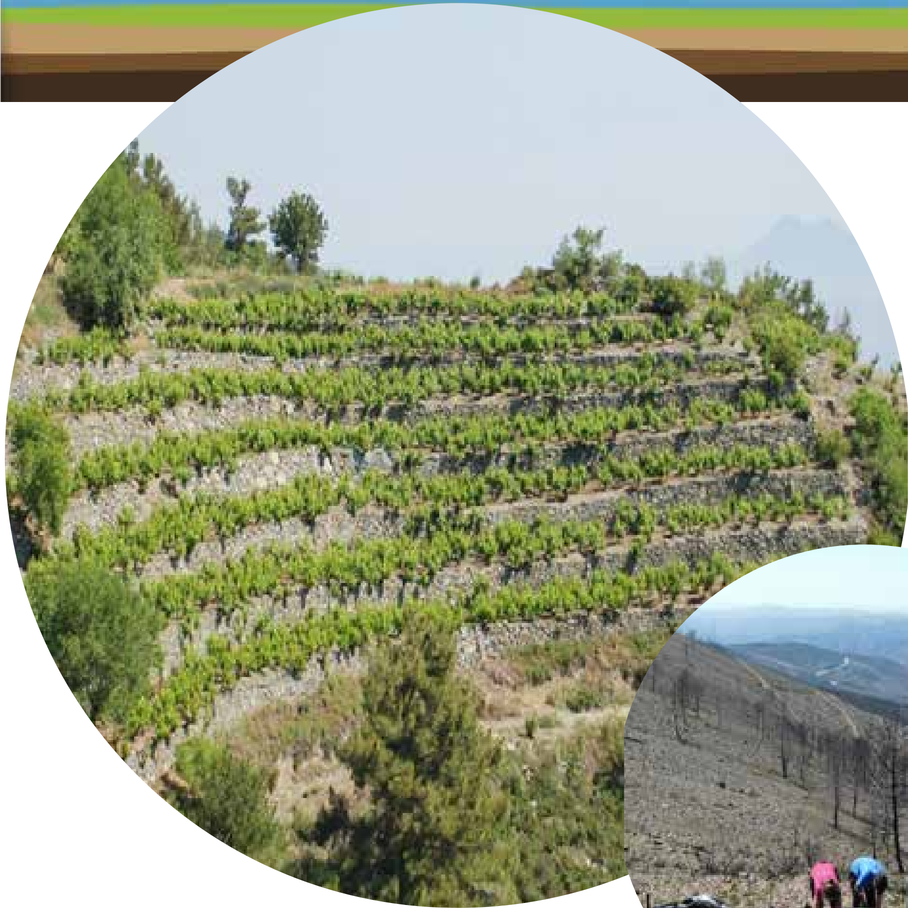


RECARE Project

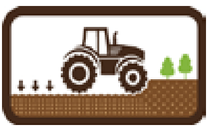
Finding and sharing solutions to protect our soils

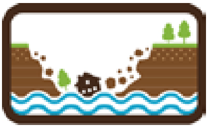
RECARE
Preventing and Remediating degradation of soils in Europe through Land Care

Introduction

Increasingly, the crucial importance of soils for the well-being of human society is being recognised. In many parts of the world, soil is being lost faster than it forms, and its functions are being lost or diminished, which impacts ecosystem services. In Europe, a number of threats to our soil have been identified in the European Soil Thematic Strategy, these include: soil erosion, salinization, compaction, desertification, floods and landslides, loss of organic matter, contamination, sealing and loss of soil biodiversity. Contemporary soil science has created a suite of practical management responses that address these threats.

This brochure describes the threats to soils in Europe, how the RECARE project has addressed these, and provides clear examples of soil management options and policy solutions.

Soil threat	Causes and effects
	**Soil erosion by water** causes loss of fertile soil as well as off-site damage. It is a problem wherever soil is combined with sloping land, low soil cover and heavy rainfall and is therefore a problem across Europe. Agricultural practices and forestry operations exacerbate erosion. **Soil erosion by wind** is another problem occurring across Europe, usually as a consequence of cultivation when fields are left exposed for a period of time.
	**Salinization** is usually closely related to human action such as inappropriate irrigation methods or overexploitation of coastal aquifers causing sea water intrusion. Once salinization occurs, it affects crop yield and can ultimately make the soil unsuitable for growing crops.
	**Compaction** of soil is human induced due to machinery use, and damages a range of vital soil functions and ecosystem services. Compaction increases the mechanical resistance to root growth and reduces soil aeration, which decreases soil productivity. It reduces soil hydraulic conductivity and thus decreases water infiltration and increases surface run-off that may induce soil erosion.
	**Sealing** causes an irreversible loss of soil and its functions. The surrounding areas of cities are usually subject to considerable growth and urban sprawl, e.g. due to residential, commercial and industrial activities. This phenomenon usually affects very productive, high quality soils since most European settlements were established in fertile regions.

