and understanding the systematic links in the Soil-Sediment-Water System. Only based on such information, tipping points can be identified. That is why the soil biology (biodiversity) should be monitored too. The number and geo-reference according to land use and soil type have to be valued to know whether or not the monitoring schemes in the EU 27 – if exist – cover the needs of the question that have to be answered. Monitoring makes only sense if you can relate the data to a certain background or threshold value. So these values have to be elaborated if they do not exist (see GEMAS-project).

Land Management: Usually the monitoring sites cover grassland, arable land, forest and sometimes some specific cultures like vineyard. A quality check is needed whether the average soil type, land use types and land management practices are covered in the existing monitoring programs. In order to improve decision making today and tomorrow, also new types of land management must be incorporated in the monitoring. The existing surveys, long-term field experiments, environmental specimen banks have to be connected to the monitoring systems in a way that allows decision makers to exploit information suitable for supporting more sustainable land management. Moreover, data and monitoring are the basis for raising awareness. Therefore a stakeholder participation is needed to join them in the monitoring and in the assessment process (citizen science). The results may cause changes in (non-sustainable) measures and action to soil. The added value for the stakeholders (e.g. farmers) should be clearly shown to motivate them in taking part in these activities.

Net Impact: Methods and Data elaboration is needed to assess the net impact to soil, water, sediment and to know how soil properties are changing in time. Monitoring is also a control of success how to meet the target of “land degradation neutrality”.

So what? Monitoring might show us when soils quality decreases to a level harmful to soil functions, food security and human health. It is one of the most important instruments counting the level of land degradation – and a measure to indicate if we achieve land degradation neutrality. A long term funding is needed to have results of – most – slowly reacting soil properties but to find an early warning system if harmful changes may occur.

Links to other fields: There is also a link to the problem of refugees, land abandonment / degradation in states suffering from war and conflicts, and problems of resettlement from rural to urban areas. These scenarios have also taken into account. Links to existing H2020-projects should be taken into account like the ISQAPER-Project.

Exemplified research questions

- How can (efforts and) results of soil quality can be monitored and by the use of which indicators? How could it be used for communication and monitoring (e.g. a threshold value)? What indicators should be used to quantify soil degradation?
- How could new methods like remote sensing (e.g. COPENICUS data) support soil monitoring?
- What data and system concepts are needed to harmonize monitoring data and make them available on a European scale? How could we deal with heterogeneous data

and which statistical methods can be used for monitoring purposes (geo-statistics, new statistical procedures)?

- How can surveys like the forest soil survey and permanent field experiments be used for monitoring purposes?
- How do we define and consequently monitor degradation neutrality?
- How could we monitor soil rehabilitation?
- What are the urgent soil monitoring questions in urban areas? Are there differences in the frequency of monitoring activities due to changes in soil / land use?
- How could we integrate information from ground water and sediment monitoring and other monitoring activities (e.g. biodiversity)?

Characteristics of IRT-1: Integrated environmental assessment and soil monitoring for Europe	
Links to identified research gaps	Indicated are numbers of relevant research topics from National Reports (cf. D2.5, Brils et al. 2016) AND for the relevant Clustered Thematic Topics (as defined above):
National research topics	AT 5; BE 1, 18; CH 2-7, 4-1, 4-4; DE 3-2, 4-1, 4-2, 5.5; ES 1, 3.5; IT 3, 3.4; FR 4; NL 5, 7; PL 4; PT 1, 2, 9; SE 8, 9
Clustered thematic topics	Demand: CTT-D1, 2, 3, 4 Natural Capital: CTT-NC1, 2, 3, 5, 7 Land Management: CTT-LM1.1, 1.3, 1.4, 3, 4 Net Impact CTT-NI1.1, 1.2, 1.3, 1.6, 2.1, 2.2, 3.2, 3.3, 4.1, 4.3
Further Characteristics	
Science fields	<input checked="" type="checkbox"/> Natural sciences <input checked="" type="checkbox"/> Social sciences <input type="checkbox"/> Engineering
Addressees	<input checked="" type="checkbox"/> Policy <input checked="" type="checkbox"/> Administration <input checked="" type="checkbox"/> Business <input type="checkbox"/> Civil Society
Regional scope	<input checked="" type="checkbox"/> Global <input checked="" type="checkbox"/> European <input type="checkbox"/> Multinational (ca. 4-8 countries) <input type="checkbox"/> Tri-/Bilateral
Duration of projects	<input type="checkbox"/> Short (< 1 year) <input type="checkbox"/> Medium (1 – 3 years) <input checked="" type="checkbox"/> Long (>3 years) <input checked="" type="checkbox"/> Very long (>6 year)



IRT-2: Recognizing the values of ecosystem services in land use decisions

Theme proposed by C. Schröter-Schlaack (UFZ) / J. Zeyer (ETH)

Background: Ecosystem services underpin human well-being and economic prosperity. Land use, such as agricultural production or forestry, and land use change, such as urban development, agricultural intensification or afforestation is influencing the bundle of ecosystem services provided. Few ecosystem services have explicit prices or are traded in markets and more often than not these marketable ecosystem services (typically, provision services such as crops or timber) are preferred over non-marketable services (e.g. regulating and cultural services, such as freshwater provision, mitigation of hazardous events or landscape beauty) in decisions about land use and land use intensity. Yet also these non-marketable ecosystem services are important to human well-being and people may hold substantial values for them, irrespectively whether they can be sold on markets or not. There is thus a huge challenge to identify and assess the benefits of such non-marketable ecosystem services affected by changes in land use and land use intensity. While many past and ongoing research projects are contributing to the assessment of the manifold values of ecosystem services, there is still a lack of consent on how these yet neglected values can be integrated (e.g. via hybrid valuation methodologies) and thoroughly recognized in decision-making. Thus, understanding driving forces of decision-making at different levels (local to national and even global), such as market trends, institutional settings, knowledge diffusion, technology development and policy incentives is another prerequisite to design land use policies that support the provision of better balanced ecosystem service bundles.

Goal: Explore on options, how the importance of the whole range of ecosystem services linked to changes in land use and land use intensity can be assessed, integrated and better recognized in decision-making and developing land use policies. Concepts should be based on recent studies, such as the MEA, TEEB and CICES systems.

Rationale from the themes: Demand: Our society has a huge demand for ecosystem goods and services. In order to safeguard ecosystem service provision it is absolutely essential that the demand does not overexploit ecosystems. A severe damage of ecosystem functions and services would trigger a number of negative feedback loops on society. Consequently, research on a well equilibrated balance between demand and the potential provision of ecosystem services is essential for a sustainable development.

Natural Capital: Some ecosystem services provided by natural capital can hardly be quantified; occasionally even a qualitative assessment is challenging because the connection between biodiversity, ecosystem functions and service provision is not fully understand. As a consequence, a decrease of the quantity and quality of the natural capital is often ignored in decision-making. Particularly in intensifying agriculture or greenfield development for housing, industry or traffic there is a tendency to overlook the decline of natural capital, even if it's irreversible. Research on structures, functions and interactions within ecosystems is essential. Research on natural capital should consider the interaction of disciplines (physics, chemistry, biology, etc. but also sociology, economics and law etc.) and systems (soil, water, atmosphere, etc.).



Land Management: Private land management decisions are mainly taken on economic reasoning, thereby neglecting the impact of management on non-marketable ecosystem services that do not resonate in private cost benefit considerations. Moreover, existing land management instruments, e.g. to enhance biodiversity protection have to compete with a strong incentives provided by market signals, production structures and policy incentives to (further) intensify agriculture production. Assessing the impacts that the disregard of certain ecosystem services pose on society (e.g. groundwater contamination, soil erosion or reduced landscape aesthetics) could help to identify counterproductive policies. Understanding the cost benefit considerations of farmers would also help to develop more effective policy responses in order to support the provision of better balanced ecosystem service bundles.

Net Impact: By now, there are only few economic assessments which appraise the value of selected ecosystem services affected by land use decisions. What is more, neither is there an agreed upon standard on if and how economic valuation of ecosystem services can be carried out, nor a shared understanding on how an integration of different value dimensions (e.g. economic, social, health, ecological) inherent to ecosystem services could be realized. Hence, there are huge gaps in understanding the net impact of different land uses and changes in land use intensities as well as the net impact of policies and regulations aiming at steering land use decisions.

So what? Assessing magnitude and societal distribution of costs and benefits of different land use options (e.g. through cost-benefit analysis, cost-effectiveness analysis or multi-criteria analysis) can help mainstreaming the values of nature and ecosystem services into decision-making.

Links to other fields: The key problem of valuing ecosystem services and value integration is evident in a number of conflicts at the interface society/economy/environment. For example (i) intensity of agricultural production (ii) greenfield development for housing, industry or traffic, (iii) forest management and afforestation or (iv) seep sea fishing versus fish diversity and abundance of fish populations to name but a few.

Exemplified research questions

- What new metrics are required to assess socio-economic, socio-cultural and environmental impacts and benefits of different land management strategies in response to (new) challenges, e.g. climate change mitigation & adaptation, demand for food, fuel, forest & fiber, housing, tourism & recreation, nature conservation?
- How can a new “value” framework, enabling better balance of benefits vs costs could look like? Valuation tools should give more weight to health, environmental and cultural parameters and should take ethical considerations into account.
- How to map and assess soil ecosystem services? How to value soil ecosystem services? How can the “bundle” of ecosystem services be gathered and evaluated? All stakeholders (including policymakers) need to take into account the value of the different soil ecosystem services in their processes and projects: how to do that?
- How can the accessibility and resolution of data on ecosystem services at relevant levels of decision-making (and in particular at local and regional level) be enhanced?
- How do stakeholders value ecosystem services and how can these result in social, economic and environmental development?

- What are the impacts of policies, regulations and incentives for resources, ecosystem service provision and society – e.g. for agricultural policies, infrastructure development, housing subsidies?

Characteristics of IRT-2: Recognizing the values of ecosystem services in land use decisions

Links to identified research gaps	Indicated are numbers of relevant research topics from National Reports (cf. D2.5, Brils et al. 2016) AND for the relevant Clustered Thematic Topics (as defined above):
National research topics	AT-9; BE-15; BE-28; FI-10; FR-2; DE-3.5; DE-6.2; IT-1; IT-4; PL-4; PT-1; PT-2; PT-4; PT-7; PT-8; SI-1; ES-3.7; ES-3.14; SW-5; SW-7; SW-8; SW-9; CH-2.5; CH-2.12; NL-1; NL-2
Clustered thematic topics	Demand: CTT-D1, 2, 4, 7 Natural Capital: CTT-NC7 Land Management: CTT-LM1, 4 Net Impact CTT-NI1.4, 1.5, 1.6, 2.2, 2.4, 2.5

Further Characteristics

Science fields	<input checked="" type="checkbox"/> Natural sciences <input checked="" type="checkbox"/> Social sciences <input type="checkbox"/> Engineering
Addressees	<input checked="" type="checkbox"/> Policy <input checked="" type="checkbox"/> Administration <input checked="" type="checkbox"/> Business <input checked="" type="checkbox"/> Civil Society
Regional scope	<input checked="" type="checkbox"/> Global <input type="checkbox"/> European <input type="checkbox"/> Multinational (ca. 4-8 countries) <input type="checkbox"/> Tri-/Bilateral
Duration of projects	<input type="checkbox"/> Short (< 1 year) <input checked="" type="checkbox"/> Medium (1 – 3 years) <input type="checkbox"/> Long (>3 years) <input type="checkbox"/> Very long (>6 year)

IRT-3: From indicators to implementation: Integrated tools for a holistic assessment of agricultural and forest land use

Theme proposed by F. Makeschin (DIU)

Background: Natural capital and land use systems are subjected by diverse disturbances and stressors. Although manifold scientific indicators are available for an ecological and socio-economic evaluation of land-use impacts, most of these used are still discipline- and sector-oriented. Examples for it are using soil chemical parameter exclusively for the productivity of sites without considering water quality or soil biodiversity indicators as sustainability criteria for land use too, or evaluating land use impacts restricted on a single field or site, whereas an interdisciplinary and spatial assessment would be necessary to integrate also the diverse impacts on a small or medium scaled landscape or regional level. Due to the complexity of factors to be involved for an integrative assessment of land use, appropriate tools for evaluation, planning, commercial and political decisions are still lacking. Thus science-based methodologies and assessment approaches are necessary for end-users like farmers or forest managers, planners and decision makers.

Goal: Elaborate end-user friendly tools for an integrated assessment of agricultural and forest land use.

Rationale from the themes: Demand: Although research and monitoring networks provided comprehensive data on land use potentials and vulnerabilities in the past, the actual knowledge about rural landscapes still remains rather fragmented. Furthermore, available



information on land use intensity and changes thereof, like agricultural intensification, is weak. Existing databases on different levels need to be augmented and existing information to be updated and harmonized. A clear structured set of indicators and agreed upon scales for analyses are needed to unify the assessment of biodiversity. Research demand exists for the availability of integrated and harmonized information about soil and land conditions to provide manageable data for assessment, decisions on land use changes and appropriate protection of natural capital on area-based, spatial information.

Natural Capital: Biodiversity is essential for the stability and resilience of ecosystems. This is particularly important with regard to land use changes and/or intensification or for climate change and extreme events which makes ecosystems vulnerable and put ecosystem service provision at risk. The carrying capacity of ecosystems is linked to their diversity important for the organisms, the genes and the ecosystems itself and their measurable functions. However, relationships between ecosystems, their functions and derived services are often extremely complex. Although there are numerous data on organism groups available, key indicators specific for land use types or climatic regions are rare. Thus integrated ecological indicators are needed for contributing to a better understanding of the relationship between ecological status of an ecosystem and the sustainable provision of ecosystem services.

Land Management: Decisions on type and intensity of land use following the objectives of sustainability crucially depend on integrated, region-specific and on easy accessible indicators. However, an integrated analysis and evaluation of land use and land use transition is hampered either by various existing definitions or missing accepted status of scientific knowledge, and not openly available sources of information. This is resulting in a deficiency in the quality and comparability of site analyses, evaluations of land use transition and the development trends that can be expected in the future. This is especially true of the goal set in the global sustainability strategy of a “land degradation neutral world” which requires further concrete and measureable indicators.

Net Impact: Integrated impact assessment approaches are a prerequisite for medium and long-term decisions of land owners, planners, public administrations and decision makers. Integrated approaches depend on meaningful and easy accessible data sets and harmonization across different geographical and temporal scales as well as governance levels. Elaborating integrated ecological key parameters (reflecting properties of ecosystems and representative land use types) and connecting them with socio-economic indicators and political goals like SDG's might contribute to farm-based decisions, supporting the analysis of the net impact of governance settings, regulation and policies and to a further development of risk assessment methods.

