SHERPA
Rural Science-Society-Policy Interfaces

SHERPA Position Paper

CLIMATE CHANGE AND ENVIRONMENTAL SUSTAINABILITY

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Acronyms

AE4EU	Agroecology for Europe
ALL-Ready	The European Agroecology Living Lab and Research Infrastructure Network: Preparation phase
C3S	Copernicus Climate Change Service
CAP	Common Agricultural Policy
CBD	Convention on Biological Diversity
CCRA	Climate Change Risk Assessment
CLLD	Community-Led Local Development
COP	Convention of the Parties. The 'Parties' are the governments which have signed the UN Framework Convention of Climate Change (UNFCCC)
COVID	Coronavirus 19
DG Agri	Directorate General Agriculture and Rural Development
EAFRD	European Agricultural Fund for Rural Development
EC	European Commission
EEA	European Environment Agency
EEEA	European Commission Regulation on European Environmental Economic Accounts
EIB	European Investment Bank
EJP-SOIL	European Joint Programme Cofund on Agricultural Soil Management
ESF+	European Social Fund Plus
ESR	Effort Sharing Regulation
EU	European Union
GHG	Greenhouse Gas
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem wServices
IPCC	Intergovernmental Panel on Climate Change
IPR	Intellectual Property Rights
IUCN	International Union for Conservation of Nature
JTF	Just Transition Fund
LAG	Local Action Group

LEADER	Liaison Entre Actions de Développement de l'Économie Rurale
LULUCF	Land Use Land Use Change and Forestry
LTVRA	Long Term Vision for Rural Areas
MAP	Multi-Actor Platform
NDC	Nationally Determined Contributions
NECP	National Energy Carbon Plan
NGO	Non-governmental Organisation
NOAA	National Oceanic and Atmospheric Administration
PV	Photovoltaic
RPC	Representative Concentration Pathway
SEEA	United Nations Systems of Environmental Economic Accounting
SHERPA	Sustainable Hub to Engage into Rural Policies with Actors
SME	Small and Medium-sizes Enterprises
UK	United Kingdom
UN	United Nations
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change

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1. Headline Messages

Tackling climate change and striving for environmental sustainability cross almost all aspects of the lives of citizens, and over multiple generations as individuals take on different responsibilities through their life course. The transitions required to achieve net zero Greenhouse Gas (GHG) emissions by 2050 requires all citizens to be agents of change.

Understanding 'how' to get to net zero GHG emissions is a key requirement in planning the just transition to climate neutrality. Reducing GHG emissions will require further incentives and measures to maximize carbon sequestration through investment in natural capital, and transitions to the production and use of energy from renewable sources. The significant interventions being planned or implemented such as woodland expansion, peatland restoration, transitions to agro-ecological farming systems, and transitions to renewable energy, all of which place rural areas at the forefront of achieving aims of carbon neutrality.

Interventions require to coherent across geographic levels and through time, and designed and implemented in partnerships between sectors, and across policy, society, business and research. This will require motivating and facilitating active participation of stakeholders to develop shared visions for planning approaches to tackle climate change. These approaches need to consider the roles of stakeholders in different land systems, with sensitivity shown to positions of different sectors relative to each other.

The long term timescales to realising the outcomes of interventions but shorter and immediate timescales of activity on the ground necessitate a diversity of actions across sectors and communities, within a coherent set of policies (e.g. planning, land use), and a systems perspective to understand the impacts and dependencies of actions in one dimension on another. However, the natural and human resources differ across Europe's rural areas and therefore there are different starting points for transitions, prospective trajectories of change, and likely endpoints on GHG emissions by 2050. Those differences should be accounted for in the types and levels of support, incentives and rewards for mitigating and adapting to climate change, and the pathways and timescales of transitions to climate neutrality.

Activities around COP26 showed how effectively young people provide visions for the future. In line with the EU Youth Strategy, a shared aim should be the creation of an international community of climate conscious citizens. To achieve this aim will require multiple, complimentary, approaches that educate, teach and demonstrate why, what and how climate change can be tackled. However, the design of measures that incentivise action or change, and overcome barriers to such action requires knowing and understanding public attitudes towards climate change and environmental sustainability.

A comprehensive strategy is required for developing human capital with training for teachers at primary, secondary and higher education levels, and Continuing Professional Development and life-long learning linked to the use of Open Science and Open Data. Such a strategy should complement: i) ongoing improvements in providing data on changes in climate relevant to decision making; ii) authoritative assessments of the impacts of climate changes, accessible by relevant groups; iii) development of tailor-made regional mitigation and adaptation measures; iv) assessment of relative costs and benefits of measures and solutions; and, v) communications which motivate actions and develop a sense of shared effort and benefits.

Mitigating the causes and impacts of climate change, and adapting to new climatic regimes requires a reconsideration of existing arrangements of governance, responsibilities and decision-making. This may necessitate change at institutional and personal levels, and changes in regulatory positions.

Achieving the aim of climate neutrality will require strong leadership, as stressed by the South Aegean Greece MAP (Kriezi et al., 2022): "strong political will and commitment is of utmost importance to change the conditions (and habits) that contribute to climate change".

Strong leadership is also required in science, business and society in their respective areas of competence and influence.

2. Introduction

"Little time is available for corrective action". was a message of the World Commission on Environment and Development: Our Common Future (1988), referred to as the 'Brundtland Report'. It continues, "while scientists continue to research and debate causes and effects, in many cases we already know enough to warrant action. This is true locally and regionally in the cases of such threats as desertification, deforestation, toxic wastes, and acidification; it is true globally for such threats as climate change, ozone depletion, and species loss."

The temperature of the Earth has increased by 0.08° C per decade since 1880, and 0.18° C per decade since 1981 (NOAA, 2022). For Europe, between 1910 and 2021, the increase has been 0.15oC per decade, with the surface temperature anomaly above the 1910 to 2000 average in 31 of the last 33 years since the Brundtland Report was published (Figure 1).