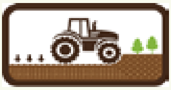
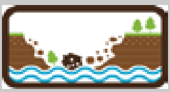
	**Desertification** is land degradation in arid, semi-arid and dry subhumid areas resulting from various factors, including climatic fluctuations and human activities. The process is extremely complex because the way desertification expresses itself is highly site specific, but leads to soil loss and the area being unsuitable for agriculture.
	**Floods and landslides** disturb soil functions despite acting over a short time period. Agents of change, such as socio-economic-political processes, agricultural and forestry activities, and climate change, affect the soil system and can cause changes in flood and landslide generation, especially at small and medium catchment scales.
	**Loss of organic matter in peat soils** occurs as a result of draining agricultural peat land. It also causes water pollution and contributes significantly to CO_2 emissions. Subsidence rates of 1 – 2 cm per year are not uncommon and make peat soils below sea-level or inland water levels prone to flooding.
	**Loss of organic matter in mineral soils** is due to long-term agriculture and is recognised as a problem in large parts of Europe, reducing productivity and the resilience of the soil. Monocultures, reduced use of organic amendments (particularly farmyard manure) and intensive tillage, are the major factors affecting soil organic matter cycles.
	**Contamination** of large areas of soil by harmful products from agriculture, industry, cities and mining has occurred over decades. It leaves soil unusable for agriculture or habitation as well as being a long-term source of pollution to the wider environment.
	**Loss of soil biodiversity** diminishes the sub-soil ecosystem of animals, insects, fungi and microbes. Existing soil biodiversity is increasingly threatened by excessive agricultural exploitation due to simplified crop rotation and monocultures, application of pesticides and fertilizers and soil compaction, leaving soil less resilient in facing challenges and less able to support wider ecosystems.

Project overview

The RECARE project brought together a multidisciplinary team of 27 different organisations to identify ways of assessing the contemporary threats to soils and to find innovative solutions to prevent further soil degradation across Europe. This was achieved through a number of objectives:

1. Filling knowledge gaps in our understanding of the functioning of soil systems under the influence of climate and human activities
2. Developing a harmonised methodology to assess the state of soil degradation and conservation
3. Developing a universally applicable methodology to assess the impacts of soil degradation upon soil functions and ecosystem services
4. Selecting innovative measures in collaboration with stakeholders and evaluate the efficacy of these regarding soil functions and ecosystem services as well as costs and benefits
5. Upscaling results from 17 case studies to European scale to evaluate the effectiveness of measures across Europe
6. Evaluating ways to facilitate adoption of these measures by stakeholders
7. Carry out an integrated assessment of existing soil related policies and strategies to identify their goals, impacts, synergies and potential inconsistencies, and to derive recommendations for improvement based on RECARE results.

As soil degradation problems are caused by the interplay of biophysical, socio-economic and political factors, all of which vary across Europe, these problems are by definition site specific and occur at different scales. Therefore, 17 case studies of soil threats were included in RECARE to study the various conditions that occur across Europe and to find appropriate responses using a stakeholder participatory process that combined both scientific and local knowledge.