So what? Currently administrations, decision makers and different scientific disciplines work on assessment methodologies in parallel. As a rule, assessment approaches are based on segregated procedures (with focus on ecological, economic, social or planning aspects), and lacking on a spatial and cross-disciplinary indication. Thus research is necessary to bridge disciplinary sectors and to develop (regional or land use type specific) methodologies for an integrated assessment manageable and implementable for end-users. Integrated tools aiming on the needs of land users, planners, landscape ecologists and decision makers have to be developed by an intensive participation of these end-users. Research should consider the current state of the art of sectoral and disciplinary methods and criteria and existing best-

practice approaches on the one hand, and manageable tools and algorithms (in the sense of summary indicators) specific to agricultural or forest land use types or climatic regions (e.g. Nordic, Mediterranean) integrating also societal demands and the socio-cultural background of regions on the other.

Links to other fields: Main gap is elaborating integrated ecological indicators (key) bridging to / with socio-economic and planning instruments and tools.

Exemplified research questions

- How soil and water-related ecosystem services can be taken into account in land use planning?
- Which regional indicators and target values (e.g. sealing, flood protection, building density, type of agricultural cultivation) could support sustainable land use? How can they be implemented?
- Develop an implementable set of indicators to monitor and evaluate the impact of e.g. annual maximum land consumption, climate change effects or sustainable land use.
- How should an adequate tool for the assessment of soil quality look like for soil sciences and spatial planning?
- How to achieve comparable and harmonized data across Europe?
- How to prevent, map and monitor, evaluate risks, remediate or manage diffuse contamination in soil, groundwater and sediments?
- What is the contribution of soil to water retention?
- How to improve analysis methods and multidisciplinary use of different sources of data (field observations, geophysical mapping, observations made by citizens, remote sensing and other GIS-based data as well as modeling and model-based data)?
- What would the criteria and ways to comprehensively assess the use of natural resources?

Characteristics of IRT-3: From indicators to implementation: Integrated tools for a holistic assessment of agricultural and forest land use

Links to identified research gaps	Indicated are numbers of relevant research topics from National Reports (cf. D2.5, Brils et al. 2016) AND for the relevant Clustered Thematic Topics (as defined above):
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National research topics	Proposal is based on cross-sectoral research themes in D 2.5: executive summaries and overarching research needs.
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Clustered thematic topics	Demand: CTT-D1, 2, 4, 5, 6, 7 Natural Capital: CTT-NC1, 3, 5, 7 Land Management: CTT-LM1.2, 1.3, 3, 4 Net Impact CTT-NI1.1, 1.2, 1.3, 1.5
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Further Characteristics

Science fields	<input checked="" type="checkbox"/> Natural sciences <input checked="" type="checkbox"/> Social sciences <input checked="" type="checkbox"/> Engineering
Addressees	<input checked="" type="checkbox"/> Policy <input checked="" type="checkbox"/> Administration <input checked="" type="checkbox"/> Business <input checked="" type="checkbox"/> Civil Society
Regional scope	<input checked="" type="checkbox"/> Global <input checked="" type="checkbox"/> European <input checked="" type="checkbox"/> Multinational (ca. 4-8 countries) <input checked="" type="checkbox"/> Tri-/Bilateral
Duration of projects	<input type="checkbox"/> Short (< 1 year) <input checked="" type="checkbox"/> Medium (1 – 3 years) <input checked="" type="checkbox"/> Long (>3 years) <input type="checkbox"/> Very long (>6 year)



FFFF: demand, potentials and risks

IRT-4: Bio-Economy – unleashing the potentials while sustaining soils

Theme proposed by S. Bartke (UBA)

Background: Europe aims at a resource-efficient and sustainable economy. Europe's Bioeconomy Strategy (2012, to be reviewed in 2017) is claimed to be a building block of a circular and more sustainable economy. The bioeconomy comprises those parts of the economy that use renewable biological resources from land and sea – such as crops, forests, fish, animals and micro-organisms – to produce food, materials and energy. The bioeconomy promises a step-change where fossil fuels are replaced with sustainable natural alternatives as part of the shift to a post-petroleum society.

The bioeconomy enables independence from finite fossil resources, however, it relies crucially on the provision of biomass and energy to be provided by the soil-sediment-water-system and the rivers and seas. In particular, the capacities of soils and their sustainable potentials to enable a bioeconomy with adequate agriculture and foresting are critical.

By taking an integrated systemic approach, there is a need extend the understanding of the complex and interrelated factors involved throughout the biomass production and consumption chain. There is an urgent need to put in place measures to better understand and limit risks and environmental impacts (e.g. understanding and minimizing negative externalities) and better cope with varying conditions and seize opportunities for new ways of production, while respecting the sustainable limits of soils to provide the renewable resources. Not least, the socio-economic drivers and inhibitors (e.g. related to regulation and acceptance) of changing to a sustainable bioeconomy need to be considered comprehensively to understand the next to the technological also the societal potentials and limits of intensification of soil use in order to accordingly steer production as well as behavioral change in agriculture, industrial processing and consumption effectively.

Goal: Unleash the potentials of soils to sustain a bio-economy in Europe by better understanding soil and economic systems in order to derive more sustainable land management, biomass production and consumption

Rationale from the themes: Demand: Europe demands resources for the satisfaction of most societal needs. Soil can provide the produce for food, energy, fibres and products being basic to modern civilization. Access to safe and nutritious food is both a basic human need and a human right. As society has an increasing demand for soil products, practice demands more efficient production means (Agriculture 4.0, GMO). Bio-Economy also needs to show how bio-based produced goods can substitute conventional fossil-based products in order to satisfy societies' demands (e.g. building materials, fuels). At the same time, soil is demanded as space for living, infrastructures but also for recreation, therefore, enough soils with sufficient soil quality have to be available to satisfy the different – competing – demands.

Natural Capital: Soils are a limited resource not only by their extent but in particular if a bioeconomy is concerned with regard to their ability to provide soil services, such as provisioning of resources for bio-based products. To efficiently exploit soil's potential, it is necessary to understand the soil system with its functions, which are basic to the services, in their interrelation and reaction to pressures such as increasing demand, fertilization, changed



crops and soil management patterns. We need to understand the limits to which soils can be exploited and intensively used without endangering the stability of the soil functions and soil quality, thereby ensuring effective soil protection.

Land Management: The competing demands for soils on the one hand, and the trade-off of limited soil capacity to provide resources with the increasing demand for biological resources requires land management decision support on different levels from farm (What to produce and how?) to local and regional (Which soils to protect? What shall be produced where?) to national and European level (Which incentives to give? How to protect soils and at same time support job and satisfaction of societal needs? How to regulate bioeconomy?). On the production level questions are urgent on sustainable land management, e.g. which and how intensively to use fertilizers or GMO. Moreover, critical stakeholders and actors of the bioeconomy and their interaction need to be understood and addressed.

Net Impact: The impact of a change to bio-economy has drastic consequences, which need to be assessed with adequate data, based on suitable indicators and methods. Such assessment is to inform and alert about the local to global impacts of changes in soil-use and land management in Europe. In particular, the potential trade-offs and synergies of ecosystem protection and satisfaction of societal challenges towards a shift from petrol to bio-based economy need to be better understood, measured, monitored and addressed. At the same time, the socio-economic adaptation process, including cultural gaps, need to be better understood.

So what? Fossil resources are limited and in the long run alternatives are needed. Soils can provide bio-based resources, but their provisioning needs to be sustained as an overuse of soils must be prevented, because this could deeply impact the soil system functioning. If we do not find efficient means to utilize the potentials of soils to supply enough produce to satisfy society's demands, severe competition of needs will need to be managed.

Links to other fields: Next to soil, also water and sediments are used in a bio-economy and research is linked to the broader system.

Exemplified research questions

- What is the production capacity of soil to support a bioeconomy? Is there enough soil and how to use it best? → What is and how to achieve a bioeconomic optimal functional landscape organization? What is the efficient production and consumption spatial level (local, regional ... global – for which goods)?
- How to model complex soil system interactions to understand critical limits, tipping points of provision of soil services and the externalities beyond the production of a single desired biomass good?
- How sustainable can a bioeconomy be? In how far must a bioeconomy be a circular economy approach? What might be unwanted impacts of a bioeconomy? What knowledge is needed?
- How to measure the success of bioeconomy? What are measures for the impact and for the policy effectiveness?
- How to optimize cascade and circular use of agricultural products to minimize demand for soil produce? How can re-cultivation of soil be achieved? Which methods enable reclamation of land? How to raise awareness for hidden potentials? How to

optimize soil fertility? How to use more waste and minimize resource input? How to balance conflicts of exploiting biomass from soils & returning organic matter to soils?

- How to raise awareness and production for the different ecosystem services of soils as products for the society (e.g. water purification, carbon sequestration)?
- How to ensure effective land-use management on the farm level based on critical data? How to motivate farmers and balance rules and incentives for a change? How to encourage the adoption of sustainable soil management practices?
- How to prevent negative changes in soil structure and functionality by agricultural machineries and optimize field traffic, machinery specifications, management practices and application techniques for sustainable intensification of soil use?
- How to steer consumption to more sustainable, bio-based products? How to drive change of consumer preferences? What are socio-economic and cultural gaps to be bridged on the path to a sustainable bioeconomy?
- How to steer with adequate policy mix and regulatory environment from the European to local level the change to a bioeconomy, in particular as related to sustainable soil management (but also considering the full production and consumption chain of biobased products and energy – and the diversity of Europe)? How can business, producers and government draw up agreements toward a sustainable bioeconomy?
- Considering the plant and animal production, how to utilize and further develop food models to inform optimized land-use? Can the interface of food security and the bioeconomy be better understood by integrated modeling of the production chain?

Characteristics of IRT-4: Bio-Economy – unleashing the potentials while sustaining soils

Links to identified research gaps

Indicated are numbers of relevant research topics from National Reports (cf. D2.5, Brils et al. 2016) AND for the relevant Clustered Thematic Topics (as defined above):

National research topics

AT 1, 2, 3, 7, 9; BE 1, 3, 9, 10, 11, 12, 14, 15, 16, 17, 18, 19, 20, 22, 23, 25, 28, 29; CZ 3, 5, 7; FI 3, 4, 5, 6, 7, 8, 9, 15, 16; FR 1, 2, 3, 4, 5; DE 2.2, 2.3, 3.2, 3.3, 3.5, 4.1, 4.2, 5.1, 5.2, 5.3, 5.4, 5.5, 6.3, 8-1, 9; IT-1, 4; PL 2; PT 1, 2, 3, 5, 7, 8, 9, 10; RO 1, 2, 3; SR-1, 2, 5, 6, 9; SI 2, 3; ES 3.2, 3.3, 3.7, 3.8, 3.9, 3.11, 4; SE 1, 3, 5, 6, 8; CH 2.2, 2.5, 2.10, 2.12, 3.1, 3.2, 3.3, 3.4, 4.1, 4.2, 5.4; NL 1, 2, 7, 8, 9, 12, 13, 15; UK 1, 3, 4, 5, 6, 7, 8, 9, 11, 12

Clustered thematic topics

Demand: CTT-D1, 2
Natural Capital: CTT-NC1, 2
Land Management: CTT-LM1.1, 1.2, 1.3, 4
Net Impact CTT-NI1.1, 1.5, 2.2, 3.3

Further Characteristics

Science fields

☒ Natural sciences | ☒ Social sciences | ☒ Engineering

Addressees

☒ Policy | ☒ Administration | ☒ Business | ☐ Civil Society

Regional scope

☐ Global | ☒ European | ☒ Multinational (ca. 4-8 countries) | ☒ Tri-/Bilateral

Duration of projects

☐ Short (< 1 year) | ☐ Medium (1 – 3 years) | ☒ Long (>3 years) | ☐ Very long (>6 year)



IRT-5: Integrated scenarios for the Land-Soil-Water-Food nexus under societal pressures and challenges

Theme proposed by F. Glante (UBA)

Background: Societal challenges impact on how humans exploit natural resources. Only few integrated scenarios exist, which include changes in soil properties, water availability, food, and timber, fibre, or bio-energy production. Consequently, mutual synergies and trade-offs, what is often referred to as the nexus, remain unknown or unconsidered. Future scenarios do exist for the impact of land use and land cover change on climate and biodiversity but not vice versa, e.g. impact of biodiversity changes due to climate change on soil properties. A few integrated scenarios do exist, which include food production, bio-energy and wood biomass production, climate change and biodiversity, exploring pathways for achieving corresponding global targets. The results show a possibility to meet the demand for food and energy security but without achieving international climate and biodiversity targets at the same time. The integrated scenarios, which have been developed so far, have not taken into account the impacts on soil, water availability, floods and droughts; the timber and fibre production; nor their vital feedback on food, bio energy, climate and biodiversity and vice versa. To find out what scenarios benefit to the society AND to the environment very comprehensive scenarios have to be elaborated. The results may be lead to soil management and to spatial planning as well.

Goal: Elaborating explorative and target oriented scenarios considering integrated, spatially-explicit models that take into account major trade-offs and synergies between ecosystem functions, land use and societal challenges. External effects of our economy (import of goods, environmental footprint into developing countries) should be taken into account as well.

Rationale from the themes: Demand: We have to secure the ability to achieve the satisfaction of secure food and energy supply while ensuring the provision of fundamental climate and biodiversity functions simultaneously. But there is the concern of uncertainty related to forecasting the actual need for additional demands for water, fibre and sustainable soils into the future; and unprecedented population increase in areas with low reserves of productive land that are also vulnerable to land degradation and climate change question our ability to satisfy societal needs. Consumption patterns, demographic growth and resource-efficiency technology transfer are key issues to be considered.

Natural Capital: Scenarios are needed for the development of demands of soil properties, amount of land (in different modeled land use strategies, e.g. organic versus conventional agriculture) but also for different purposes (food, fibre, fuel, fodder). Natural capital as a limited resource needs to be considered in such scenarios. Carry capacities, tipping points and so forth are to be considered for developing reliable and consistent scenarios. Scenarios should include all types of land use (urban, forest, agriculture, grassland) to find out which type of use is recommended under certain soil properties and societal demands.

Land Management: Scenario development is used to better understand potential futures. It helps to better understand the drivers and inhibitors of a potential (desired or undesired) scenario and, thereby, gives indicators which can inform land management. – How we can compensate the gap between demand and existing soil properties by sustainable land management? How can we remediate degradation? What alternatives are given beside

typical agriculture (urban agriculture)? Developing land use models that incorporate natural and human-induced factors as well that contribute to the halt of land degradation and that could be used for land planning and land management are needed. Road map for the implementation and operationalization of the SDG-target “land degradation neutral world”.