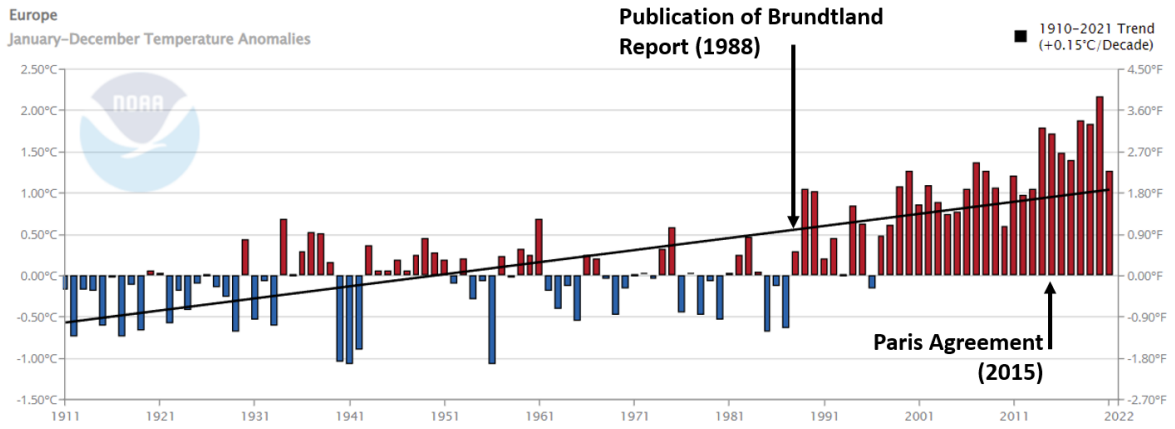

Figure 1. Annual surface temperature anomalies for Europe (annual temperatures are in comparison with the average annual temperatures for the period 1910 to 2000; Source, NOAA, https://www.ncei.noaa.gov/cag/global/time-series/europe/land/ann/3/1880-2022?trend=true&trend_base=10&begtrendyear=1880&endtrendyear=2022)

Following the Brundtland Report came the Rio Sustainability Summit in 1992 and setting up of the UN Framework Convention on Climate Change with a shared obligation that ...

"Parties should protect the climate system for the benefit of present and future generations of humankind, on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities."

Restricting global warming by 2100 to 1.5°C above pre-industrial levels between is recognised as critical for avoiding many natural systems reaching critical turning points (IPCC, 2022; European Environment Agency, 2021). To restrict warming to 1.5°C, global net anthropogenic CO_2 is required to decline by approximately 45% from 2010 levels by 2030, reaching net zero by 2050 (IPCC, 2022), and continue to reduce through the remainder of the century (IPCC, 2018). The closest available data for the period since the Rio Summit (1990 to 2020) shows that greenhouse gas emissions (GHGs) in the EU have decreased by 31%, from approximately 4,700 Mt CO_2e to 3,200 Mt CO_2e in 2020 (European Environment Agency, 2021). In 2019, the LULUCF sector at EU level represented a net carbon sink of approximately 249 Mt CO_2e, corresponding to absorption of 7% of total GHG emissions (European Environment Agency, 2021).

Projections of pathways of GHG emissions required to restrict warming to 1.5°C requires is for them to peak between 2020 and at the latest by 2025 (IPCC, 2022). That aim is now unlikely to be met and the IPCC expresses doubt that the current development pathways and acceleration of climate mitigation are adequate to achieve the Paris mitigation objectives. The modelling reported by the IPCC are of temperatures that exceed the aimed for maximum of 1.5°C of the Paris Agreement, which then reduce later in the 21st century due to the effects of negative GHG emissions (Wolf, 2021).

The IPCC (2022) concludes that ...

"Projected global GHG emissions from NDCs announced prior to COP26 would make it likely that warming will exceed 1.5°C and make it harder after 2030 to limit warming to below 2°C".

Through Multi-Actor Platforms (MAPs) in Czechia, Greece, Italy, the Netherlands, Portugal and the United Kingdom, and its EU level MAP, the SHERPA process has gathered evidence from across Europe, at multiple levels, of the types of transformational changes which are necessary to transition in an effective and just manner to climate neutrality by 2050.

The MAPs were invited to identify and reflect on local threats and challenges to living and working in ways that will enable transitions towards climate neutrality, and opportunities which could or are being created and pursued. Their reflections and debates covered:

1) The transitions required to achieve climate neutrality in the context of the MAP;

2) How policy interventions can enable or facilitate these transitions, considering the solutions needed at local and national levels, and related implications for the wider policy framework (EU and global);

3) The research needs and gaps.

The outputs of the deliberations of the MAPs are the identification of themes are pathways to just transitions involving reducing the emissions of greenhouse gasses, and adapting to climate change.

3. Policy Commitments to Limiting Global Warming

The United Nations Paris Agreement (United Nations, 2015) sets out the global aim to limit global warming to 1.5°C. Individual agreements struck at COP26 (Glasgow, UK, November 2021) claim to 'keep alive the Paris Agreement target of limiting global warming to 1.5°C.' Notable amongst these agreements are: i) the Declaration on Forests and Land Use, which refers to "promoting an inclusive rural transformation", and building resilience, enhancing rural livelihoods and recognising the multiple values of forests; ii) the Global Methane Pledge to reduce global anthropogenic methane emissions across all sectors by at least 30 percent below 2020 levels by 2030 including the "abatement of agricultural emissions through technology innovation as well as incentives and partnerships with farmers".

The implications of the agreements and commitments made at COP26 are pathways to between 1.8°C and 2.4°C of warming, above the Paris Agreement target of 1.5°C. Elements of those pathways rely on or have implications for rural areas of Europe including policy aims (e.g. Climate action in peatland through carbon farming, Rural Action Plan; European Union, 2021a) and support for measures (e.g. local strategies with Common Agricultural Policy (CAP) funding, in Enhanced networking for LEADER/CLLD and Smart Villages).

Recognising the imperative of tackling climate change, and commitment to the United Nations Paris Agreement (United Nations, 2015), the European Union has set the ambition for Europe to be

the world's first climate neutral continent by 2050, meaning "net zero greenhouse gas emissions for EU countries as a whole" (European Union, 2021b). This is enshrined in the European Union Climate Law (European Union, 2021b), as an irreversible transition, to be achieved in a socially fair (i.e. a just) and cost-efficient manner, further details are described in the SHERPA Discussion Paper on Climate Change and Environmental Sustainability (Miller et al., 2021).

Designing the pathways to climate neutrality by 2050 requires actions at all levels, international, European, national and regional. To achieve this aim, the EU has had to increase its targets of reducing greenhouse gas emissions to at least 55% below 1990 levels by 2030, as set out in the European Union 2030 Climate Target Plan (European Union, 2021b). This Plan includes commitments to coherent, sector-specific roadmaps, including enhancing the carbon sink in the EU through a more ambitious LULUCF regulation, whilst protecting the natural environment.