SOIL THREAT	CASE STUDY AREA	MAIN MEASURE TRIALLED
	Frienisberg, Switzerland	Damming potato furrows with the ‘dyker’ technology
	Caramulo, Portugal	Post-fire mulching with eucalyptus logging residue
	Peristerona Watershed, Cyprus	Maintenance/rehabilitation of dry-stone terraces
	Timbaki, Crete, Greece	Use of biological agents to increase crop resistance to salinity
	Aarslev, Denmark	Identifying thresholds in wheel load and inflation pressure
	Wroclaw & Warsaw, Poland	Effects of spatial planning for improved soil protection based on soil quality information
	Canyoles River Basin, Spain	Mitigating soil erosion through straw mulching
	Gunnarsholt, Iceland	Use of seeding, fertilizer and tree establishment to reclaim land
	Vansjø-Hobøl Catchment, Norway	Flood retention measures and the impact of vegetation on river bank stability
	Myjava Catchment, Slovakia	Use of small wooden check dams for the stabilisation of gullies
	Veenweidegebied, The Netherlands	Use of submerged drains to reduce peat oxidation (so loss of OM)
	Broddbo, Sweden	Alternative grass species, such as Reed canary grass and Tall fescue, to reduce CO_2 emissions
	Olden Eibergen, The Netherlands	Grass undersowing in maize
	Veneto region, Italy	Continuous soil cover and conservation agriculture practice
	Guadiamar, Spain	Amendment additions, such as Sugar lime, Biosolid compost and Leodardite
	Copsa Mică, Romania	Amendments to reduce heavy metals mobility in soil and enhnce uptake by plants
	Isle of Purbeck, United Kingdom	Use of sulphur to change soil biodiversity to remediate heathland

Improved scientific understanding

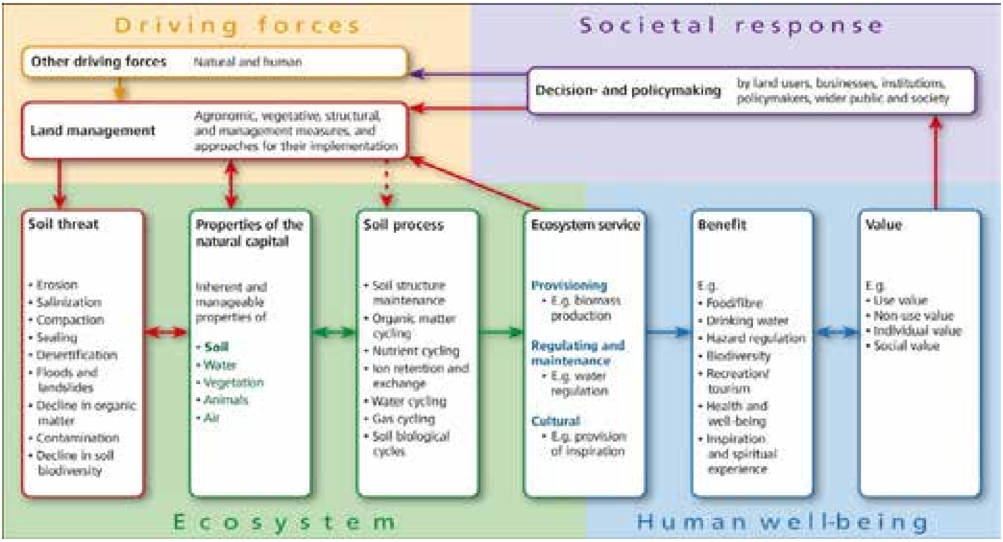
After a rigorous review and analysis of existing literature, RECARE updated information on the concepts, definitions and the processes of soil degradation occurring in the soil threats. RECARE found a need for understanding the processes that are involved when several soil threats are interacting. Moreover, results of interventions to improve the status of soil quality focusing on one threat should be assessed for other soil threats as well. By recognizing the interaction among soil threats, a more holistic approach for mitigating soil threats can be achieved. Analyses of the effects of soil threats on soil functions are starting to evolve. The holistic approach in dealing with soil threats, i.e. linking soil quality status, soil functions and ecosystem services is important to understand relationships between, and to assess effects of drivers on soil threats and ultimately the societal benefits of soils.

Although there is considerable knowledge available on soil threats in Europe, some knowledge gaps remain:

1. At the level of individual soil threats, there are still issues with definition, assessment methods, lack of standardisation and lack of data. This inhibits the development of a full and consistent overview of the status of each soil threat at EU level.
2. Although it is conceptually clear that different soil threats interact, there is not enough information on how exactly the different threats interact. Nor is there sufficient understanding how measures taken against one particular soil threat influence other soil threats.
3. There is a lack of evidence on how soil threats and measures impact on the delivery of ecosystem services, especially in cases where different soil threats interact. As a result, assessments of how soil threats impact ESS remain largely qualitative.
4. Any assessment of soil threats, measures against soil threats, and their effects on soil functions and ecosystem services should take into account local conditions (bio-physical, economic, social, policies) as soil degradation is highly context specific. This means that blanket approaches are not possible, and that detailed knowledge in various disciplines is needed to effectively combat soil threats. Such knowledge is at present often still incomplete.