Net Impact: Methods and Data elaboration is needed to count and assess the net impact to soil, water, sediment and products (4 F) in order to achieve food security and land degradation neutrality.

So what? Caused by a growing population, increasing soil and land degradation the remaining scarce fertile soils with good properties are in danger to become overused. This may lead again to more degradation. To know by modeling scenarios and to assess the major impacts in every scenarios might decrease further degradation, secure food and give answers to the way how to reach the target of 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 nexus.

Links to other fields: There is also a link to the problem of refugees, land abandonment / degradation in states suffering from war and conflicts, and problems of resettlement from rural to urban areas. These scenarios have also taken into account.

Exemplified research questions

- Who needs the scenarios most? What legal instruments are needed to implement the results / options of the scenarios?
- Under which scenarios of land use is the impact on soil properties tolerable with regard to food safety, biodiversity, and land degradation neutrality?
- How could we assess overuse of soils?
- What are the key drivers and inhibitors of future developments that impact the quality and availability of fertile soils?
- How can we compensate the gap between demand and existing soil properties by sustainable land management and how can we remediate degradation?
- What alternatives are given beside typical agriculture (urban agriculture)?
- What measure should be taken to reduce the flow from (young) population to urban areas?
- What scenarios can be elaborated for investment in agriculture but to avoid land grabbing, land speculation?
- What measures have to be developed to compensate impact on soils and climate?
- How can we link in ideas on ecosystem services and ‘soil resilience’? How does soil quality affect the wider system (and vice versa)?
- How can threats to food security caused by climate change and other ecosystem changes or collapses be managed and avoided?
- How the information of scenarios can be implemented in the common agricultural policy (CAP)?
- Which scenarios do we have for “sustainable” or “ecological” intensification (definition, impact, consequences)?

Characteristics of IRT-5: Integrated scenarios for the Soil-Water-Food nexus under societal challenges

Links to identified research gaps	Indicated are numbers of relevant research topics from National Reports (cf. D2.5, Brils et al. 2016) AND for the relevant Clustered Thematic Topics (as defined above):
National research topics	AT 5, 8; BE 22, 27; CZ 6; DE 1.2, 2.2, 3.2, 3.4, 3.5, 4.1, 4.2, 6.2; ES 3.1, 3.13, 3.15, 3.5; NL 13; FI 5, 7; PT 4; S 4; SE 5, 8; SR 5; UK 4
Clustered thematic topics	Demand: CTT-D1, 2, 3, 7 Natural Capital: CTT-NC1, 2, 3, 5, 7 Land Management: CTT-LM1, 2, 4 Net Impact CTT-NI1, 2, 3, 4
Further Characteristics	
Science fields	<input checked="" type="checkbox"/> Natural sciences <input checked="" type="checkbox"/> Social sciences <input type="checkbox"/> Engineering
Addressees	<input checked="" type="checkbox"/> Policy <input checked="" type="checkbox"/> Administration <input checked="" type="checkbox"/> Business <input type="checkbox"/> Civil Society
Regional scope	<input checked="" type="checkbox"/> Global <input checked="" type="checkbox"/> European <input type="checkbox"/> Multinational (ca. 4-8 countries) <input checked="" type="checkbox"/> Tri-/Bilateral
Duration of projects	<input type="checkbox"/> Short (< 1 year) <input type="checkbox"/> Medium (1 – 3 years) <input checked="" type="checkbox"/> Long (>3 years) <input type="checkbox"/> Very long (>6 year)

IRT-6: Indicators for assessing the efficiency of the Soil-Sediment-Water-Energy nexus of resources

Theme proposed by J. Villeneuve (BRGM)

Background: The responsibility for a sustainable handling and management of natural resources is indispensable for providing the needs of a growing and affluent population and at once to safeguard the environment. Particularly, the EU's growth strategy for a smart, inclusive and sustainable economy (Europe 2020 strategy) supports a shift towards sustainable growth via a resource-efficient, low-carbon economy. Further, the move "Towards a Circular Economy" is supported by measures driving a more efficient use of resources and waste minimization.

At present, the resource efficiency indicators available in the Eurostat scoreboard represent the evolution of the relation of gross domestic product (GDP) with different inputs such as energy, water, land or material resources (including biomass and minerals). Biomass production (food, feed, fiber, fuels – 4Fs) is the result of the use of the interconnected resources soils/sediments, water and energy. This nexus of resources is not accounted as such in the indicators. Further, there is still at the moment a "conceptual gap" in the method for accounting of biomass in the "resource efficiency", as most of it is produced by humans. The relations between the production of biomass and the use of the soil-water-energy nexus need further investigations.

Goal: The goal is to understand the links between the consumption of our societies and the use of natural resources like the SSW system services: the need is to quantify and map in time and space the use of the nexus of SSW and energy resources related to the final consumption of products and services.



Rationale from the themes: Demand: The demand for the goods and services provided by natural resources is driven by the total final consumption of our societies. So far, the demand for bio-sourced products (4Fs) particularly is indirectly a demand for SSW system services.

Natural Capital: Natural capital provides the society with a wide range of goods and services, which are often considered to be free of charge. A steady supply of all these services is only guaranteed if the environment is healthy and if ecological structures and functions are preserved. These conditions need to be embodied in the assessment of the efficiency of the use of the SSW-energy nexus.

Land Management: Important role of land management is to balance the demand for and supply of resources and natural capital in urban and rural areas. Land management includes the institutional capacity of local, regional and national governments to identify and protect vulnerable areas and resources, ensure long-term productive potential of agricultural land, enhance adaptation to the climate change and to provide strategies to reduce the urban sprawl, as well as to reuse degraded, derelict or abandoned sites into new function.

Net Impact: The provision of many ecosystem services is interlinked with each other and/or linked to biodiversity, land use and land use change to increase the productivity of ecosystems is inevitable coupled with ecological, economic and societal impacts on global, EU and local scale as well as on different temporal scales.

So what? Most of the competencies of territorial authorities (national, regional, local) are organized by domain (e.g. water, agriculture, urban planning, tourism). These 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. In the future, this “footprint” type of indicators will permit the statistical scoreboard to be complemented to analyze the environmental impacts through the whole global economic cycle and thus to better balance the societal benefits and ecological effects of different resource-use options.

Links to other fields: This IT can be part of researches on more complete resource nexus (water-energy-food, minerals-water-energy, water-energy-minerals-food-land).

Exemplified research questions

- What would be the criteria and ways to comprehensively assess the use of natural resources?
- How to achieve integration of approaches, solutions and policies in the nexus between the use of water, energy and food to support an efficient and sustainable utilization of natural resources?
- What importance do ecosystem services have in their relations to one another? Ecosystem services should be considered together and standards and/or indicators should be developed. In order for this to happen, synergies and ecosystem services trade-offs must be understood.
- Which indicators can improve the evaluation of qualitative and quantitative aspects of the needs of soil and water and allow the study of land use transition in urban and rural areas?
- How to assess the relationships between economy and ecosystem?

- How to favor swift decisions and flexibility in delivering permits for specific uses on land for limited periods (interim use of land) and (if necessary) under specific servitudes, taking into account the cause-effect relationships between soil degradation and our way of life?
- What are cost-effective investments for a circular economy? Strategies to reduce (improve efficiency of) the use of natural resources (re-use, technical innovations)?

Characteristics of IRT-6: Indicators for assessing the efficiency of the Soil-Sediment-Water-Energy nexus of resources

Links to identified research gaps	Indicated are numbers of relevant research topics from National Reports (cf. D2.5, Brils et al. 2016) AND for the relevant Clustered Thematic Topics (as defined above):
National research topics	Examples. FR 5; SE 1; NL 9
Clustered thematic topics	Demand: CTT-D1, 3, 4, 5, 7 Natural Capital: CTT-NC1, 3, 7 Land Management: CTT-LM, 1, 3, 4 Net Impact CTT-NI 1, 2, 3, 4
Further Characteristics	
Science fields	<input checked="" type="checkbox"/> Natural sciences <input checked="" type="checkbox"/> Social sciences <input type="checkbox"/> Engineering
Addressees	<input checked="" type="checkbox"/> Policy <input checked="" type="checkbox"/> Administration <input type="checkbox"/> Business <input checked="" type="checkbox"/> Civil Society
Regional scope	<input checked="" type="checkbox"/> Global <input checked="" type="checkbox"/> European <input type="checkbox"/> Multinational (ca. 4-8 countries) <input type="checkbox"/> Tri-/Bilateral
Duration of projects	<input type="checkbox"/> Short (< 1 year) <input type="checkbox"/> Medium (1 – 3 years) <input checked="" type="checkbox"/> Long (>3 years) <input type="checkbox"/> Very long (>6 year)

IRT-7: Farming systems to maintain soil fertility while meeting demand for agricultural products

Theme proposed by C. Schröter-Schlaack (UFZ)

Background: A growing world population and increasing demand for food and non-food agricultural products puts high pressure on farming systems to intensify production. At the same time, it becomes more and more obvious, that intensifying conventional farming may be accompanied by severe negative environmental consequences, such as reduced bio- and agrobiodiversity, nutrient leaching to groundwater and rivers, eutrophication of lakes and the sea, and in particular loss of fertile soils due to erosion, nutrient loss and soil compaction. There are now several agricultural production techniques being developed that may allow for better maintenance of soil fertility and reducing negative environmental impacts of conventional farming in rural as well as urban and peri-urban contexts. However, it is yet unclear, if these farming techniques could be scaled up to attain the goal of food security and the demand for non-food products. Moreover, it needs to be better understood what role technology development e.g. precision farming might play in reducing environmental externalities of conventional farming systems and increasing return of soil-friendly agricultural practices. Finally, it needs to be revealed what would be necessary in terms of knowledge transfer and reforms of policies and regulations to set incentives for adopting sustainable soil management practices at farm level.



Goal: Understanding how sustainable soil management by appropriate agricultural production systems can contribute to sustainable food security, if and how these solutions can be scaled up and widely implemented on farm level.

Rationale from the themes: Demand: Sustainable handling and management of natural resources is indispensable for meet the increasing demand of a growing and affluent population for agricultural products while coping with other societal challenges such as climate change and a shrinking availability of arable soils due to urban development and afforestation. A rising demand challenges production systems to improve overall production that has to be supported by resource and energy efficient agricultural production systems. Land use, however, cannot be only considered under a productivity vision but sustainable handling and management is necessary to safeguard the environment and to protect productive soils in the long run.

Natural Capital: A well equilibrated balance between demand and supply for the multiple ecosystem goods and services produced by agriculture is essential for a sustainable development. For agriculture not only soil quantity but also soil quality is a crucial factor. A fertile unspoiled soil provides important structures (e.g. habitat for organisms) and functions (e.g. ability to catalyse biogeochemical cycles). A healthy soil with an adequate plant and tree cover is also an important stability factor with regard to erosion, landslides and avalanches. Intensification of conventional farming systems is reducing bio- and agrobiodiversity and thereby the ability to provide also other ecosystem services than just provisioning services. As soils and other environmental factors (e.g. climate, hydrology, topography) are locally highly different,

Land Management: An important role of land management is to balance the demand for and supply of resources and natural capital in rural areas. Land management includes on the hand the institutional capacity of local, regional and national governments to identify and protect vulnerable areas and to ensure long-term productive potential of agricultural land. It is key in this regard to match locally highly diverse soils and ecosystems with appropriate agricultural production systems. On the other hand, land management is also concerned with the availability of knowledge and new technologies at farm level to reduce negative environmental effects of highly productive agricultural systems as well as the incentives for farmers set by policy frameworks at EU and national levels to adopt new technology or adapted production techniques.

Net Impact: There is a call to improve the knowledge about socio-economic and environmental benefits and costs resulting from different land management strategies in particular to meet the societal goals of food security, climate change adaptation and mitigation, health as well as economic development and livability of rural areas. There is a need to better understand the impact of (agricultural) land use intensity and land use changes on ecosystem provision and (changes in) organic carbon, soil fertility, soil erosion or water quality; all necessary to safeguard long-term provision of agricultural products. There is also a need to raise social awareness on the pro and cons of dietary patterns as well as different agricultural production systems to stimulate market demand for more sustainably produced food and non-food products. Finally, it is necessary to understand what impact policies and regulations have on decisions taken at farm level to support decision-makers in land management and policy at different governmental levels.



So what? Understanding the potential of different agricultural production systems to achieve the goal of food security while sustain soil fertility and reduce negative environmental impacts coming along with intensification of conventional farming would clarify the role of these different techniques to. This is fundamental to increase knowledge about economic and technical aspects of organic farming, their advantages and disadvantages. It will provide knowledge to improve competitiveness and sustainability and will be useful for farmers and decision-makers in order to mainstream sustainable agricultural practices.

Links to other fields: There are linkages to other potential research topics, such as how to reconcile conflicts between different societal goals (e.g. food security, climate change mitigation, biodiversity conservation, reduced nutrient loads to waterbodies, etc.) or how to spatially optimize (local/regional) land uses (i.e. understanding local soil capacities / thresholds in terms of land use intensity and adapting land use accordingly).

Exemplified research questions

- Identify necessary technology or operation materials to increase the efficiency of agriculture and food security. What can agricultural production systems contribute to reduced environmental impacts (reduction of fertilizer / raised ability of plants to take in nutrients, soil erosion) and how these system solutions can be scaled up?
- How can (efforts and) results of soil quality care be monitored and by the use of which indicators? How could it be used for communication and monitoring (e.g. a threshold value)? What indicators should be used to quantify soil degradation?
- How does biodiversity influence soil fertility, and how does soil fertility influence biodiversity? How to keep soil fertility in climate conditions favorable to high mineralization? What role does soil structure play for soil fertility?
- What are options for resolving conflicts between urbanization and agriculture, e.g. urban farming, small-scale production in urban or peri-urban areas, use of urban organic waste to increase soil carbon on fields?
- How to improve the level of awareness and understanding regarding the environmental benefits of adapted farming systems in agricultural schools and universities and among farmers?
- What are the drivers of decision on production system at farm level? What is the role of policy frameworks (agriculture, climate, housing etc.) and incentives provided to farmers and what are options for the reform of such policies to support implementation of practices to maintain soil fertility?