EU Member States set out approaches to tackling climate change through 2021 to 2030 in National Energy Carbon Plans (NECPs). These are "a policy tool and an investment agenda that provide business and investors a forward looking framework" (European Commission, 2020a). At a national level several European countries (Germany, Netherlands, Spain, Switzerland, United Kingdom) committed to the Policy Action Agenda for the Transition to Sustainable Agriculture. This sets them on pathways for repurposing public policies and supporting food and agriculture, enabling just transitions, and respecting and upholding rights of all actors in the farming systems and value chains in changing to new farm practices and structure of farming systems.

International, European and national approaches to limiting global warming recognise the symbiosis of the climate crisis with the biodiversity crisis, and the close links between climate justice and social justice. Consistent with this, the European Commission has committed to measures that are designed to realise the social potential and economic dimensions of a green transition in setting out how to make a Just Transition a reality in the EU. The EU Just Transition Mechanism "provides targeted support to help mobilise around €55 billion over the period 2021-2027 in the most affected regions, to alleviate the socio-economic impact of the transition." It comprises three pillars of the Just Transition Fund (JTF), the EUInvest Scheme, and loans facilitated by the European Investment Bank (EIB).

The Just Transition Fund will provide €17.5 billion of investment in the period from 2021 to 2027. Eligibility for those investments will be informed by Territorial Just Transition Plans, and the 2020 European Semester Country Reports. Many areas identified are in rural Europe, the sites of which reflect the locations of the natural or economic resource (e.g. peatland, for its restoration). The geographic extent of eligible areas may reflect that of the citizens employed in industries being phased out or their supply chains. Examples are coal, peat and oilshale extraction industries, which are estimated to employ 237,000, 10,000 and 6,000 people respectively. Investment from the JTF has to be consistent with "environmental sustainability requirements, in line with the biodiversity objectives of the European Green Deal" (European Commission, 2021a).

Countries and regions have different starting points in their transitions towards climate neutrality, and have different human and financial capacities to take action (European Commission, 2021a), or timescales over which actions are feasible. Approaches need to motivate or trigger actions or provide means by which they can take place. In its approach to achieving net zero, the United Kingdom Government (UK Government, 2021) sets out four principles of: i) working with the grain of consumer choice (e.g. no requirement to immediately replace a car or boiler); ii) ensure biggest polluters pay the most for the transition through fair carbon pricing; iii) ensure the most vulnerable people are protected through energy bill discounts, energy efficiency upgrades; iv) working with businesses to deliver deep cost reductions in low carbon technologies.

The set of SHERPA Multi-Actor Platforms which deliberated on the pathways towards a just transition to climate neutrality of Europe by 2050 identified opportunities to contribute to that objective, challenges that could be encountered, and priorities for policy, practice and research. Those deliberations are provided in the Position Papers of the MAPs of the River Dee Catchment (UK), Rural Scotland (UK), Emilia Romagna (Italy), South Aegean (Greece), Greenport Gelderland (Netherlands), Alqueva (Portugal) and Climatically Friendly Villages (Czechia), and the perspective of the EU level MAP. A synthesis follows of the issues identified and the positions

adopted.

4. Climate Change Threats and Greenhouse Gas Emissions

The set of MAPs deliberating on climate change and environmental sustainability represents a subset of the geography of Europe. Therefore, the nature of the threats and experiences of direct impacts of climate change will vary, and not represent the full range currently or likely to affect Europe (e.g. as summarised in the SHERPA Discussion Paper, Miller et al., 2021).

Hagyo et al. (2020) in Maes et al. (2020) report on high-level trends in climate change across Europe determined as significant in their bioclimatic indicators for assessing ecosystem condition. Those include a measured increase in annual mean temperature of 0.325°C per decade (1960 to 2018), and a reduction of 12 mm per decade in effective rainfall (1960 to 2016). Data on a country-by-country basis is accessible in the report by the Joint Research Centre of Maes et al. (2020).

Changes in climate are projected to continue, one scenario of which in south-east Europe is of 1.0oC to 1.2oC in the period 2021 to 2050, compared to 1961 to 1999, and by 1.9oC to 2.2oC in the period 2071 to 2100 (South Aegean Greece MAP). In south-west Europe, the most severe climate scenario for Portugal (IPCC RCP 8.5), are of an increase in temperature of 5°C by 2100, particularly during the summer and interior Portugal, and an increase in the number of tropical nights and longer and more frequent heat waves. Precipitation is expected to be down by between -10% and -50% by 2100. In north-west Europe, in central Scotland as an example, the projections are of summers to become warmer and drier (2oC by mid-Century), and winters to become warmer but considerably wetter (4°C by mid-Century) (UK MAPs, Miller et al., 2022a).

The direct impacts, or perceptions of threats, of climate change have consequences for livestock, especially during the summer. Examples of the impacts that are arising or expected in the environments represented in the 6 MAPs are: i) increased needs for water and reduced resilience and production of farmed animals (South Aegean Greece MAP); ii) infrastructure (e.g. transport networks, UK MAPs; reduction of drinking water reserves, South Aegean Greece MAP); iii) economic activities (e.g. drought on agriculture, Emilia Romagna Italy MAP, Pellegrini et al., 2021; damage to horticulture, Greenport Gelderland (Netherlands), Groot and Seerp, 2021; soil and organic matter, Alqueva Portugal MAP, Santos and Pais Dias, 2021); iv) pollinators and biodiversity (Emilia Romagna Italy MAP); v) human physical and mental health and wellbeing (UK MAPs). An increase in frequency of extreme events of storms and floods (e.g. UK) and wildfires (e.g. Portugal) are of particular significance to these rural areas, triggering requirements for Damage Risk Reduction (Montara et al., 2014).

Understanding of the types, frequency and magnitude of threats of climate change continues to develop through expanded capabilities for observation and measurement (e.g. Copernicus

Climate Service), and modelling and expert analysis (e.g. Independent Assessment of UK Climate Risk, CCRA3, Climate Change Committee, 2021; Mapping and Assessment of Ecosystems and their Services: An EU ecosystem assessment, Maes et al., 2020), and reporting (e.g. European Environment Agency, dashboards and interactive maps).

Such resources enable the provision of headline messages relevant to short-term events and weather patterns, and longer term climate change. Example observations from the Copernicus Climate Change Service, Climate Bulletin, February 2022 are:

> "Europe, saw pronounced dry conditions in the southwest, especially on the Iberian Peninsula. Wetter-than-average conditions dominated in much of the north";
>
> "During winter, maximum and minimum temperatures over north-eastern Europe were up to 6°C and 9°C warmer, respectively, than the 1981–2010 average".