Development of a universally applicable framework to assess the impact of soil degradation and conservation upon ecosystem services.

Although a wealth of information is available about the topics of soil functions, ecosystem services, valuation of ecosystem services, and ways to define and determine these, no universally applicable methodology has existed to integrate these principles into a coherent system for use in soil degradation and soil rehabilitation studies. RECARE has developed a framework specifically for assessing the ecosystem services derived from soil. This framework was applied in each of the 17 case studies.



Key lessons:

- Analysis of the impacts on ecosystem services (ES) of selected measures showed that most measures had a positive effect on targeted as well as other ES.
- The case studies found it challenging to introduce the ES concept to stakeholders and to assess the impacts of trialed measures looking through the ES lenses. However, the ES perspective did help to identify unexpected benefits (or drawbacks) that otherwise would have gone unnoticed.
- ES were valued differently by different stakeholders, for example provisioning services were highly valued by land users, but often undervalued or ‘ignored’ by other stakeholders, and researchers and government organisations tended to emphasise the regulating services.

Development of a participatory planning process to identify, select, evaluate, and adopt innovative measures combating different soil degradation threats

To achieve maximum benefit and adoption among stakeholders, measures to address soil degradation must be chosen based on jointly assessed impacts and stakeholders' preferences and adapted to local conditions. Assessing options in an interactive, participatory, process-focused way is necessary for creating a sense of ownership of the solution and facilitating effective decision-making and adoption. RECARE used a participatory planning process selecting, implementing and evaluating measures with local stakeholders.

Key lessons:

- Achieving the desired results from a participatory planning process (e.g. building the network, building trust, fostering knowledge exchange, selection and implementation of measures) requires a long process of interactions with the land users and stakeholders, which exceeds the 5-year duration of the RECARE project. Those case studies that achieved most success built on a previous project.
- The participatory methodology may not work well for all of the soil threats addressed in RECARE. Soil organic matter loss, for example, may be undervalued by land users as its impact is felt in the long-term. Other soil threats may also be less straight-forward to define and assess, such as soil sealing, where the soil damage is easily overlooked and some people benefit from the threat, or loss of soil biodiversity which is often the result of many other threats.
- Although the participatory selection of measures is necessary to select measures that are suitable for, and supported by, stakeholders, it was also observed that stakeholders have a tendency to select measures that they already know something about. As a result, there is a risk that promising, more innovative measures are not selected.
- The RECARE stakeholder workshop approach and methodology successfully initiated and fostered transdisciplinary learning processes between the researchers and stakeholders and from the local to the (sub-) national level. It also brought together different stakeholders, who (in many case studies) would not necessarily interact and jointly discuss soil threats, and identify and evaluate ways to solve them.

Effective remediation, restoration and prevention measures

Remediation and restoration measures selected and implemented by stakeholders in a participatory process were evaluated in RECARE for their efficacy. Examples of a number of measures that show clear potential for immediate exploitation are provided below:

Portugal – post-fire mulching to prevent soil erosion

Application of eucalyptus logging residues (‘mulching’) was highly to extremely effective in reducing post-fire soil erosion as well as organic matter losses. Stakeholders generally accepted mulching as an effective post-fire hillslope stabilization measure. At the same time, stakeholders identified financial aspects and, to a lesser extent, also agronomic (availability of residues) and technical (logistics of application) aspects as barriers for widespread adoption of post-fire mulching in the future. In recognition of its effectiveness the Portuguese government is now piloting the use of mulching in post-fire areas.

The Netherlands - Submerged drains to prevent loss of organic matter in peat soils

Submerged drains regulate groundwater levels in peatland; they increase levels in dry (summer) periods and drain the fields in wet (winter) periods, thereby reducing CO_2 emissions by reducing peat oxidation. In the Netherlands, the use of submerged drains was found to raise groundwater levels and conserve peat soils, reducing peat oxidation and so subsidence and CO_2 emissions and loss of organic matter by 30 - 50%. As a result of these findings the Dutch government is now considering incentivising the use of submerged drains in order to reduce the national CO_2 emissions from agriculture.