Characteristics of IRT-7: Farming systems to maintain soil fertility while meeting demand for agricultural products

Links to identified research gaps	Indicated are numbers of relevant research topics from National Reports (cf. D2.5, Brils et al. 2016) AND for the relevant Clustered Thematic Topics (as defined above):
National research topics	AT-1; BE-10; BE-11; BE-23; FR-5; FI-7; DE-5.5; IT-1; PT-2; PT-5; RO-1; RO-2; RO-3; ES-3.8; SW-5; NL-1; NL-11; NL-13
Clustered thematic topics	Demand: CTT-D1, 2, 6, 7 Natural Capital: CTT-NC1, 2, 5, 7 Land Management: CTT-LM1.1, 1.2, 1.3, 4 Net Impact CTT-NI1.1, 2.2, 3.2, 3.3, 4.1, 4.3

Further Characteristics

Science fields	<input checked="" type="checkbox"/> Natural sciences <input checked="" type="checkbox"/> Social sciences <input checked="" type="checkbox"/> Engineering
Addressees	<input checked="" type="checkbox"/> Policy <input checked="" type="checkbox"/> Administration <input checked="" type="checkbox"/> Business <input checked="" type="checkbox"/> Civil Society
Regional scope	<input checked="" type="checkbox"/> Global <input checked="" type="checkbox"/> European <input type="checkbox"/> Multinational (ca. 4-8 countries) <input type="checkbox"/> Tri-/Bilateral
Duration of projects	<input type="checkbox"/> Short (< 1 year) <input checked="" type="checkbox"/> Medium (1 – 3 years) <input type="checkbox"/> Long (>3 years) <input checked="" type="checkbox"/> Very long (>6 year) – depending whether new field trials are necessary (very long) or whether research focuses on existing evidence that is to be scaled up and mainstreamed in to land use on the ground (medium)

IRT-8: Circular land management

Theme proposed by U. Ferber (StadtLand)

Background: Ongoing urbanisation due to the remaining insufficient level of urban regeneration and persistence of brownfields. Growing and shrinking cities with different land dynamics and development objectives. Demographic change leads to new requirement on urban structures.

Goal: Minimize the consumption of land by continuously renovating settlement structures and overcoming the past's legacy by reusing and redeveloping abandoned, derelict and under-used land. Modernising permanently existing settlement structures by circular land management. exchange and use of existing local, regional and national initiatives and tools at a wider level.

Rationale from the themes: Demand: The demand on land to be used for new settlement areas and infrastructure is constantly increasing. Land use in itself is in constant transition according to the needs of stakeholders. Expansion, density and type of use all effect the social, economic and environmental quality of cities and regions as well as the soil and city climate. European cities are challenged by the need for developing inner development concepts for **gaps** in built-up areas, brownfield regeneration, densification and the replacement of older constructions. Stakeholders require new forms of cooperation such as that between planning and environmental administrations and public-private stakeholders. The adaption of planning and administrative processes to the current demands and at the same time the development of management strategies in cooperation with private land owners is required.



Natural Capital: Land is a finite resource that's why better land use and management should present a strategic approach for the sustainable development of settlement structures as well as the efficient use of land as resource.

Land Management: Land use from the perspective of a Circular Economy refers to circular land use management. This concept can be described with the slogan “reduce - recycle – prevent”, and is focused on new innovative ways to minimize the consumption of land by reusing and redeveloping abandoned, derelict and under-used land sites. In this context, circular land management presents a comprehensive strategic approach for steering the development of settlement structures but should profile the identity of cities and support citizen needs.

Net Impact: Circular land management offers a starting point for the achievement of the international goals related to a “no-net-land-degradation” on the EU and UN levels. Furthermore, circular land management can contribute to the implementation of strategies for climate adaption and “healthy” cities.

So what? Research is required to understand the patterns of behaviour and interdependencies of actors 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. Specific attention should be taken on the interaction with landowners.

Links to other fields: Circular land management is related to all topics linked to Governance, spatial planning and conflict management.

Exemplified research questions

- What drivers are responsible for the consumption of land (for example private investments, city development or investment-oriented assistance programs)?
- How can dynamic scenarios for land use transition be displayed to predict needs and to provide a contribution to the integration into spatial planning?
- Which legal, economic and planning instruments and tools are needed and how could they interact to create positive synergies in relation to the land cycle?
- How do legal and administrative frameworks and governance hinder or enhance the land cycle and how could this frameworks be implemented?
- How could CLM include the population and support conflict management?
- How can stakeholders, especially landowners, be included in circular land management?
- How could planning procedures be reformed in order to enhance the modernization of settlement structures?
- What role plays interim and underused land in the system?
- How can sectoral and spatial assistance programmes be better coordinated with one another?
- What would a monitoring concept which focuses on natural science and the social evaluation and assessment of land use transition look like?

Characteristics of IRT-8: Circular land management	
Links to identified research gaps	Indicated are numbers of relevant research topics from National Reports (cf. D2.5, Brils et al. 2016) AND for the relevant Clustered Thematic Topics (as defined above):
National	AT 5/ 9/10/13, BE 5/6/10/13/18/24/26, CZ 1/2/6, FI 1/4/6/7/ 9/11/13, FR 2/5, DE 2.1/2.3 3.1/3.5/5.1, 5.3, It 2/3, PL 2/3/ 4/6 PT1/2/ 5/6 RO 2, SK4/9, SL 1/5/3, ES 3.1/3.1/4/6/7, SW 2/3/5/6 Ch 2.1 NL 1/3/5/6/8/12/15 UK 2/3/4, IR 1
Clustered thematic topics	Demand: CTT D3, CTT D7 Natural Capital: - Land Management: CTT-LM 1,3,5,7 Net Impact CTT- NI 1.4
Further Characteristics	
Science fields	<input type="checkbox"/> Natural sciences <input checked="" type="checkbox"/> Social sciences (Economy) <input type="checkbox"/> Engineering
Addressees	<input checked="" type="checkbox"/> Policy <input checked="" type="checkbox"/> Administration <input checked="" type="checkbox"/> Business <input checked="" type="checkbox"/> Civil Society
Regional scope	<input checked="" type="checkbox"/> Global <input checked="" type="checkbox"/> European <input checked="" type="checkbox"/> Multinational (ca. 4-8 countries) <input checked="" type="checkbox"/> Tri-/Bilateral
Duration of projects	<input type="checkbox"/> Short (< 1 year) <input type="checkbox"/> Medium (1 – 3 years) <input checked="" type="checkbox"/> Long (>3 years) <input type="checkbox"/> Very long (>6 year)

IRT-9: Policies to effectively reduce land consumption for settlement development

Theme proposed by C. Schröter-Schlaack (UFZ)

Background: Land use for settlements is a main driver of loss of fertile soils and agricultural land. Land consumption, however, is itself driven by a range of different motives: changing life-style patterns, demographic change, economic developments (e.g. e-commerce, logistics), infrastructure development, trends in property and financial markets, housing policy, regional planning, building codes as well as agricultural and nature conservation policies. In turn, efforts to promote compact city development, revitalize inner-city brownfields and abandoned sites and reduce consumption of fertile soils for settlements and related infrastructure often fail due to a lack of policies and regulations effectively addressing the drivers of land consumption.

Goal: A better understanding what drives land consumption for settlement development and what constitutes incentives or obstacles for the enforcement of planning and policies to reduce land consumption will help to create policy interventions in property markets and settlement development more effective.

Rationale from the themes: Demand: On the one hand, there is a demand for conserving fertile soils for agriculture production and other non-urban land uses, such as forestry, biodiversity conservation or tourism & recreation. Moreover, there is a demand for revitalizing inner-city brownfields and abandoned sites as well as for maintaining historical buildings and cultural heritage to enhance the livability of urban areas and to utilize the capacity of existing infrastructure. On the other hand, there is a demand to provide proper housing conditions. Land developers are often not willing to take on the risk of dealing with contaminated sites.



Lastly, retaining property rights and rights of ownership constitute strong societal demands that restrict the impact of policies on mobilizing inner-city land and increasing density of housing. Thus, there is a need to identify policies, planning approaches and regulations that balance these trade-offs legitimately, transparently and effectively.

Natural Capital: Land consumption for settlement development and associated infrastructure (e.g. transportation, powerlines etc.) is one of the main drivers for the loss of biodiversity, soil degradation, and landscape fragmentation. As city development historically took place at naturally favored sites (e.g. in regions with fertile soils), land consumption reduces the provision of highly demanded agricultural goods and services. For the containment of land development as well as the implementation of green infrastructures in rural and urban landscapes solid policy tools and planning approaches are needed to mobilize inner-city land.

Land Management: There is a need to understand the drivers of land consumption, the impacts of settlement development on natural capital and the provision of ecosystem services as well as on the sometimes conflicting societal demands with regard to housing conditions and livability of municipalities and cities to develop policies tools and planning solutions. Urban planning is often focusing on above-ground impacts of urban development, while impacts on the soil-water-sediment nexus is taking place on another time scale.

Net Impact: There is a need to better understand policies' and planning solutions' impacts on land consumption, ecosystem service provision and society to get insights whether to further develop or promote policies and regulations. What methods should be developed for analysis of social, natural and economic consequences of plan implementation? How can policy pilots be used to avoid mismatches between policy and practice?

So what? Spatial planning and soil management is often not hampered by a lack of scientific knowledge on the benefits of reduced land consumption for settlement development but by a lack of understanding what actually drives land consumption and how to address these drivers. In turn, existing legislation and planning to steer land development is often failing to address these drivers and moreover characterized by loose implementation and enforcement. 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.

Links to other fields: Steering urban development is but one societal challenge where information about how to design effective policy responses would be beneficial. Other areas include e.g. the implementation of sustainable agriculture, the regulation of pollutants, or incentives to promote the re-use of revitalized brownfields.

Exemplified research questions

- Identify and monitor the drivers of land use that eventually lead to land consumption and urban sprawl: improve understanding of impacts of life-style patterns, demographics, economic trends, spatial policy, site competition and tax policy, agriculture and nature conservation policies on spatial development. Gain insights on impacts of capital markets on construction, real-estate sector, investment business.
- Is demand for land in different sectors (housing, industry and traffic) driven by different factors?
- Building up a monitoring system to observe the drivers of land consumption and urban sprawl.
- Take stock of different approaches used in different European countries and assess what works and what do not work? What insights can we gain from good examples / best practices as well as from policy failures experienced elsewhere?
- How can the often fractured responsibilities of public power between national state, regions and municipalities be better coordinated or unified to improve sustainable settlement development and reduce land consumption?
- What is the role of “territorial” expert knowledge (land use, soil, water etc.) on policy-making and how can it be used to develop more effective regulations?
- How could 3D-planning (recognizing the different time-scales of impacts on the soil-water-sediment nexus) look like?
- How to solve the trade-off between preserving cultural heritage and addressing challenges for urban development (such as climate change adaptation, energy efficiency, or natural hazards – earthquakes / floods)?

Characteristics of IRT-9: Policies to effectively reduce land consumption for settlement development

Links to identified research gaps Indicated are numbers of relevant research topics from National Reports (cf. D2.5, Brils et al. 2016) AND for the relevant Clustered Thematic Topics (as defined above):

National research topics	AT-6; AT-13; BE-2; FI-11; FI-15; FR-1; DE-2.2; DE-5.3; DE-5.4; PL-4; SR-7; SI-1; SI-2; ES-3.1; CH-1.1; CH-1.3; CH-2.12; NL-9; NL-10
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Clustered thematic topics	Demand: CTT-D1, 2, 3, 7 Natural Capital: CTT-NC1, 5, 7 Land Management: CTT-LM1.1, 1.2, 3 Net Impact CTT-NI1.4, 2.4, 2.5, 3.1
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Further Characteristics

Science fields	<input type="checkbox"/> Natural sciences <input checked="" type="checkbox"/> Social sciences <input type="checkbox"/> Engineering
Addressees	<input checked="" type="checkbox"/> Policy <input checked="" type="checkbox"/> Administration <input checked="" type="checkbox"/> Business <input checked="" type="checkbox"/> Civil Society
Regional scope	<input type="checkbox"/> Global <input checked="" type="checkbox"/> European <input checked="" type="checkbox"/> Multinational (ca. 4-8 countries) <input checked="" type="checkbox"/> Tri-/Bilateral
Duration of projects	<input type="checkbox"/> Short (< 1 year) <input checked="" type="checkbox"/> Medium (1 – 3 years) <input type="checkbox"/> Long (>3 years) <input type="checkbox"/> Very long (>6 year)



IRT-10: Stakeholder participation to facilitate the development of livable cities

Theme proposed by C. Schröter-Schlaack (UFZ)

Background: Urban development and creating livable cities involves of a huge variety of stakeholders, such as private households, business, planning authorities, land developers, conservationists and has to find a transparent and legitimate balance between the different interests of these groups and people. Against this background, stakeholder participation seems a promising approach in order identify mutual benefits but also conflicts between different interests. Participation processes, related infrastructure and tools may also provide a platform for exchange and communication. However, a wide range of open questions has to be answered to exploit the full potential of participatory processes and to enhance decision-making in terms of legitimacy, acceptance and local ownership.

Goal: Understanding how stakeholder participation may facilitate urban development and the creating of livable urban spaces, what pro and cons different participatory approaches entail in a given context and how it might be best embedded in the course of planning and project development.

Rationale from the themes: Demand: Urban land use is in constant transition according to the needs of stakeholders. Expansion, density and use type all affect the social, economic and environmental quality of cities and have effects on human well-being, economic development but also microclimate and urban biodiversity. The high demand for land from various groups and for various uses leads to land use-conflicts, for example, for settlement and infrastructure as well as green infrastructure in urban areas that need to be settled.

Natural Capital: Green and blue-infrastructures provide a range of ecosystem services to different actors in urban regions. Inhabitants may benefit from enhanced access to green spaces for recreation and leisure, reduced air pollution (e.g. particular matters), noise reduction and cooling effects. City authorities might recognize the benefit of green infrastructures to make their city more resilient to extreme events (heat stress, flooding, etc.). Business may benefit from (touristic) attractiveness of their location.

Land Management: A main task for sustainable urban management is to find ways of balancing the needs and pressures of urban dynamics with the opportunities and constraints of the environment and human well-being. The fundamental challenge to create livable cities is to find acceptable solutions that integrate the different interests of the various stakeholders involved, and to find appropriate instruments for solving land-use conflicts resulting from this interplay of interests.

Net Impact: Stakeholder participation may help to identify winners and losers of urban development and support urban planning in finding acceptable and legitimate planning solutions that reduce negative impacts of urban development on the environment and enhance the attractiveness and livability of cities. However, participation may bring along transaction costs and may reduce predictability of planning processes. So there is a need to identify cost-effective solutions and tools to realize the full potential of participation for supporting urban planning.

So what? Understanding the potential of stakeholder participation will help to ensure the livability of urban development and enhance transparency and legitimacy of decision-making.