Similarly, the measurement and modelling of greenhouse gas emissions is providing guides as to progress towards policy targets. For the European Union, the net zero greenhouse gas emissions have reduced by 31% between 1990 and 2020, exceeding its target by 11% points. This reduction includes the effects of fossil fuel prices and policy measures, and the Covid-19 pandemic. The European Environment Agency (2021) notes that Member States have not yet realigned their ambitions to align with achieving the new target of the EU of a net 55% reduction by 2030. The profile of GHG emissions required to reach that target, and net zero by 2050, is shown in Figure 2, with projections for both existing measures and additional measures, including the contributions of sequestration by Land Use Land Use Change and Forestry (LULUCF), indicating that it will be challenging for the target for 2030 to be met.

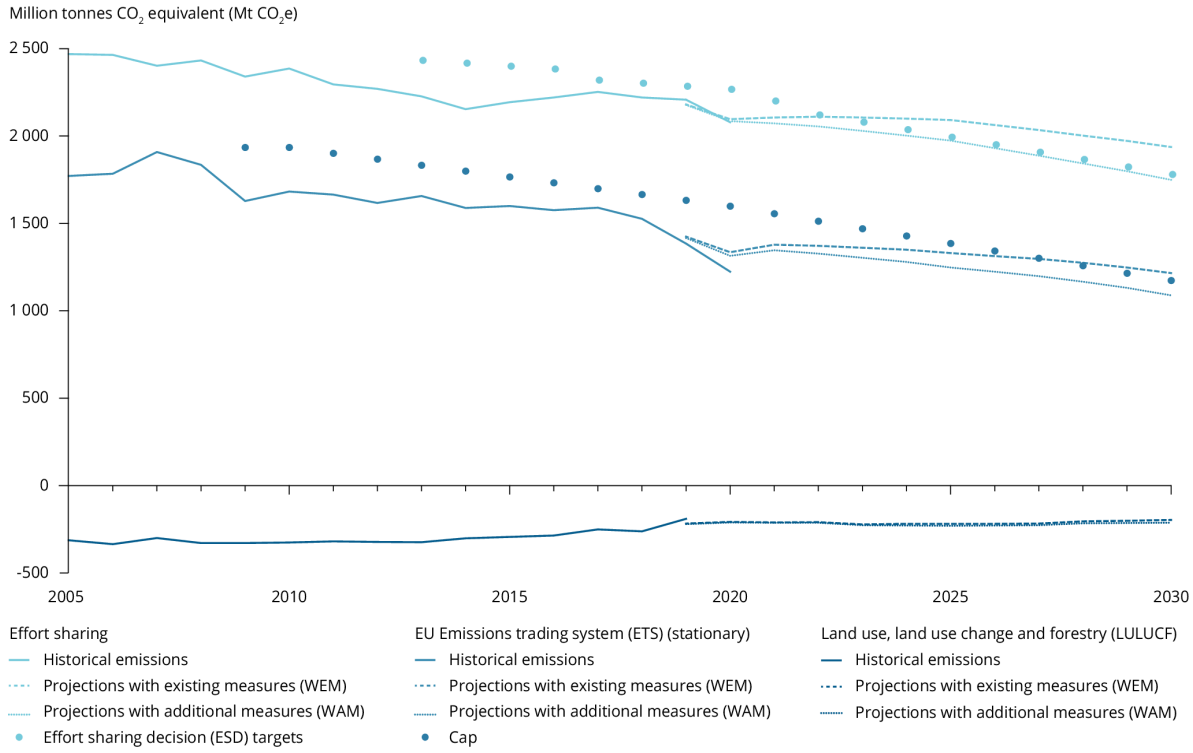

Figure 2. Historical trends and future projections of greenhouse gas emissions (Source: European Environment Agency, 2021).

The trend is of reductions in GHG emissions, with significant contributions being made from rural areas through the LULUCF sector, which includes Forest land, Cropland, Grassland, and Wetlands (including peatlands). Where data is available, reporting at national and regional levels shows reductions of equivalent magnitudes (e.g. between 2005 and 2019, GHG emissions from Scotland, UK, reduced by 34.7%, from 47,532.3 kt CO_2 to 31,045.2 kt CO_2, UK MAPs), reflecting

policy measures such as woodland expansion and the restoration of peatlands (UK MAPs).

In its assessment of the NECPs of the Member States, the European Union noted that Luxembourg, Slovakia, Slovenia and Sweden have set more ambitious targets than those in the Effort Sharing Regulation (ESR). Several other Member States have projections showing that their plans will lead to a greater reduction in GHG emissions than their ESR targets (European Commission, 2020a). National targets for reducing GHG emissions are enshrined in law in Denmark, the Netherlands and the United Kingdom, including means of independent monitoring and reporting (e.g. UK Climate Change Committee).

Planning pathways to net zero GHG emissions relies heavily on the scientific evidence and knowledge of the links between them, observed and projected climate change, and the physical, economic and social impacts of such change. Scientific knowledge is significantly enhanced by practice knowledge of business and society, often gathered and shared informally. Policy teams also contribute to the pool of knowledge required to tackle climate change, learning from the evaluation of processes of the development and of the effectiveness of policy measures.

Strategies for motivating changes in behaviours by citizens and business require to be underpinned by robust scientific evidence, on which targets and plans can be set for achieving climate neutrality. However, no surveys of public attitudes directly refer to emission or sequestration of greenhouse gases by sector. No research findings have been identified that links public attitudes towards changes in behaviour or public policy to return on reducing GHG emissions. Thus, there appears to be a gap in understanding of stakeholders and public audiences of the trade-offs people may be required to make under different strategies for reducing emissions of GHGs.

Further requirements for policy and research

Policy -

- Support for enhancing relevant academic and practice knowledge bases through ongoing financial and technical support for the measurement and interpretation of GHG emissions with respect to impacts on climate change, and their communication.
- Support for the maintenance of ongoing calculation of projections of climate change, but with improvements in the quality and spatial and temporal resolution.
- Tailoring messages of how climate change may impact upon people in areas in which they live, work and recreate is a core part of a strategy for raising public understanding of the magnitude and potential impacts of climate change.

Research -

- Increase in the types of sites at which GHG emissions are monitored and reported, distributed across different types of land uses, soils and land management practices, through deployment of sensors and Internet of Things (see also Section 5.1, Land Management and Systems).
- Increased availability of easily accessed and understood data and information, forming part of a strategy for communication and societal engagement of changes in climate, and tangible links to actions of business and citizens.
- Development of effective means of communication of changes in GHG emissions, learning lessons from recent experiences of provision of information relating to COVID-19, and the emergence of online dashboards, storymaps and infographics as outputs from Open Data and Open Science.