Spain and Romania – Use of amendments to remediate contaminated soil

In Spain, the addition of soil amendments, particularly sugar beet lime, was very effective in increasing soil pH and reducing availability of trace elements. In the long-term, planted trees, in particular *Ceratonia*, *Fraxinus* and *Populus* contributed to increases in soil pH and stabilization of trace elements. In Romania, the soil amendments dolomite and Na-bentonite, significantly reduced the availability of metals although this reduction was not sufficient to produce safe food or fodder. However, reducing the metal toxicity and improving the soil fertility led to the development of a consistent vegetation cover with positive effects on soil erosion and loss of soil biodiversity.

Developments to inform decision-making

RECARE Integrated Assessment Model

RECARE has developed a Europe-wide Integrated Assessment Model (IAM) to evaluate the applicability and effectiveness of prevention, mitigation and remediation measures across the range of soil threats. It also assesses the implications of adopting these measures and the resulting changes in soil threats on a set of (soil functions impacting on) ecosystem services. Due to the importance of the local context in such assessments, and to be able to capture local dynamics, the model operates at a 1 ha resolution. It includes a time horizon up to 2050 and assesses changes to the soil threats and the effectiveness of the mitigation options under conditions of climate change and socio-economic developments. Changes are simulated at a monthly or yearly time interval - monthly to capture the seasonal variations and yearly to best capture the socio-economic processes.

By incorporating and integrating a suite of models related to climate, hydrology, vegetation, soil, land use, crop choice, land management, soil functions, ecosystem services, and their feedback mechanisms, the RECARE IAM provides a novel approach to understanding and mitigating soil threats, by simulating:

- the changing susceptibility of the threats over time
- the interactions between threats
- the effects measures may have on multiple threats
- the link to delivery of ecosystem services

RECARE policy impact assessment

The policy impact assessment conducted in the RECARE project aimed to examine the effects of EU soil-related policies, and identify gaps, contradictions and incoherencies. The assessment built on: a stocktaking and mapping of policies; 17 case studies based on interviews and expert assessments; and an online survey among European soil practitioners. Because there is no dedicated EU soil policy with binding requirements, but rather a diffuse set of policies affecting soil management, it has proven difficult to establish and quantify causality between EU policies, soil management practices and impacts. The lack of systematic monitoring of policy impacts limits the availability of data for the assessment.

Overall, respondents ascribe a neutral to mildly positive effect of the main EU soil-related policies related to agricultural and forest management, with key policies being: Common Agricultural Policy, Water Framework Directive, and Nitrates Directive. The majority view is that in the absence of these policies, ambition for soil management would be lower still. Some stakeholders and case studies have pointed out that these policies have also had some negative effects. For soil contamination, Industrial Emissions Directive, Waste Framework Directive, and Environmental Liability Directive are central. Also gaps in relation to historical contamination were emphasised.

Most respondents highlighted that much more ambitious soil management would be feasible given the knowledge and technologies available, but the existing policies fail to address this potential. The EU-wide trends on soil threats underline this message. The case studies produced clear evidence that improvements in soil management practices can deliver reduction in soil threats and improve soil functions and ecosystem services.

Barriers to uptake of measures and soil protection more broadly

RECARE analysed the barriers to the uptake of specific soil management measures, as well as the barriers to more effective soil protection policies. The analysis identified a range of different types of barriers that cover institutional, policy implementation, financial, personal, socio-economic, cultural, and historical features.

In case study sites, the main barrier to uptake that emerged from the analysis of experiences is linked to ill-defined institutional arrangements. This results in a perceived lack of support for innovative measures, evidenced by the absence of, or conflicting guidance from, regulatory bodies and other organisations concerned. Secondly, limited collaboration among key stakeholders was identified as a common barrier. The full potential of knowledge co-generation is, therefore, not yet fully operationalised. Better engagement of key stakeholders across multiple levels will be instrumental in supporting better land management decisions.

Policy assessment identified a wide range of barriers to better soil protection. Stakeholders interviewed as part of the policy assessment most often pointed to a lack of political ambition, an absence of overarching soil protection legislation and long-term strategies, as well as a lack of financial resources. Moreover, a lack of clear leadership and coordination for soil policy and limited institutional capacity were stressed. In addition, limited technical knowledge in public authorities and among decision-makers, and missing risk information and monitoring were identified as very relevant barriers.