Links to other fields: While urban green infrastructure constitutes just an example for the need to recognize and moderate conflicting land use-interests, research regarding the benefits of participation, the design of participatory measures and the pros and cons this might entail would be of great benefit for other conflict situations, too, e.g. in deciding upon land use intensities, designating protected areas, spatially optimizing land use at landscape level and so forth.

Exemplified research questions

- How can methods be designed so that the participation of the public in evaluating land-use options becomes possible? What are best practices and good examples across different countries and fields of application – but also: what can be learned from failures of participatory processes elsewhere?
- How to develop cost-effective participatory tools that also motivate people to participate to ensure inclusive decision making and social empowerment?
- How to take into account long-term consequences of decisions?
- How can knowledge about impacts of land use (change) and land use planning be translated into information for stakeholders taking part in participation processes?
- How to take into account the interest of those not participating?
- What is the relationship between participation and democratic process?
- What is the best time and stage for participation in course of a development project?

Characteristics of IRT-10: Stakeholder participation to facilitate the development of livable cities

Links to identified research gaps	Indicated are numbers of relevant research topics from National Reports (cf. D2.5, Brils et al. 2016) AND for the relevant Clustered Thematic Topics (as defined above):
National research topics	AT-11; BE-6; BE-24; CZ-6; FI-11; FI-15; DE-2.1; DE-6.2; IT-4; PT-5; PT-6; SR-7; SI-1; ES-2; ES-3.14; SW-4; CH-5.1; NL-5;
Clustered thematic topics	Demand: CTT-D2, 3 ,6, 7 Natural Capital: CTT-NC2, 4, 5 ,7 Land Management: CTT-LM1.3, 3 Net Impact CTT-NI3.2, 3.3, 4.1, 4.2, 4.3
Further Characteristics	
Science fields	<input type="checkbox"/> Natural sciences <input checked="" type="checkbox"/> Social sciences <input type="checkbox"/> Engineering
Addressees	<input checked="" type="checkbox"/> Policy <input checked="" type="checkbox"/> Administration <input type="checkbox"/> Business <input checked="" type="checkbox"/> Civil Society
Regional scope	<input type="checkbox"/> Global <input type="checkbox"/> European <input checked="" type="checkbox"/> Multinational (ca. 4-8 countries) <input type="checkbox"/> Tri-/Bilateral
Duration of projects	<input type="checkbox"/> Short (< 1 year) <input checked="" type="checkbox"/> Medium (1 – 3 years) <input checked="" type="checkbox"/> Long (>3 years) <input type="checkbox"/> Very long (>6 year)

Challenge: Integrated urban management

IRT-11: Integrated management of soils in urban areas

Theme proposed by J.Gorgoń & A.Starzewska-Sikorska (IETU)

Background: Urban development has been defined by expansion of urban structures into surrounding rural areas, cropland and forests. Urban soils are created by the process of urbanization, therefore they become an immanent part of the urbanized areas. Urban activities could create different types of new man-made soils, but all soils situated within cities or urbanized areas should be included to category of urban soils. Due to a multi-functional role of the soil in urban areas the sound management of this resource is of a key importance in urban land management. Typology of urban soils is important to perceive these soils through the wide perspective including diversity of soil functions. It is also important to define the suitability of soils for different urban land uses. Soil characteristics and quality should be taken into consideration by spatial (urban) planning. From the perspective of ecosystem services and SSW system, urban soils are an important part of green infrastructure. Especially soil of a high quality should be protected to maintain the habitat and support ecosystem services potential. Also agricultural role of soil in urban areas should not be neglected, especially in the context of urban farming and gardening, as well as from the perspective of the global food production market.

Goal: Better understanding the role of urban soils and their importance on improving quality of urban space and consequently on health and living quality.

Rationale from the themes: Demand: Demand for soil in urban areas is connected with the need for food production (agricultural function and urban gardens areas), recreation areas but also other unsealed areas and green areas. They are needed for ecosystem services, biodiversity and climate change adaptation support. These functions compete with other like housing, infrastructure, transport and industry. Soils are subjected to major changes, especially those resulting from investment and construction activities. Soils have also to cope with high load of waste materials like solid waste, sewage and chemical pollutants.

Natural Capital: Soil as an important part of our natural capital are providing a lot of ecosystem services to society. Soil fertility refers to the ability of a soil to sustain plant growth. That's why the restoration or re-cultivation of unused or polluted areas is essential for protection of urban soils. Soil is functioning as a water reservoir (40% of soil is porosity). In order to provide a cooling effect better soils have better "water" efficiency. This role of soil in urban areas is extremely important. That's why urban soils management need to consider impacts on groundwater and surface water.

Land Management: There is a need of joining the soils management and land use management in urban areas. The urban soil are not enough protected in many countries, It is mainly connected with changing the agricultural function into different one (e.g. housing, industry and urban infrastructure) therefore in a consequence we have a significant fragmentation of the landscape in urban areas. Urban sprawl plays an important role in this process, by increasing soil sealing. Also functions of industrial, urban soils are important from the perspective of integrated land management. Effective, integrated urban soils management needs to define rights and duties of private owners. For spatial planning



procedures is important to introduce new solution concerning economic scenarios for urban soils management. These scenarios should propose solutions like temporary use of urban abandoned soils as an alternative to remediation when this is not economically feasible. Scenarios could also propose compensations instruments related to protection of green fields and uses of brown fields, as well as management of contaminated soils.

Net Impact: The role of soil in urban areas seems to be more and more important in the context of a present threats coming from climate change and demographic impacts. In a global scale this threat is visible in all urban areas. Therefore there is a need of scientific argumentation to what extent ecosystem services in urban areas can contribute to decrease negative impact and could support biodiversity preservation.

So what? In order to steer better use of urban soils in a sustainable way, a proper management of soil resources is needed. The soil management systems that efficiently protect the best soils should be introduced in cities. There is also need of reuse and improving of urban soil quality by innovative remediation technologies. A multidisciplinary approach is necessary for better understanding of the soil role in urban environment in order to ensure its optimum use and provide the functions needed, like water filtering and storage, space for fauna and flora, provision of recreation areas etc. Human health is also important in the context of urban soils management, and should be take into account in urban planning and land management.

Links to other fields: Next to urban soils, also water and sediments in urban areas are important in the context of ecosystem service research.

Exemplified research questions

- Do we understand the role of urban soil and its different function in the urban areas?
- How to secure safety and health in the context of contaminated soil management?
How to deal with urban soil pollution? How to introduce temporary use of contaminated soils in land management?
- What are the possibilities for re-cultivation of abandoned land and what are the benefits for sustainable land management?
- How to take into account various types of urban soils in spatial planning?
- How to introduce into spatial (urban) planning soil quality management aspects?
- How to integrate soil management with climate change aspects?
- How to conserve the fertility of soil in the long term?
- How can we develop a policy to prevent soil sealing? How can we integrate these policies in spatial planning processes? ? How to reduce the pressure on land?
- How do different land use policies, such as agricultural policy and city planning policy, contribute to the environmental impacts of land use?
- Approaches, methods and instruments of the productive land protection against its transformation towards build-up areas.
- How to deal with private land ownership in relation to urban soil protection?

Characteristics of IRT-11: Integrated management of soils in urban areas	
Links to identified research gaps	Indicated are numbers of relevant research topics from National Reports (cf. D2.5, Brils et al. 2016) AND for the relevant Clustered Thematic Topics (as defined above):
National research topics	AT 7, 8; BE 11, 12, 16, 21, 28; FI 1, 4, 11; FR 1, 3; DE 4.1; NL 5, 7, 13; PL 3, 4
Clustered thematic topics	Demand: CTT-D1, 2, 3, 4 Natural Capital: CTT-NC1, 2, 3, 5, 7 Land Management: CTT-LM1.1, 1.3, 1.4, 3, 4 Net Impact CTT-NI1.1, 1.2, 1.3, 1.6, 2.1, 2.2, 3.2, 3.3, 4.1, 4.3
Further Characteristics	
Science fields	<input checked="" type="checkbox"/> Natural sciences <input checked="" type="checkbox"/> Social sciences <input type="checkbox"/> Engineering
Addressees	<input checked="" type="checkbox"/> Policy <input checked="" type="checkbox"/> Administration <input checked="" type="checkbox"/> Business <input type="checkbox"/> Civil Society
Regional scope	<input type="checkbox"/> Global <input checked="" type="checkbox"/> European <input checked="" type="checkbox"/> Multinational (ca. 4-8 countries) <input type="checkbox"/> Tri-/Bilateral
Duration of projects	<input type="checkbox"/> Short (< 1 year) <input type="checkbox"/> Medium (1 – 3 years) <input checked="" type="checkbox"/> Long (>3 years) <input type="checkbox"/> Very long (>6 year)

IRT-12: Environmentally friendly and socially sensitive urban development

Theme proposed by S. Schubert & S. Bartke (UBA)

Background: Urban development is confronted with heterogeneous and often conflicting needs. Concerns of urban environmental protection and precautions are strongly interconnected with urban development and have to be considered in planning and decision making processes in manifold ways. However, they are just one concern out of many and have to be balanced with other challenges of urban development, not least with social concerns. The latter reflects for instance the needs for affordable housing and security of energy and water supply. On the one hand, social and environmental needs can have synergies and the concept of environmental justice is an upcoming but central interface. On the other hand, conflicting goals of an environmentally friendly and at the same time socially sensitive urban development can be detected, as for example in the field of energy poverty (greener but more expensive renewable energy puts some households at poverty risk). Moreover, complexity is added as also in different cities different societal groups will not have the same interests and, hence, social contexts differ nationally and across Europe.

Goal: Better understand potential synergies and trade-offs of environmental and social concerns in urban development. Identify and more clearly describe conflicting goals and measures with sufficient indicators and find solutions to reduce and dissolve them.

Rationale from the themes: Demand: Urban environmental protection and at the same time social cohesion in the urban society put high demands on a sustainable urban development. Solutions have to be defined to react e.g. on climate change mitigation and adaption requirements, pressure on the quality of the urban environment, demographic change, migration and needs for affordable and adequate living spaces at the same time. While even more people are moving to urban areas, especially in metropolitan regions with consequences for real estate markets and a high pressure on land demand, other regions sorrow by shrinking population density, which also has implications on the environmental and



social dimension of urban planning. Questions arise on which services are needed and to which extent in order to provide urban citizens with a good quality of life. In particular, trade-offs and synergies with environmental goods and services must be understood.

Natural Capital: In the light of rapid urbanization processes the urban environment is under high pressure to preserve healthy living conditions for all citizens and protect the functioning urban ecosystem and biodiversity. The urban hinterland is closely connected to the urban ecosystem, its quality and limits as supplier e.g. for energy, water, food, area for recreation as well as sink for disposal. Limits and pathways for an environmentally friendly urban development offering healthy living conditions in relation of cities have to be better understood. Questions arise on the limits of natural capital to enable urban ecosystem services demanded by modern cities and on how to protect them effectively. In particular, trade-offs and synergies of environmental goods and services with human health must be understood.

Land Management: To balance the needs for an environmentally friendly and socially sensitive urban development, solutions have to be defined in daily practice of urban planning on the regional, urban to neighbourhood development level. In order to trade off the satisfaction of urban demands with recognition of the limits of natural capital, appropriate information and tools are needed that are practicable and comprehensive at the same time. Moreover, management is related to questions such as: Which line of arguments do we need to strengthen the consideration of environmental and/or social concerns in planning decisions? What are the instruments to realize urban renewal in a way that addresses social and environmental concerns similarly regarding healthy living conditions, access to affordable infrastructure services, environmental justice and adequate living space for all? Effective urban land management needs to find a way to engage with all societal groups, sharpening their awareness for the environmental impacts of urban development and use efficient economic, regulatory and legal incentives to steer sustainable behavior.

Net Impact: The realization of a socially and environmentally friendly urban development is crucial and its success or failure can have impacts on other regions nationally and internationally, which are often not fully considered in land management on a daily bases given constraints of limited resources (data, time) for decision making. If, for example, socially deprived groups cannot afford life in cities, they have to move to sub-urban areas, with negative impacts on land-take, mobility needs and an adequate social mix of society. Especially in a global context and in fast and unplanned growing urban areas, unhealthy living conditions due to a poor standard of environmental protection can endanger social cohesion. People who can afford it will move while the poor have to arrange with difficult living conditions. Often such direct or indirect impacts on local, regional or global level are unknown and information on them as such as well as methods and data to assess and monitor the impacts are needed in order to inform decision making.

So what? Urban development is stressed by environmental and social framing conditions. Solutions to 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 better integrated and new questions arise at the interface of both dimension, especially addressing implementation and daily practice of urban planning.

Links to other fields: Research in this field is linked to understanding trade-offs and synergies in the different dimensions of sustainable development more generally. Insights might also be relevant for other (than urban) areas of natural resources protection.

Exemplified research questions

- What are the main conflicts of goals between environmental and social concerns which have to be addressed in district development? Can the ecosystem services approach link the dimensions?
- How to better understand and then steer behavior? What are drivers (markets and economy, regulation [local, EC], awareness of ecosystem services in cities, ecology)? How can the individual demands of different individuals in an area be met and still be environmentally friendly?
- What are facilitators for awareness of environmental and social dimensions equally (urban agriculture/gardening, climate/weather extremes, education)? What are drivers and inhibitors of behavioural change?
- How to efficiently integrate citizens in social and environmental decisions on urban development? How to enable more efficient stakeholder (e.g. NGO) engagement?
- How can environmental and social concerns be strengthened in planning processes of formal and informal instruments of urban planning? How can the interplay of environmental, health and social concerns in planning and decision making on the local level be better integrated to reach more environmental justice and social cohesion?
- How to balance strict environmental protection without limiting societal discourse on desired urban development? (Is environmental protection regulation too strict? Can strategic environmental assessment be improved?)
- Which financing mechanism on the municipal, state or national level bear barriers for the implementation of environmental and social measures in urban development and how can they be overcome? Can participatory budgets align citizens with environmental goals better? How can regulation and taxation reflecting an ecosystem approach be implemented?
- Which settlement and building structures allow a land-saving, dense and lively but to the same time healthy and quiet urban living conditions? What is the maximum density that is still regarded as high-quality of living? How to add more green and living area to a given urban setting?
- What is the link of milieus and environment? Have rich and poor the same access to urban green? Are rich locating in silent healthy areas and poor on brownfields? How to address social inequalities?
- How to better implement the available expertise on how to better design building and settlement structures which are energy efficient, supplied by renewable energies, allow decentralized rain- and greywater management and are still affordable for all?
- Can a systemic database be provided with best- and worst-practice examples of environmental and social conclusive urban development measures/approaches?