5. Contributions of Rural Areas to Pathways to Climate Neutrality

5.1 Opportunities in Rural Areas

Pathways to a just transition to climate neutrality by 2050 require both mitigation of GHG emissions, and adaption to climate change. Rural areas are the location of many of the natural resources for mitigating climate change and offering opportunities for adapted land systems under climate change.

To achieve the interdependent aims of net zero GHG emissions by 2050 and reversing loss of biodiversity, requires a coherent set of public policies, across levels (e.g. EU, national and regional) and sectors (e.g. planning, land use). A systems perspective is required to understand the impacts and dependencies of actions on one dimension on another. Where appropriate, a spatial perspective should be taken to inform geographic and place-based considerations of territories (e.g. protection of areas of natural and cultural heritage significance), their dynamics (e.g. Alqueva Portugal MAP), and linking spatial plans with development strategies design to lead to sustainable landscapes (Climatically Friendly Villages Czechia MAP; Trantinová et al., 2021). However, note should be taken of the differences in opinion amongst public audiences on measures of mitigation (e.g. woodland expansion, UK MAPs; adverse impacts of wind turbine development on protected areas, animals and tourism, South Aegean Greece MAP).

Further requirements for policy, practice and research

Policy -

- Spatial plans for land uses should be reviewed in a structured way that enables them to be informed by relevant new evidence (e.g. GHG emissions estimated from updated data on land use and land management practices), and be responsive to the changing circumstances of territories (Alqueva Portugal MAP).

- Actions to mitigate GHG emissions require approaches to financial support which are coordinated across types and levels of governance and responsibilities (e.g. EU, national and regional public authorities; investment and business).

Discussion follows of particular opportunities which focus on rural areas.

1. Renewable energy generation

It will not be possible to achieve carbon neutrality without an energy transition of activities that consume fossil fuels (e.g. transport, heating, production of nitrogen fertilizer). An essential element of that transition is the production of renewable energy for which rural areas are the most significant onshore sites in Europe (hydro, wind, biomass, biofuel, solar PV). Investing in and supporting the development of renewable energy is necessary for both mitigating GHG emissions and adapting land systems for business, farmer and community benefits (South Aegean Greece MAP; Climatically Friendly Villages Czechia MAP; Alqueva Portugal MAP; UK MAPs), including developing distribution networks for clean energy (Alqueva Portugal MAP).

Despite the acceleration of installed capacity of renewable energy in Europe, its roll-out continues to face a range of barriers. Examples of such barriers from different contexts in Europe are a lack of information on requirements for the planning, installation and maintenance of renewable energy systems (e.g. solar), resilient links to the electricity network and maintenance in times of natural hazards (e.g. wildfire, storms, flooding), and sources of funding (e.g. crowdfunding) (South Aegean Greece MAP).

Key developers of renewable energy systems in rural areas are the owners and managers of land where the wind resource is suitable, and outwith constraints of natural and cultural heritage. Elements of the energy transition includes making more efficient use of energy, and encouraging early adoption of new technologies of which hydrogen is identified as offering particular opportunities (Alqueva Portugal MAP; UK MAPs).

Following the successful uptake of changes in practices and the maturing of new industries, the emphasis of public policy should change towards supporting other sectors or components in the supply or value chains. For example, in some areas of Europe, renewable energy production has become a mature part of rural businesses or farming systems. In those areas, the focus of support should evolve from one of encouraging uptake towards its use in transforming other elements of rural business. Examples are investing in infrastructure to ensure security of electricity supply commensurate with the transitions from petrol and diesel to electric vehicles, and infrastructure to support the generation of hydrogen from renewable sources to fuel farm and industrial vehicles (Alqueva Portugal MAP; UK MAPs).

Recommendations for policy

Policy -

- Resilience and fairness need to be built into the provision of renewable energy through public strategies that support investment across a diverse range of sources and increasing the benefits to rural areas of components of their value chains (e.g. micro- and small business, landowners and managers, residents).

- Measures should be designed and implemented to support reductions in energy consumption and increase energy efficiency throughout supply chains (e.g. upgrading infrastructure and production units of livestock informed by criteria of energy use), thus contributing to the broader aims of the EU Green Deal of a 'modern, resource-efficient and competitive economy'.

- Strategic planning should be encouraged to take account of future phases of renewable energy generation, such as returbining of existing onshore windfarms, in the context of wider strategies on land use with remits to contribute to pathways to net zero GHG emissions by 2050.

- Investment in increasing relevant human and social capital associated with the development of local energy systems, amongst all relevant actors and stakeholders, and at all relevant levels of governance.

2. Land management and systems

Climate change has been impacting choices of land management practice in crop systems, which reflects changes in crop suitability and productivity, soil characteristics (e.g. moisture), time to access land, and the impacts of intense rainfall. Similarly in mixed livestock systems changes have been triggered by reductions in water availability, increases in feed costs, changes in animal appetite and health, and increased risks of disease in livestock (e.g. liver fluke, Fasciola hepatica). Likely outcomes of these changes are reductions in the availability of some products (e.g. not possible to grow some products or raise livestock under changes in climate), the emergence of new products, or existing products that are new to an area (e.g. viticulture), changing mechanisms of operation (e.g. transition to all-electric or hydrogen vehicles), new regulations, and modifications to requirements on suppliers or supply chains (Alqueva Portugal MAP; UK MAPs).

Systems and practices of managing land and associated measures are recognised as crucial for mitigating and adapting to climate change. In many areas land used for agriculture has to be managed to ensure the organic carbon remains stored in the soil (Alqueva Portugal MAP; UK MAPs). Well designed and implemented land management practices can deliver multiple benefits of mitigating climate change, enhancing biodiversity (above and below ground), increasing water retention capacity (Greenport Gelderland Netherlands MAP), and contributing to cultural services such as landscapes (Climatically Friendly Villages Czechia MAP; UK MAPs). However, there is a need for better understanding of: i) GHG emissions of different farming systems designed around sustainable intensification and agroecology, under different biophysical and social contexts; ii) pathways for how such systems could change through time; and, iii) trade-off decisions that should be expected between environmental, economic and social factors.