Opportunities for policy

The RECARE project identified a number of opportunities for improved policies at EU level. Several policy briefs have been produced that outline the messages for specific soil threats. The key overarching messages are:

- Based on RECARE findings a coordinated approach at EU level dedicated to soil protection that includes binding targets would be highly beneficial to better address the urgent need to halt and reverse soil degradation

A dedicated legally binding framework with binding priorities and targets could lead to progress in addressing the policy gaps that currently exist in many countries, for example in relation to historic soil contamination or subsoil compaction. Priorities and targets would increase the ability to integrate soil concerns across different policies, provide a basis for more systematic monitoring of policy implementation and soil trends, and increase incentives to act in countries where there is a lack of political will to address soil protection in a coordinated way. A binding legislative proposal, as mandated by the 7th Environment Action Programme, has not yet been proposed by the European Commisison.

In the absence of legally binding objectives and targets, there is limited ability and willingness in practice to overcome the barriers that limit sustainable soil management (including, for example, lack of institutional clarities, lack of funding, lack of access to information).

Given the experience with the Soil Framework Directive, the challenge is to find a legally binding approach that is both workable and agreeable to Member States with different biophysical and institutional contexts, as well as sometimes quite different stages in the development of soil protection policies.

- Build capacity in the land management community

The starting point for engaging farmers and other land managers is to empower them by providing training and capacity building campaigns. Specifically, this can be done by giving farmers indicators and knowledge to manage their soils sustainably, fostering group activities that encourage peer to peer learning and ensuring that farmers take part in such training activities, for example, through conditions linked to farm payments. To support farmers' knowledge on good soil management also requires that such knowledge is available in basic agricultural training (e.g. agricultural schools) and supported by applied research. Sufficient funding and investments, as well as institutional and cultural change in advisory services, are required.

- Common Agricultural Policy (CAP) has significant potential to improve its contribution to soil management objectives

The CAP is the single most important policy instrument with potential to improve soil management on agricultural and forest land. In general, the CAP post 2020 needs to earmark sufficient support and set out ambitious requirements for the environment and sustainable soil management. The strategic planning at Member State levels needs to clearly identify and address soil management needs and objectives and put in place monitoring to measure the policy impacts. More specifically, individual mechanisms need to be well defined to ensure their effectiveness. For example, the GAEC 6 standard would increase its effectiveness by being rephrased from 'Minimum land management under tillage to reduce risk of soil degradation including on slopes' to 'Sustainable land management to reduce risk of soil degradation including on slopes'. This would ensure that subsoil compaction and other non-erosion threats are duly integrated. Moreover, compulsory training associated with receipt of payments needs to address regionally relevant soil threats.

Selected further reading

Selected Key Deliverable Reports

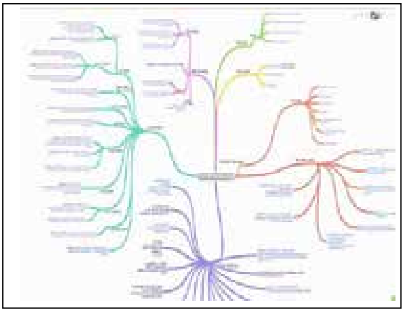
D2.1 Soil threat in Europe: Status, methods, drivers and effects on ecosystem services
D3.2 Report on the current state of degradation and conservation
D4.2 Report about stakeholder valuation of ecosystem services
D5.2 Participatory decision-making on sustainable land management to combat soil threats in Europe
D6.2 Assessment of the effectiveness of implemented measures regarding combating soil degradation, and to restore soil functions and ecosystem services
D7.1 Impact Assessment on Ecosystem Services
D7.2 Model assessments of the cost-effectiveness of prevention/remediation/restoration measures for all Case Study areas
D8.3 Report on inter-threat comparison
D8.4 Report on barriers and opportunities of adoption at European scale
D9.1 Up-to-date review of EU policies and integrated impact assessment methodology
D9.2 Report on the integrated impact assessment of national and EU policies
D9.3 Final policy recommendations

All deliverables can be accessed via:
http://recare-hub.eu/tools-and-outputs/project-reports

Key scientific papers

Over 50 peer-reviewed scientific papers have been published from the RECARE work.

All scientific papers can be accessed via:
http://recare-hub.eu/tools-and-outputs/scientific-journal-articles
or via the RECARE Publication Trees:
http://recare-hub.eu/tools-and-outputs/publication-trees



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