Characteristics of IRT-12: Environmentally friendly and socially sensitive urban development

Links to identified research gaps

Indicated are numbers of relevant research topics from National Reports (cf. D2.5, Brils et al. 2016) AND for the relevant Clustered Thematic Topics (as defined above):

National research topics

AT 5, 10, 11, 14; BE 6, 9, 13, 22, 24, 26, 27; CZ 1, 6, 8; FI 3, 11, 14, 15; FR 5; DE 1.1, 2.1, 2.2, 2.5, 3.4, 6.1, 6.2, 6.3; IT 3, 4; PL 1, 3, 4; PT 5, 6; SR 2; SI 1, 4; ES 2, 3.9, 3.13; SE 2, 4, 7, 9; CH 1.2, 2.1, 2.3, 2.11, 2.12, 5.1; NL 5, 8, 10; UK 6

Clustered thematic topics

Demand: CTT-D2, 3, 6, 7
 Natural Capital: CTT-NC1, 7
 Land Management: CTT-LM 1.2, 1.3, 3
 Net Impact CTT-NI 1.1, 1.3, 1.5, 1.6, 2.2, 2.4, 3.1, 3.3, 4.2

Further Characteristics

Science fields ☒ Natural sciences | ☒ Social sciences | ☒ Engineering

Addressees ☐ Policy | ☒ Administration | ☐ Business | ☒ Civil Society

Regional scope ☒ Global | ☒ European | ☒ Multinational (ca. 4-8 countries) | ☒ Tri-/Bilateral

Duration of projects ☐ Short (< 1 year) | ☐ Medium (1 – 3 years) | ☒ Long (>3 years) | ☐ Very long (>6 year)

IRT-13: Urban Metabolism – Enhance efficient use of soil-sediment-water resources through a closing of urban material loops

Theme proposed by D. Reißmann, S. Bartke (UBA)

Background: Provision, use and consumption of resources are usually considered merely with regard to specific products or services. However, a systemic understanding is needed for sustainable development – not least in the case of resources of the soil-sediment-water system. The concept of urban metabolism tries to integrate all urban material flows, stocks, loops and their internal and external interdependencies in a comprehensive way.

Urban metabolism – according to urbanmetabilism.org – is the study of material and energy flows arising from urban socioeconomic activities and regional and global biogeochemical processes. The characterization of these flows and the relationships between anthropogenic urban activities and natural processes and cycles defines the behavior of urban production and consumption. Urban metabolism is therefore a deeply multi-disciplinary research domain focused on providing important insights into the behavior of cities for the purpose of advancing effective proposals for a more humane and ecologically responsible future.

Goal: Through a comprehensive understanding of urban material flows, stocks and loops and their environmental impacts the concept aims to develop practically useful strategies, tools and instruments to enhance urban resource efficiency, consistency and sufficiency and to minimize direct and indirect negative environmental impacts that are initiated by urban areas.



Rationale from the themes: Demand: Urban areas are the central habitats of humanity, especially in Europe where around 75 % of the population lives in cities. Hence, urban areas are hubs of resource consumption. Nearly all materials in cities are more or less directly from soil (may it be from agriculture, forest or mining activities – all having environmental impacts). These consumption activities are based on demand of the urban population for food, energy, water, housing, infrastructure and a variety of products and services. It's predicted that in 2030 about 80 % of global consumption will be generated by urban areas. Enormous material flows are initiated by urban activities (i.e. through the construction sector) which lead to a high consumption of the materials itself (i.e. natural resources) but also of scarce land.

Natural Capital: To satisfy the requirements for resource consumption, natural resources and land/soil are needed. But these resources are limited and some of them are very scarce, which increases the limitation furthermore. Worldwide, the natural capital (e.g. minerals, biomass) is mostly exploited to satisfy the needs of the urban areas, because people and their consumption needs accumulate there as described above. Hence, enormous resource flows are initiated through activities in urban areas (driving force) and this in a very complex way (several factors need to be considered). This leads to land consumption (e.g. for mining or agriculture) and consumption of natural resource (e.g. for construction). The concept of urban metabolism could be used to monitor the initiated resource flows, also with regard to the global hinterland. It is crucial to understand the urban resource flows, their driving forces, their ecological effects and their impact on consumption of land and natural resources regionally and worldwide. The urban metabolism is a very useful methodological concept which could serve as basis for this process understanding.

Land Management: The enormous resource flows that are initiated through consumption activities in urban areas challenge the global resource basis and aggravate the limitation of scarce resources. This likely leads to a non-sustainable development which is based on consumption and growth without the recognition of ecological, social and economic limits. It is crucial to solve this trade-off between urban consumption and resource depletion. Instruments and strategic tools are needed to enable a more sustainable management of urban resource flows under the premise that urban quality of life is ensured.

However, the cities are also becoming spots of intense accumulation of resources. In the infrastructures, landfills and urban buildings enormous resource stocks were built and measures are needed to re-/use these stocks effectively, e.g. with urban mining activities. Here, efficient regulations including health and safety rules are needed in as much as an awareness of the potentials. Another critical management task relates to the optimization of the logistical handling of resources – in particular their storage.

Urban metabolism as an analytical tool could identify potentials for a more resource efficient way of urban activities (e.g. through the realization of an urban circular economy). It's also possible to include aspects of consistency (e.g. materials used for construction) and sufficiency (e.g. the consumption behavior of people) into the strategic instruments or overall framework based on the knowledge which is generated through the understanding of the urban metabolism.



Net Impact: Strategic tools and instruments that are based on the concept of urban metabolism should be able to identify the critical stocks and flows of materials and resources. In a comprehensive assessment, they should also address externalities and negative ecological, social and economic impacts that occur indirectly or unconsciously. This includes rebound effects of efficiency measures, indirect land consumption through initiated resource flows, indirect emissions through initiated resource flows (e.g. through the production of cement and steel as construction materials) and more. Also the cultural and economic drivers and inhibitors of a systematic implementation of the urban metabolism concept need to be understood. This also concerns the awareness of different actors, including the urban inhabitants, for the footprint and impact of their resource use. These issues are critical, because their consideration enhances the overall complexity of the analysis. Nevertheless, it is necessary to assess these indirect impacts, because otherwise especially unintended and negative ecological shifts could occur.

So what? Without further development of the methodological concept of urban metabolism, it will be not possible to identify comprehensive measures enhancing urban resource efficiency, consistency and sufficiency. This is the to develop instruments and tools for actors on different scales (local, regional, national and supranational) which foster resource friendly urban areas based on the above mentioned principles of efficiency, consistency and sufficiency. The developed tools need to address indirect impacts, such as rebound effects or indirect land consumption. Further research in this issue is crucial for a sustainable development, because through these instruments and tools it becomes possible to save our common resource basis, minimize negative ecological effects, foster the local economy through an urban circular economy and guarantee a high level of urban quality of life also into the future.

Links to other fields: The urban metabolism links to a variety of different fields, e.g. resource efficiency, construction, urban planning, infrastructure design and more.

Exemplified research questions

- What are the negative externalities (emissions, land consumption, pollution load etc.) of currently dominating construction materials from soil in cities and how can the usage of regional and/or renewable materials improve the picture? What measures identify “hidden flows” in urban processes, products and services? If new materials are to replace old ones, what are the side effects?
- Can the concept of “land footprint” inform decision making? Which indicators are easy to be understood by citizens to increase awareness of resource use impacts? How to raise awareness in the public for the land and soil-sediment-water impacts of urban resource consumption and storage?
- What are/is the optimal scale/s that ensure/s an efficient and controllable urban circular economy (building, district, city, region ... - and for which type of resource / material)? Which are suitable indicators for assessment and monitoring? What is the optimal size of the city to enable most efficient metabolism?
- What are the main driving forces for urban resource and material flows and which stakeholder group could influence these driving forces directly or indirectly? Who should bear and who bears responsibilities? Are new rules needed to steer sustainable flows or what can be efficient means to better management?

- Which and how many resources have been accumulated in cities (what are today's stocks)? Which urban materials are suitable for recycling (urban mining)? Is it possible to "produce" suitability through conditioning of materials?
- What are the theoretical and practical potentials of urban and landfill mining under scenarios of different market resource prices? What is the impact of material markets and competition and how to trade off different material demands sustainably?
- What are technical barriers for the realization of the urban circular economy? What are limits of the usage of RC-materials for specific construction purposes, techno-economic limits for the recycling of phosphorus and reusing organic waste or sewage for fertilization and soil improvement? How to depollute materials for reuse?
- How can building and infrastructure construction be improved to be demountable without remaining impacts for the soil, i.e. keeping all soil functions?
- What are socio-economic, cultural and legal barriers for an integrated urban metabolism management? Which agents are crucial to enable the concepts implementation? Which governance and policy is needed? How to raise acceptance for recycled products? How can proper spatial planning reduce raw material needs in the city?
- How safe is the handling of materials? Which materials are safe to use?
- How to steer the role of industry as integral part of the city? How can local reuse of outlet of one industry be used by another one?

Characteristics of IRT-13: Urban Metabolism – Enhance efficient use of soil-sediment-water resources through a closing of urban material loops

Links to identified research gaps

Indicated are numbers of relevant research topics from National Reports (cf. D2.5, Brils et al. 2016) AND for the relevant Clustered Thematic Topics (as defined above):

National research topics	AT 5, 7; BE 5, 6, 9, 13, 24, 26; CZ 1, 2, 4; FI 5, 9, 11, 13; FR 1; DE 2.3, 2.5, 4.2; IT 3; PL 3, 4; PT 2, 3, 5; RO 3; SR 3, 7; SI 2; ES 3.1, 3.3, 3.4, 3.6, 3.8, 3.9; SE 3, 4, 7; NL 5, 6, 7, 8, 9; UK 3, 5; IR 1
Clustered thematic topics	Demand: CTT-D3, 4, 5, 7 Natural Capital: CTT-NC1, 3, 6 Land Management: CTT-LM1.4, 3 Net Impact CTT-NI1.1, 1.2, 1.6, 2.3, 3.

Further Characteristics

Science fields	<input checked="" type="checkbox"/> Natural sciences <input checked="" type="checkbox"/> Social sciences <input checked="" type="checkbox"/> Engineering
Addressees	<input checked="" type="checkbox"/> Policy <input checked="" type="checkbox"/> Administration <input checked="" type="checkbox"/> Business <input checked="" type="checkbox"/> Civil Society
Regional scope	<input checked="" type="checkbox"/> Global <input type="checkbox"/> European <input type="checkbox"/> Multinational (ca. 4-8 countries) <input type="checkbox"/> Tri-/Bilateral
Duration of projects	<input type="checkbox"/> Short (< 1 year) <input type="checkbox"/> Medium (1 – 3 years) <input checked="" type="checkbox"/> Long (>3 years) <input type="checkbox"/> Very long (>6 year)

Disturbed landscapes

IRT-14: 'Emerging contaminants' in soil and groundwater – ensuring long-term provision of drinking water as well as soil and freshwater ecosystem services

Theme proposed by C. Schröter-Schlaack (UFZ) and Frank Glante (UBA)

Background: Deteriorating groundwater quality and reduced soil ecosystem services are serious issues in various European countries. Immission of 'emerging contaminants', e.g. pesticides used in agriculture, chemical substances used in industrial production or from waste and sewage may worsen the problem. However, by now it is often unclear what are the impacts of these substances on different temporal and spatial scales, how impacts may be altered by mixing of those contaminants and what are cost-effective strategies to minimize their discharge or to remediate contamination.

Goal: Better understand the impacts of 'emerging contaminants' to develop cost-effective management opportunities for safeguarding freshwater and soil related ecosystem services

Rationale from the themes: Demand: Europe demands soil ecosystem services and groundwater resources to satisfy the need for drinking water and to produce healthy food. Moreover, contaminated groundwater may impact surface waters and the sea, thereby putting fish and seafood production as well as recreational services provided by these ecosystems at risk. At the same time, increasing productivity in agriculture may demand the development and application of new fertilizer and pesticides that may cause the emission (and mixing) of substances with yet often unknown consequences for ecosystems, the provision of ecosystem services and ultimately human health.

Natural Capital: Soils, aquifers and rivers play important roles in freshwater provision; inter alia by waste and pollutant degradation. Some contaminants can be decomposed by microorganisms, metals can be chemically and biologically converted (e.g. redox reactions). So the potential of natural attenuation should take into account in describing effects and impacts of these contaminants. Contamination, in particular caused by (mixing of) 'emerging contaminants' may pose a serious threat to ecological functioning of ecosystems and thus the provision of ecosystem services. To effectively exploit the potential of soils, aquifers and rivers to provide freshwater and related ecosystem services, it is necessary to understand the soil functions, which are basic to the services, their interrelation and reaction to pressures such as increasing demand, fertilization, changed crops. We need to understand the limits to which soils can be exploited without endangering the stability of the soil system.

Land Management: Developing innovative solutions and respective institutional capacities to deal with (mixed) 'emerging contaminants' in soils and groundwater requires adapted, holistic and systemic approaches to land management. Setting up regulations on critical loads and what substances should be allowed to use, where and when needs a consideration of net impact of different management alternatives. An implementation of (stricter) regulations and adapted management measures will have tremendous impact for small- and large-scale farmers, industrial producers as well as drinking water facilities and consumers that need to be moderated by governance and policy mechanisms.

Net Impact: There is a lack of information about the impact of ‘emerging contaminants’ on groundwater (as well as on soils, sediments and surface water bodies) and the impact of mixed pollutants coming from a range of different sources. There is also a lack of knowledge about contaminants properties and their distribution in the different environmental matrices. Furthermore, there is lack of knowledge on the impacts of these contaminants on drinking water quality and human health, the use of groundwater for other purposes than drinking water production (e.g. irrigation) and on freshwater related ecosystem services, such as food production or recreation. In this regard it will be necessary to develop methods of (integrated) valuation of different impacts (e.g. health, drinking water treatment, agriculture production, food provision, cultural ecosystem services) of different management alternatives.

So what? The lack of knowledge about ‘emerging’ and mixed contaminants properties, their distribution in the different environmental matrices, in particular in groundwater and soils, the interaction of those contaminants with human health as well as soil and freshwater related ecosystem services has to be filled in order to avoid risks for public health and to ensure long-term provision of ecosystem services. Definition of what are emerging contaminants are needed as well as methods of analyzing and assessing. Therefore threshold values for these contaminants have to elaborate (methods, pathways, food-chain, and human health) for substances but also for mixtures. Environment specimen banks can provide samples retrospective to analyze if and when an emerging substance was found first in the environment (www.umweltprobenbank.de). More samples (media) than existing are needed.

Links to other fields: Next to pollution of groundwater, also soils and sediments are of importance to understand the impact of (mixed) ‘emerging contaminants’ on human health and soil and freshwater ecosystem services and may be subject to specific research efforts.