Investing in natural capital and environmental restoration can deliver benefits of mitigating GHG emissions, new means of economic development, and enhancing social capital in rural areas (UK MAPs, Emilia Romagna Italy MAP). Such investments can create new foci for environmental and agri-tourism, often linked to enhancing cultural services, and exploiting the potential for uses of digital technologies for explaining features, and promoting places and their histories (e.g. peatlands, UK MAPs; South Aegean Greece MAP).

The types of natural capital in which investments can be made will differ across Europe, such as carbon rich soils (UK MAPs, Alqueva Portugal MAP), woodlands and agroforestry (Climatically Friendly Villages Czechia MAP), and water management (South Aegean Greece MAP). Examples are emerging of how to stimulate natural capital investment markets, and how businesses and communities could benefit, such as through models of social innovation (UK MAPs). Such investments should reflect a wider valuation of ecosystem services produced by land managers (e.g. farmers, foresters). To be effective, they also require the alignment of related policies and measures (e.g. planning, infrastructure) to provide the catering, accommodation, energy, water and transport links to enable an attractive proposition to prospective visitors.

Increasing the uptake of land management practices which contribute to reducing GHG emissions also requires investment in infrastructure (e.g. changes in farming systems to on-farm manure production; conversion to hydrogen fuelled tractors; internet of things across farms and supply chains), and human capital (e.g. new skills). This is in line with the policy aim of transitions to agro-ecological farming systems and practices (EU Farm to Fork Strategy), and reflected in the proposed EU Partnership on Accelerating farming systems transition: agroecology living labs and research infrastructures, and the EU Soil Strategy which notes promotion of "the development and use of digital and remote sensors, apps and handheld samplers to assess soil quality" (European Commission, 2021b).

A lack of suitably designed measures will inhibit farmers and land managers transitioning to new farming systems and practices, with some locked into existing practices (e.g. due to contractual obligations, traditions or lack of human capital in the land management system) (Climatically Friendly Villages Czechia MAP). Some measures require commitment to long term change (e.g.

locking in to 30 year agreements), such as agriculture to forestry, peatland restoration, about which land managers or owners may be cautious. In line with Sections 5.2 and 5.4, a strategy for transitions to climate neutrality and environmental sustainability should link training, education and communications with the types of changes required in land management (e.g. land manager career changes, implications for families and stakeholders in supply chains) (UK MAPs).

The benefits of practices that protect and enhance natural resources and ecosystem services require to be explained effectively and demonstrated in biophysical and socio-economic contexts which producers recognise as relevant to them (e.g. Alqueva Portugal MAP; Climatically Friendly Villages Czechia MAP). Awareness is needed throughout the supply chain of how farming systems can contribute to reducing GHG emissions, reversing the loss of biodiversity, and rebalance social inequalities (UK MAPs).

Achieving transformational change will require multiple, interlinked strategic pathways addressing the whole food system and its components (SHERPA Conference). As per the EU Farm to Fork Strategy, there is a significant role for agro-ecological farming systems in achieving these aims. Transitioning to such farming systems will require greater cooperation within short supply chains, investment in local processing, strengthening links between consumers and producers, and policies for stimulating demand for its products (e.g. proposed EU Partnership on Agroecology) (see also SHERPA Discussion Paper Towards sustainable & resilient value chains, Bognar and Schwarz, 2022). It also requires innovation in products and processes.

New entrants to food systems are one important source of innovation which can also improve the sustainability of land management systems and contribute to rural development. However, opportunities for new entrants to try a career in farming are constrained by limited access to land due to, for example, land price, forms of tenure, and traditions and public policies towards land ownership. The most appropriate means of overcoming these barriers will differ by jurisdiction but include Share Farming, Contract Farming, Tenancies, Partnerships, Short term leasing or licencing, and buy-outs by individuals or communities. Facilitation of means of overcoming such a barrier requires finance (e.g. public funds to support community buy-outs), the provision and access to information about approaches for new entrants to farming (e.g. technical and legal advice), and the sharing of experiences of those who are recent entrants to farming and land management (e.g. Emilia Romagna Italy MAP, UK MAPs).

Monitoring and reporting characteristics of the environment are key requirements for informing pathways to climate neutrality and environmental sustainability (e.g. watertable levels at peatland restoration sites, UK MAPs), and as explained in the European Joint Programme Cofund on Agricultural Soil Management (EJP-SOIL). Wider adoption of technologies that support digitally enabled data measurement (e.g. using LoRaWAN) should be encouraged and facilitated, and consideration given to the governance and access to the data generated, with principles established for identifying what data are public or private goods, and reporting at multiple levels (local, regional, national) (UK MAPs). The feasibility of digital solutions is aided by their low cost, flexibility and ease of deployment. However, further development is likely to be required to ensure they are durable under the practicalities of field conditions in different biophysical environments, and able to operate under extreme climatic occurrences (e.g. heat, cold, precipitation).

Recommendations for policy and research

Policy -

- Regulatory positions need to remain contemporary to reflect new and emerging technologies (e.g. gene editing and CRISPR [clustered regularly interspaced short palindromic repeats], vertical farming, artificial intelligence). This can be aided by improving the chain of transfers of knowledge of potential technical and social impacts of new knowledge and tools, and what technologies could be disruptive. (UK MAPs).

- National CAP Strategies should include incentives and measures to incentivize and reward

practices that reduce GHG emissions or increase the role of carbon sinks on farms (e.g. Emilia Romagna Italy MAP), water retention on farms, and enhance biodiversity, ensuring that the value created is internalized on the farm (e.g. Alqueva Portugal MAP).

- Measures should be designed that support management plans which will realise multiple functions of land at levels consistent with characteristics of local landscapes and inspiring or maintaining community support. Such measures could include the concept of soil health certificates envisaged in the EU Soil Strategy (European Commission, 2021b).

- Guidance is needed for land manages on phasing implementation of transitions to climate neutrality. Evidence suggests there is less advice available to land managers once they start implementing innovations and embedding them in businesses. Yet, this is the stage when modifications are needed to suit businesses and farmers are at risk of 'dropping' the innovation if it appears too complicated.

- There is a need to understand lock-ins experienced by land managers and communities which may prevent or inhibit realisation of new opportunities (e.g. regulatory restrictions on land use change towards new forms of food production; land management contracts that do not draw on latest knowledge; commitments to customers which restrict uptake of agro-ecological farming systems).

Research -

- Methods for measuring and reporting of characteristics of land under practices that deliver sustainable management (e.g. GHG emissions in real time; carbon stocks in soils) should be prototyped and mainstreamed, and assessments made of the effectiveness of practices on reducing adverse impacts (e.g. wildfire fuel sources). Data from such observation mechanisms should be open and accessible by all audiences in line with principles of Open Data and Science (see Section 6.4).