Exemplified research questions

- Which (emerging) contaminants remain a (potential) risk to health (drinking water) or ecosystems?
- Need to research on how to consider emerging contaminants into risk assessment models and to develop threshold values for emerging contaminants. How could we learn from dealing with “classical” contaminants?
- Need to define harmonized methods for sampling and analyses of such contaminants in soils, sediment and water.
- Can polluter pays principle be adapted to producer pays principle (legal research)?
- What is the role of soil in the spread and risk of (emerging) contaminants such as medicines and nanoparticles?
- How do contaminants (such as PFAS, fertilizers, and pharmaceuticals) affect raw water quality, treatment processes and mixture toxicity and human health?
- What entails the presence of substances alien to the system for the quality and resilience (biological control) and other qualities and functions of the soil-sediment-water system?
- What techniques, examples and BAT we already have to give solution in acting with emerging contaminants?

- What are the effects from diffuse contaminant sources or sum of contribution from many "small" sources, from contaminant mixtures and what is the impact of contaminant sinks (such as sediments, fibre banks etc.) on ecosystem services
- How do soil, sediment and water and the substances inside interact (soil-sediment-water system)? What is the potential of the soil and subsurface to provide natural attenuation of contaminants and how can this potential be deployed?
- Which effects of soil biota and in the food chain do we find?
- How could we avoid emerging substances in our economy?
- Do we have solutions against spreading the contaminants due to recycling, reuse?

Characteristics of IRT-14: 'Emerging contaminants' in soil and groundwater – ensuring long-term provision of drinking water as well as soil and freshwater ecosystem services

Links to identified research gaps Indicated are numbers of relevant research topics from National Reports (cf. D2.5, Brils et al. 2016) AND for the relevant Clustered Thematic Topics (as defined above):

National research topics

BE-2; BE-4; IT-2; SW-2; SW-7; CH-3.3; CH-4.2, NL-2; NL-7

Clustered thematic topics

Demand: CTT-D2, 4, 7
 Natural Capital: CTT-NC1, 3, 4
 Land Management: CTT-LM1.1, 1.2, 3, 4
 Net Impact CTT-NI1.1, 1.2, 1.3, 1.5, 2.3, 3.2, 4.1

Further Characteristics

Science fields

☒ Natural sciences | ☒ Social sciences | ☒ Engineering

Addressees

☒ Policy | ☒ Administration | ☒ Business | ☒ Civil Society

Regional scope

☐ Global | ☒ European | ☐ Multinational (ca. 4-8 countries) | ☐ Tri-/Bilateral

Duration of projects

☐ Short (< 1 year) | ☐ Medium (1 – 3 years) | ☒ Long (>3 years) | ☐ Very long (>6 year)

IRT-15: Sustainable management to restore the ecological and socio-economic values of degraded land

Theme proposed by F. Makeschin (DIU)

Background: Long-term exhaustive industrial and land use activities affected natural, agricultural and forest land by mining (e.g. peat, lignite), contamination, salinization or erosion in vast areas in Europe and left degraded and often abandoned land. Available information suggests strong evidence that these processes will further increase if no action is taken. Furthermore, the potential for the further degradation of land and the multiple services it provides will continue. Affected land in the EU-25 is estimated to about 3,5 million contaminated sites and soils to about 15% of surface area, both varying highly in its nature and consequent impacts. Exclusive for soil degradation the costs for erosion, organic matter decline, salinization, landslides and contamination would be up to €38 billion annually for EU25. As a consequence, soil and landscape functions are harmfully reduced or sites and landscapes even destroyed, and surface and ground water contaminated. The knowledge about dimensions and especially the grade of degradation is still low, hindering an ecological sound and an economically viable reclamation of these sites and water bodies in a landscape context towards bringing back to ecological functions for alternative adapted land use forms. The direct impacts of degradation are a major cause for concern; however, the indirect consequences and the loss of services potentially have greater implications for society.

Goal: Develop suitable restoration and rehabilitation approaches along the SSW approach to ensure the ecological and socio-economic values of degraded land appropriate to site conditions and type and intensity of degradation

Rationale from the themes: Demand: Dimensions, regional distribution and intensity versus quality of degraded land are rather unknown, current knowledge is still based on rough estimations. The data base is very weak and insecure, the knowledge about the current ecological potentials concerning important functions for soils, water bodies and organisms poor. According to the nature and intensity of degradation, future potential for sites, landscapes and regions on the one hand, and for the economics (both restoration and rehabilitation costs and benefits) on the other has to be known in order to complete future potentials for biomass production and ecological functions, especially water household in landscapes. Thus current and future potential for food and non-food production or environmental purposes (water in landscapes, bio-diversity, water retention areas) has to be investigated.

Natural Capital: Similar to demand, the knowledge about the current status of natural capital, its areal dimensions and distribution, the endangerment and released elements and ecosystem functions and services of degraded sites and landscapes is insufficient. There is a strong demand on specific (degradation focused) mapping and assessment of natural capital. This knowledge will dominantly determine assessment and, for future valorization of degraded sites, restoration and rehabilitation techniques. Crucial to be known are therefore specific functional ecological targets for degraded sites in a regional or landscape context.



Land Management: In Europe management of industrially degraded landscapes resorts on a long experience and tradition. Good knowledge is available in techniques for brownfields. However, since land degradation comprises highly variable causes and types, appropriate rehabilitation and restoration procedures and techniques are required. Approaches concern industrially contaminated sites (e.g. de-contamination), agricultural land (e.g. cropping systems, tillage, water management), forests (fly ash and heavy metal or acidic impacts) and natural land (disturbance of habitat structures or eutrophication). Beside restoration or rehabilitation techniques, another main target is how to integrate and optimize the specific management in spatial planning processes. Even if there is knowledge related to restoration and rehabilitation of contaminated land available, a sustainable management should be continuously updated, fine-tuned and disseminated in order to keep the implementation (including policy making) sustainable, cost-effective and capable to tackle possible risks due to contamination.

Net Impact: Both the degradation process as well as restoration or rehabilitation of land is dominantly affected by external man-made and climate induced factors. Considering net impacts therefore is crucial not only for protect land in the future, but also for appropriate handling and management of degraded land in any circumstances. Key questions on the one hand are efficient, economically viable restoration or rehabilitation activities: how to make those for contaminated soil, groundwater, and sediments sustainable and cost-effective. Which potential for soil and landscape functions can be expected in the medium and long term. And how can funds or incentives be used in a sustainable way, and what will be the acceptance by the civil society. Tools for decision support are therefore indispensable.

So what? Land is a vital resource enabling the production of food, the preservation of biodiversity, and facilitating the natural management of water systems and acting as a carbon store. Appropriate management can protect and maximize the services land provides to society. The degradation of land is, however, common in Europe and a consequence of physical, chemical and biological shifts driven by environmental, social and economic pressures. Land degradation is the consequence of multiple processes that both directly and indirectly reduce the utility of land. Due to the high extend of degraded land and areas, reversing degradation into functionally valuable land is indispensable. The concrete goals for restoration or rehabilitation have to be specified according to the type and intensity of degradation on the one hand, and the specific target conditions on the other; just using general ecological value targets used for un-degraded land is inadequate. Thus linking classification of degradation together with future targets for future alternatives (soils, ecosystem functions, water resources, biomass production) are necessary reaching assessment to planning and realization. The application of organic residues with very low contaminant level (e.g. urban composts, residues from food industry, treated grey water) as part of restoration has to be investigated. Here learning from good practices for resetting degraded land into ecological functions (historical experiences) is a prerequisite for future innovative management and spatial planning. The legal framework and private ownership will significantly determine the options and realization for re-grading land; thus considering socio-economic and legal conditions will play a crucial for restoration or rehabilitation. Therefore dedicated research is needed to elaborate degradation-type and region-specific restoration and rehabilitation approaches for valorization of degraded areas.

Exemplified research questions

- How to advance the recycling of limited mineral and nutrient resources (e.g. through capturing phosphorous from wastewater or landfill mining)?
- How can the consideration of soil quality for infrastructure projects be improved?
- Define and design sustainable land management approaches to maintain soil fertility and alternatives for soil regeneration, applying some in pilot projects.
- Define alternative technologies and practices for soil and water remediation and to minimize pollution, accounting the various sources of elements, and assessing the costs associated.
- How can funds or incentives for re-cultivation support sustainable land use?
- How big is the potential to grow “usable and sustainable” energy crops on contaminated land?
- How optimized soil functions could support societal demands in urban areas?
- How can sealed areas be re-cultivated to fulfill soil functions and improve land sparing elsewhere?
- How control and improve water quality in contaminated land management from both diffuse and point sources, including emergent contaminant classes?
- Research on technical, structural and innovative solutions, instruments and policies for redevelopment and urban requalification.
- Approaches of rehabilitation for degraded soil systems (heavy metals, pesticides, salted soils etc.)
- Creating awareness with the public on the value of sustainable management of degraded land

Characteristics of IRT-15: Sustainable management to restore the ecological and socio-economic values of degraded land

Links to identified research gaps Indicated are numbers of relevant research topics from National Reports (cf. D2.5, Brils et al. 2016) AND for the relevant Clustered Thematic Topics (as defined above):

National research topics AT-4; AT-5; AT-6; AT-7; AT-10; BE-2; BE-5; BE-6; BE-8; BE-9; BE-19; CZ-1; CZ-2; CZ-5; CZ-6; CZ-8; FI-4; FI-9; FI-10; FR-1; FR-5; DE-2,2; DE-7; IT-2; PL-3; PL-6; PT-1; PT-3; PT-6; SR-9; SW-7; UK-2; UK-3

Clustered thematic topics Demand: CTT-D1, 2, 3, 4, 5
 Natural Capital: CTT-NC2, 3, 4, 5, 7
 Land Management: CTT-LM1.2, 1.3, 1.4, 3, 4
 Net Impact CTT-NI1.1, 1.3, 1.5

Further Characteristics

Science fields	<input checked="" type="checkbox"/> Natural sciences <input type="checkbox"/> Social sciences <input checked="" type="checkbox"/> Engineering
Addressees	<input type="checkbox"/> Policy <input type="checkbox"/> Administration <input checked="" type="checkbox"/> Business <input checked="" type="checkbox"/> Civil Society
Regional scope	<input type="checkbox"/> Global <input checked="" type="checkbox"/> European <input type="checkbox"/> Multinational (ca. 4-8 countries) <input type="checkbox"/> Tri-/Bilateral
Duration of projects	<input type="checkbox"/> Short (< 1 year) <input checked="" type="checkbox"/> Medium (1 – 3 years) <input checked="" type="checkbox"/> Long (>3 years) <input type="checkbox"/> Very long (>6 year)



IRT-16: Innovative technologies and eco-engineering 4.0: Challenges for a sustainable use of agricultural, forest and urban landscapes and the SSW system

Theme proposed by F. Makeschin (DIU)

Background: Increasing societal demand on land resources and biomass cause land use pressure and endanger ecosystem functions and sustainability of land, water and bio-resources. Classical technologies focus preliminarily on conventional sectors like agricultural mechanization or landscape engineering. Innovative Key Enabling Technologies KET and eco-engineering as basis for integrated solutions may facilitate a greener economy at larger scale for farmers, forest managers and rehabilitation-related SME to support a future development contributing to a sustainable land management. However, the societal acceptance for KET is restricted. Thus understanding and raising awareness for modern sustainable technologies is also a key challenge.

Goal: Develop land use and region-specific manageable, economically viable and sociologically sound technologies and eco-engineering for agricultural, forest and urban areas contributing to a productive and safe environment

Rationale from the themes: Demand: Knowledge and application of suitable approaches in order to increase potentials and reduce risks of technologies (such as rebound effects) which contribute to a sustainable planning, management, and governance of land use. Research demand is on modern and cost-efficient on-site monitoring sensitive with sensor techniques for water, nutrient (e.g. nitrogen) and vulnerability status of soil and water that may result in an advanced survey of quality-proven data at larger scales. In this regard, success and advances in remote sensing technologies will be useful for determining fertility status (crop yield, plant nutrition, soil compaction), soil quality (e.g. control and prevention of soil erosion and -salinisation), plant cover (farming, up-ground biodiversity), pattern recognitions and land use changes at the micro- and meso-scale.

Natural Capital: Both sustainable use and preservation or protection of natural capital and ecosystem services need innovative technologies which can support the future potential of biological, soil and water resources. Special attention should be given to degraded rural, industrial and urban areas: there technological tools for minimization and remediation of soil and water pollution or for re-vegetation of degraded areas (soils, vegetation cover) can be improved by bio-engineering and restoration using modern breeding and planting techniques.

Land Management: For a future sustainable land management ecologically sound and economically viable technologies are crucial prerequisites which must be accepted and operated by land users and the civil society in order to be efficient. This concerns the whole value-chain in agricultural and forest management (from seeding/planting to harvest), subsequent conversion of harvested biomass, innovative approaches in recycling of residues (e.g. composting), conservation agriculture and procedures, and for managing contaminated sites (e.g. phyto-sanitation). This importance holds both for conventional and for organic farming. For water technologies there is a demand for an increasing water use efficiency; special attention needs grey-water treatment and re-use in agriculture and horticulture improving water resources especially in continental and Mediterranean regions.



Net Impact: Provision of permanently available quality-proven data (scenarios) and technologies are crucial for land users, planners and decision makers. Currently, data access and -availability are severely delayed due to data gaps, bad data quality, or incompatible data formats, a long time-span between data acquisition and data processing, and access to (site-/ region specific) data for farmers, planners, decision makers and the civil society, . Focus should be given on regional-specific land use ownership and small- to medium-scaled enterprises. Data security is overall the most challenging issue in future data management. Furthermore, there are considerable knowledge gaps for how to bridge public reservations against new technologies and their considerations with regard to their future potentials and risks.

So what? Modern rural and urban land use without sound and appropriate sustainable technologies, comprehensive data availability, and purposeful communication is no longer imaginable today. Eco-engineering deals with the design, monitoring and management of both rural and urban ecosystems and can integrate human society into the natural and man-made environment. Future innovative technologies and eco-engineering must consider the regional societal demands and socio-economic conditions. The need for reaching a sustainable intensification via conventional- or organic agriculture and forestry, a region- and site-specific reclamation and rehabilitation of degraded or stressed landscapes is high serving to assess and manage also smaller farm or economic structures. Research demand exists for agricultural- and forest land management (e.g. soil cultivation, planting and plant protection, harvest), for a efficient and clean re-use of nutrients and water (e.g. composts, grey water), for storm water management, for reclamation of brownfields and heavily degraded areas (erosion, landslides), for high-quality on- and off-site sensor techniques, and for communication technologies to reach distinct target groups inside (farmers) and outside (civil society). Sound innovative technologies may support biological conservation or rehabilitation of heavily degraded landscapes. Focus should be given also to modern, target-group specific information technologies for raising a science-based knowledge and awareness. And finally, industry strongly needs planning security in order to invest in goal-oriented new technologies targeting the Sustainable Development Goals.

Links to other fields: Technologies in their broader context gain increased importance not only for the conventional management of rural and urban resources, but also for an appropriate, target-group specific knowledge transfer and participation.

Exemplified research questions:

- How can new technologies and advanced digitalisation (in terms of databases, communication) help farmers and foresters to adapt to climate change?
- How to improve the development and use of technologies by business models, private-public partnerships, policies and legislation?
- Which modern technologies for environmental control may serve for a better actual status and future risk prediction (on-site / remote)?
- How to optimize existing and innovative remediation technology for contaminated soil, groundwater, sediment (e.g. for big urban VOC-plumes, e.g. for low permeable geology, e.g. cleaning soil contaminated with multiple parameters)?
- Which technologies may contribute to a better de-contamination and recycling of organic wastes and industrial residues?

- Which appropriate on-site and off-site technologies may improve the monitoring and remediation?
- What are the social- and environmental impacts of new technologies?
- What kind of knowledge is needed to stimulate the reactivation of brownfields?
- Development and use of high tech monitoring and data collection in relation to soil and land use: e.g. real time monitoring using satellites, precision farming, remote sensing and (geo-tele)detection, use of drones.
- How to ensure that the best available technology is used and lifecycle sustainability is taken into account reuse/recycling of excavated contaminated soil materials?
- Set up monitoring devices of soil conditions, the balance genesis vs erosion, the carbon content and carbon stock and the GHG emissions using instrumentation at different scales.
- How can new media and technology, for example social media with a “soil function app”, be used to engage with the broader public?
- What developments in technology are required in agriculture? E.g. remote sensing by satellite, plant disease pattern recognition by drones?
- Development of practical tools able to respond to risks induced by soil degradation processes under the global climate change impact.

Characteristics of IRT-16: Innovative technologies and eco-engineering 4.0: Challenges for a sustainable use of agricultural, forest and urban landscapes and the SSW system

Links to identified research gaps	Indicated are numbers of relevant research topics from National Reports (cf. D2.5, Brils et al. 2016) AND for the relevant Clustered Thematic Topics (as defined above):
National research topics	AT-3; AT-7; BE-5; BE-8; BE-19; BE -25; FI-6; FI-9; DE-4.1; DE-8.2; IT-1; PL-1; PL-6; PT-2; PT-3; ES-3.6; ES-4; SW-4; SW-6; CH-2,.10; NL-14
Clustered thematic topics	Demand: CTT-D3, 5, 6 Natural Capital: CTT-NC3, 4, 5, 6 Land Management: CTT-LM2, 3, 4 Net Impact CTT-NI1, 2

Further Characteristics

Science fields	<input checked="" type="checkbox"/> Natural sciences <input type="checkbox"/> Social sciences <input checked="" type="checkbox"/> Engineering
Addressees	<input checked="" type="checkbox"/> Policy <input type="checkbox"/> Administration <input checked="" type="checkbox"/> Business <input checked="" type="checkbox"/> Civil Society
Regional scope	<input type="checkbox"/> Global <input checked="" type="checkbox"/> European <input type="checkbox"/> Multinational (ca. 4-8 countries) <input type="checkbox"/> Tri-/Bilateral
Duration of projects	<input type="checkbox"/> Short (< 1 year) <input checked="" type="checkbox"/> Medium (1 – 3 years) <input checked="" type="checkbox"/> Long (>3 years) <input type="checkbox"/> Very long (>6 year)



Climate change challenges

IRT-17: Climate change challenges - improving preparedness and response for climate conditions and related hazards

Theme proposed by J. Gorgoń (IETU)

Background: Climate change is seen to be a very complex and challenging issue, which refers to the urban and rural areas management at all scales from global to the local. It has been mentioned in almost all national reports as very important and affecting every topic concerned issue. This theme is also coherent with the EU Strategy on adaptation to climate change (adopted by the European Commission in April 2013), which sets out a framework and mechanisms for taking the EU's preparedness for current and future climate impacts. Also COP21 results and guidelines should be taken into consideration, especially those related to carbon sequestration in soils, because fertile soils are able to cope with the effects of climate changes. Important for planning systems and land management practices is taking into account IPCC scenarios with regards to various level of legal and administrative responsibilities (national, regional and local). Time frame for all activities related to climate change mitigation and adaptation should be precise (including short, medium and long-term actions).

Goal: To introduce or strengthen climate change aspects into spatial planning and land management practice, and to reinforce administrative, technical and societal preparedness for climate extremes and related hazards.

Rationale from the themes: ***Demand:*** Europe demands all land resources as well as land itself - for location of new investments of various types. The soil sealing, increased vulnerability of water resources, coastal zones, and ecosystems in urban and rural areas are results of these activities which reinforce negative impact of climate changes.

Natural Capital: The natural capital provides the society with a wide range of goods and services, which are often considered to be free of charge. The ecosystem services help to credit the economic, health, and social benefits derived from functioning natural environment and land. Due to its specific features land is perceived as a stock of natural resources including soils, water, sediments and vegetation, as well as like resource itself. In the context of climate change, land management has to consider the potential and the limits of what natural capital can offer and ecosystem approach is crucial to cope with climate change impacts.

Land Management: Land management needs to ensure efficient use and protection of resources and natural capital including its services and thereby contribute to solving existing problems and future challenges. Climate change mitigation and adaptation are strongly related to almost all land management topics. Respond to climate impacts like extreme weather events, flooding, drought and environmental stresses impose new demand on spatial planning and land management. These stresses are impelled by climate change, but also by the way we have built on the land. Sprawl and intensive land development practices continue to remove the natural resources and their functions from the landscape, thereby increasing environmental stresses and vulnerability to climate change hazards. It is also important to underline relationship between climate change and land use changes. Spatial planning, land use policies and regulations for development should introduce prevention and



precautionary principles referring to climate hazards. Adaptation options for climate change require integrated demand-side and supply-side strategies, which should be implemented into land management practices.

Net Impact: Implications of climate change in many cases are irreversibly. That's why it is important to estimate, what global climate changes will mean for the EU and, how local and regional decisions related to the soil and land management will impact on global scale. The impact of climate change has serious consequences, which should be assessed at different levels from local to global.

So what? Climate change affects all European countries. Vulnerabilities and impacts for nature, the economy and society differ across regions, territories and economic sectors in Europe. Challenges of climate change require two types of responses. First is related to climate change mitigation, second is adaptation activities to deal with the unavoidable impacts. Spatial planning could be an instrument for coping with effects of climate change, but it requires better understanding of its role in the process of climate change mitigation, adaptation and counteracting negative climate phenomena. Integrated strategies on climate change mitigation and adaptation referring to soil protection and land management should answer questions: how to reduce direct and indirect impacts from climate change. Land management could play an important role in coping with climate change impacts by introducing new innovative technical and operational solutions, as well by including broad scope of stakeholders into this process. Both, spatial planning and land management could improve climate change resilience, but it need to reinforce co-ordination between them.

Links to other fields: Climate change challenges are related to all topics linked to the soil and land protection and management, however there is need to strengthen research efforts and interrelate to economy and social sciences.

Exemplified research questions

- How to adapt to climate change by an appropriate spatial (urban and rural) land planning and management? How can land management influence climate change mitigation? How to formulate criteria on mitigation and adaptation for its integration with spatial planning?
- How to distinguished and monitor climate change impact on different areas -urban and rural? Need for key indicators defined by appropriate criteria.
- How to address climate change policy questions, respecting different level of responsibility? How to integrate the decision making process with different levels?
- How to implement tools and instruments concerning vulnerability into spatial planning? How to improve resilience of urban and rural areas?
- How to design technologies and planning tools for climate change adaptation of resource efficient wastewater systems for a sustainable built environment?
- How to improve resilience, adaptation capacity through land use planning by paying attention to flood management and other ecosystem-based ways of adaptation? How to take advantage of ecosystem services in climate change policy (in urban and rural areas)?
- What can land use and management of the soil-sediment-water system contribute to tackling challenges related to climate change?

- What are the costs and benefits of climate adaptation and mitigation policy for the soil-sediment-water system?
- What methodological approach is required for concepts of climate change adaption? Need for integration: spatial planning, civil engineering, water management, etc.
- How to improve social responsibility and awareness on climate change issues?
- What can we do now to adapt for climate change?

Characteristics of IRT-17: Climate change challenges - improving preparedness and response for climate conditions and related hazards

Links to identified research gaps	Indicated are numbers of relevant research topics from National Reports (cf. D2.5, Brils et al. 2016) AND for the relevant Clustered Thematic Topics (as defined above):
National	AT-4; AT-10; CZ-4 ;FI-4; FI-7; FI-12; FI-16; FR-2; DE-2.5; DE-7; PL-1 PT-4; PT-5; PT-10;RO-1;SR-4; SR-8; SI-2; ES-3.11; ES-3.12; SW-1;SW-4;CH-2.8; CH-3.3; NL-3; NL-5;
Clustered thematic topics	Demand: CTT-D2, 3, 4, 5, 7 Natural Capital: CTT-NC1, 2, 3, 5, 7 Land Management: CTT-LM1.1, 1.2, 1.3, 1.4, 2, 3, 4 Net Impact CTT-NI1.1, 1.2, 1.3, 1.5, 2, 3.2, 4.1
Further Characteristics	
Science fields	<input checked="" type="checkbox"/> Natural sciences <input checked="" type="checkbox"/> Social sciences (Economy) <input checked="" type="checkbox"/> Engineering
Addressees	<input checked="" type="checkbox"/> Policy <input checked="" type="checkbox"/> Administration <input checked="" type="checkbox"/> Business <input checked="" type="checkbox"/> Civil Society
Regional scope	<input checked="" type="checkbox"/> Global <input checked="" type="checkbox"/> European <input checked="" type="checkbox"/> Multinational (ca. 4-8 countries) <input checked="" type="checkbox"/> Tri-/Bilateral
Duration of projects	<input type="checkbox"/> Short (< 1 year) <input type="checkbox"/> Medium (1 – 3 years) <input checked="" type="checkbox"/> Long (>3 years) <input type="checkbox"/> Very long (>6 year)



3.6 Prioritization of the Clustered Thematic Topics (CTTs) and Integrated Research Topics (IRTs) by NKS

In total 165 stakeholders participated in the online-based prioritization procedure. The final evaluation of the CTTs and IRTs by the National Key Stakeholders revealed a comprehensive view of the thematic and strategic interests in research and allows valuable considerations for weighting and assessing the contents based on stakeholder groups and their professional homes and fields of activity or responsibility within countries and European regions. Overall, the feedback and the quantitative scorings of the NKS validated the finally revised CTTs and IRTs as relevant and complete trans-national research topics.

The methodological approach of INSPIRATION consistently shows the value and high importance of integrating representative key stakeholders into a research topic identification process (see also chapter 2.3). This process started in WP2 in national platforms, then continued in the engagement of selected NKS during the hearings in WP3-NKS workshops in Faro and Venice (as well conducted by an online consultation process in between also involving NFPs), and was finalized by a final evaluation process in the first week of October 2016.

The online prioritization survey results in brief show:

- The dominant type of stakeholders that participated in the evaluation was the one of knowledge providers (61%) followed by end users of research (29%) and funders (10%).
- According to their background, NKS affiliated to land-use management (52%) significantly outnumbered those with backgrounds related to soil (35%) and to water and sediment (each <10%).
- The scoring of Clustered Thematic Topics within all 4 themes of the conceptual model (Demand, Natural Capital, Land Management, Net Impacts) dominantly ranged in the upper three categories of importance (high to key importance) for the perspectives of stakeholder individual view, by addressing the stakeholder's country needs as well as for addressing the EU Societal Challenge 5, respectively. Slightly lower importance was only addressed for geological subsurface resources both in the CTTs of Demand and Natural Capital.
- All 17 Integrated Research Topics were scored by dominantly high to key importance.

3.7 Activities towards transferring the results of WP3 into a Strategic Research Agenda and Match-Making process in WP4

3.7.1 Concluding valuation by WP3

The methodological approach of INSPIRATION has been based on a consequent bottom-up procedure with participation of national key stakeholders of the 17 INSPIRATION countries in several workshops and consultation phases. Their national research demands were summarized in the final report D2.5 of WP2. INSPIRATION WP3 kept continuing application of an innovative approach: elaborating the European research demand by consequently following the bottom-up approach – in the end having involved about 500 stakeholders (with different background from funders, knowledge providers, end users) from about twenty EU countries.

The main messages and the research demands from NKS facilitated by their respective NFP were targeted at in WP3 by investigating first the D2.5. Finding a high diversity of ideas and proposals, it was decided to implement a stepwise process according to an accepted concept, which was therefore validated in a workshop with the NFPs and Coordinator. In this approach the most challenging task was continuously to understand, consider and integrate the manifold expectations of NKS by collating these in a clear overall concept, while not neglecting or over-weighting specific network, lobbying, national or regional interests.

The results might be assessed as a real leap from segregated, sectoral research interests towards integrated research topics that are bridging the gap to integrative research concepts. CTTs and IRTs form valuable mosaic stones for further formulating a SRA. The unique selling proposition of INSPIRATION is the bottom-up approach and the quality of a "European key stakeholder research agenda".



3.7.2 Follow-up process for transferring the results towards WP4

At the end of WP3, a meeting of the Core Group in Berlin on 13 October 2016 was conducted for discussing the next working steps of transferring the results of WP3 (Trans-national commons) to WP4 for elaborating a Strategic Research Agenda and initiating a match-making process of INSPIRATION stakeholders. The results of the core group meeting were:

Comments on CTTs and IRTs:

As a result of the prioritization of NKS (see 3.6 above), it was concluded that no justification can be derived for deleting any CTT or IRT from the list. All topics for pieces of a mosaic falling into a complete picture.

However, in order to ensure that the context and specific objectives of the CTTs and IRTs are easy to assess and clear for third parties, the CG recommended that a further sharpening of the "motivation" and "goals" of CTTs and IRTs between WP3 and WP4 was needed. To carve out core content of each topic, WP4 will study and review them individually and comment to TLs and IRT advocates what WP4's 'naive' take is on the key goal/motivation of each topic (by end October 2016). Then TLs and advocates will clarify based on WP4's comments the description of the topics in a SMART (specific, measurable, assignable, realistic, time-related) way (by mid November 2016).



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