- The potential for rewards for carbon-neutral or positive farming practices through payments in carbon credits which are exchangeable between entities in different territories.

- The potential roles of a certification of soil health as a characteristic of a land holding in its valuation, and on site and wider strategic land use planning.

- Further advances in developing the circular economy in agriculture. Progress has been made in the development and use of new technologies (e.g. drones, precision agriculture, reprocessing systems, green chemistries and crop wastes), alongside changes in attitudes of land managers towards the re-use of products. However, more work is required on valorising agri-food waste, closing nutrient loops, and the use of big data analysis in agricultural production.

3. Natural capital

The concept of natural capital provides considerable opportunities for making progress towards net zero targets. Natural

capital can be described and explained at different levels whether functional or geographic, but there is a need to understand how to assess natural capital at multiple levels such as individual land-based business, clusters of collaborating businesses, catchment, landscape, regionally and nationally.

A useful step in the process is the plans of the EC to revise the Regulation on European Environmental Economic Accounts (EEEA) (European Commission, 2011) and expand their coverage to include a natural capital accounting to be consistent with the United Nations Systems of Environmental Economic Accounting (SEEA). This will contribute to evolving approaches to quantifying and valuing natural capital, about which there is considerable debate, and which are inhibited by weak understanding of the beneficiaries and what it offers stakeholders (e.g. land managers, citizens). Addressing these questions is of particular significance to the application of natural capital approaches in the aims and prospective funding associated with emerging initiatives in governance (e.g. Regional Land Use Partnerships in Scotland, UK, and development of Regional Land Use Frameworks focusing on tackling the climate and biodiversity crises; UK MAPs).

Further support is required for the provision of environmental data (e.g. soils, land cover, water quality) to support the implementation of natural capital approaches, the effectiveness of which are contingent on the availability of data of relevance, and sufficient accuracy. Aspects of natural capital are also noted under the following sub-sections on peatland restoration and woodland expansion.

Further requirements for policy and research

Policy –

- The formulation of incorporating natural capital into processes relating to strategic planning (e.g. of land use), payments under the CAP (e.g. land management measures), and levering resources for communities or businesses (e.g. valuation of carbon). The outcome sought is an increase in the investment in natural capital to reduce GHG emissions and benefits for environmental sustainability.

Research -

- Evidence is required of the magnitude and timescales for managing natural capital to contribute to achieving targets of net zero GHG emissions and wider environmental sustainability to aid meeting expectations of funders and those undertaking management actions.

- There is a need for realistic assessments of the state-of-the-environment and the role of land management in enhancing or degrading Europe's natural assets, for which research is required into the tools suitable for assessment and reporting, and capitalising on existing datasets.

4. Peatland restoration

Globally, peatlands contain approximately 25% of the carbon locked in soils, albeit these figures are subject to considerable variation depending upon the definition of peatland and the approach to its mapping. Beaulne et al. (2021) summarise estimates of carbon stocks in the Boreal Biome (i.e. including most of Scandinavia) as 272±23 Gt carbon in forests (approximately 8% of the world's land surface) and 415±150 Gt in peatlands (approximately 2% of the world's land surface). One of the most highly emitting IPCC peatland categories is 'eroded peat' where vegetation cover has been lost. The condition, or health, of the peatland is dependent upon physical, hydrological, and ecological factors, which influence each other in self-regulating feedback, leading to resilience to variations in climate, over time periods of thousands of years. However, where peatland has been damaged to the extent that the self-regulation no longer functions the losses in capability will be for water storage and filtration, reducing flood risk and pollution, supporting biodiversity, and contributions to cultural services such as historical

archives and sense of place in rural areas (UK MAPs).

The protection or restoration of peatlands and wetlands is identified in the EU Biodiversity Strategy for 2030 (European Commission, 2020b), in NECPs of several countries (e.g. Germany, Ireland, Estonia and Lithuania), and other national and regional strategies (e.g. UK; Scotland). Peatland restoration should be regarded as a process and not as a one-off restoration event', planned to be most effective over the long term. (Defra, 2021; UK MAPs). For every 10 cm the watertable is raised there could be a reduction of 3 tonnes CO_2 $ha^{-1}y^{-1}$ (Evans et al., 2021) (Figure 3), taking potentially 50 years for the restoration of peat drained to 1m depth and putting the site on a road to recovery.

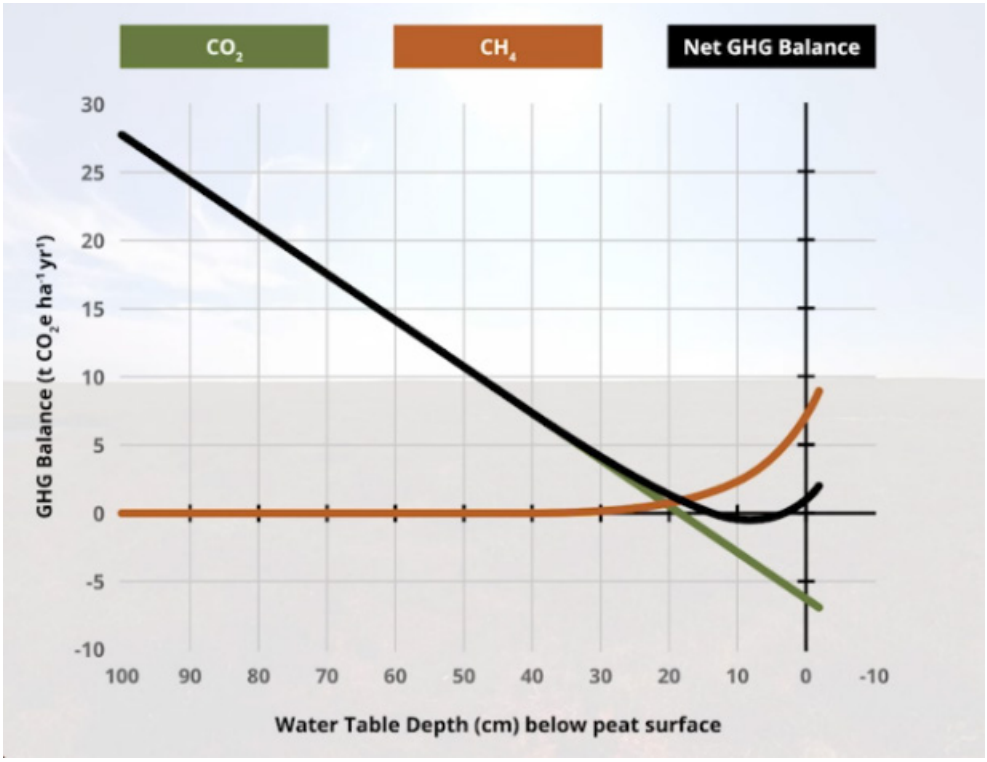

Figure 3. Indicative change in GHG balance by depth of watertable (drained to 1m below surface; Source: Evans et al., 2021).

Strategies for the use of peatlands in tackling climate change should be designed to enable: i) early interventions on less damaged bogs with the aim of preventing a process of degradation and so to a higher emitting state; ii) later interventions on severely damaged sites, recognising they will take longer to progress to a state of good hydrological and ecological function. Scaling up of capabilities between restoration sites (e.g. land managers, communities) will be required to enable sufficient degraded peatlands to be placed onto pathways to recovery. Lessons could be learnt from the approaches of sharing expertise and experiences, and prospective benefits and risks, between communities developing renewable energy, and peer-to-peer learning in agriculture (e.g. supported through Rural Development Programmes), including transnational learning (i.e. across countries and regions). Mechanisms should be established to ensure such sharing of knowledge rather than relying on community-led initiatives.

This could provide sufficient demand for centres of expertise, sharing of knowledge and development of local capabilities. Sources of training could form part of a wider programme of skilling and reskilling, and prospectively new careers and businesses. [Also reflected in recommendations in Sections 5.3].

Its importance is reflected in the LTVRA Action Plan flagship of building up carbon sinks in its *Climate action in peatland through carbon farming* (European Union, 2021a).

Further requirements for policy, practice and research

Policy -

- Strategies for education and training should have appropriate alignment with the provision of new knowledge and skills to enable implementation of peatland restoration (e.g. understanding links between peatlands, their restoration, and sequestering GHGs; monitoring the presence and types of vegetation and watertable levels).

- Strategies for training should support increasing capabilities at local levels, including SMEs and micro-businesses and community initiatives, with a view to peatland restoration actions being hubs for natural capital innovation, investment and economic activity.

Practice -

- An aim of projects and practices should be to create 'peat citizens' similar to the envisaged emergence motivation and empowerment of energy communities and energy citizens.

Research -

- Understanding the extent to which intact peatlands will be able to withstand future climate change, including the consequences of patterns of seasonal changes in temperatures and precipitation, and aggregate changes.

5. Woodland expansion

Woodland protection and expansion are key components of several EU and national strategies in delivering on international commitments, notably the COP26 Declaration on Forests and Land Use, on promoting an inclusive rural transformation, and building resilience, enhancing rural livelihoods and recognising the multiple values of forests, and Forest Biodiversity in the Convention on Biological Diversity. The National Energy and Climate Plans (NECPs), EU Biodiversity 2030, and EU LTVRA Action Plan all recognise the multiple roles of forestry to rural development and other environmental benefits (e.g. protecting soils, reducing flood risk, landscape aesthetics).

Benefits offered by woodlands to mitigate climate change is through sequestering carbon over the long term cycles of forestry, soil carbon accumulation and the substitution benefits accrued from timber products, such as building materials of concrete or brick with timber. However, achieving the aims of net carbon sequestration requires account to be taken of the environment in which the woodlands are planted, the soil type, the choice of forest management, soils and antecedent land cover type. Such factors influence the timescales of carbon uptake, with examples in areas with carbon rich soils of a net loss of carbon over 30 years before sequestration becomes positive (UK MAPs).

The emphasis of each NECP differs, reflecting the levels of current cover, the contributions of woodlands and wood products to the economy, and their cultural functions. Countries with such references in their Plans include Lithuania and Romania (promoting carbon accumulation with extensions of forestry), the Netherlands (expanding the extent of natural areas, restoring landscape structures, limiting deforestation and planting new trees), and Greece (promotion energy crops including woody biomass and coppice plantations). Similarly, the UK, and Scotland, have targets for expanding woodland as elements of strategies that tackle crises of climate change and loss of biodiversity with transformations in uses of land including an increase from 13% woodland in the UK to 18% by 2050 (UK MAPs), of which in Scotland the aim is to plant 18,000 trees each year by 2024.

One approach to expanding woodlands is by introducing or evolving land systems in which they are an integral part, notably agroforestry. In several areas of Europe the biophysical and socio-economic contexts comprise agroforestry as traditional land systems (e.g. Montado, Portugal), introductions of new systems, or as remnants of traditional system (e.g. grazed orchards), which have been preserved in places with conditions unfavourable for intensive agriculture (Climatically Friendly Villages Czechia MAP). However, some such systems are under pressure due to the abandonment of land as a result of reduced agricultural activity. In turn, some species and the habitats upon which they depend only exist because of those agricultural activities. So, there is a need to recognise and the importance of the functions of extensive production systems even if they may not be viable from solely an economic perspective (Alqueva Portugal MAP).

In some geographic areas there is resistance from land managers (currently in farming) to agro-forestry systems, reflecting perceptions of the loss of productive land and changes in timing of capital requirements and income. Education and training on agro-forestry systems is included in some degree programmes and promoted through communities of interest (e.g. Czech Society for Agroforestry; Climatically Friendly Villages Czechia MAP). However, in some regions agroforestry remains a very small component of rural land systems, with restricted financial support mechanisms and access to examples of systems with which to stimulate wider uptake.

Strategies for woodland expansion, and models of spatial options, tend to focus on biophysical and economic factors, with little in terms of social acceptability, land ownership or tenure. There appears to be little account taken of changes in context over time, such as the effects of climate change on crop growth, changes in land ownership or tenure, or any effects of the dynamics within ecosystems such as interactions between plants, animals and water. There are also inconsistencies within countries or regions on approaches to issues such as site planning (e.g. planting plans, approach to eradicating invasive species; Climatically Friendly Villages Czechia MAP).

For woodland expansion to be taken up widely, and over a sufficiently long time, there is a need to ensure public and land manager support, and to recognise factors that can be expected to change which may lead to accelerating or decelerating rates of change, and changes in the trade-offs associated with woodland. Evidence shows opinions in some communities that woodland expansion, sometimes driven by the availability of carbon credits, is at the expense of biodiversity ("local opinions may not consider forestry or woodland expansion to be 'habitat restoration', and instead consider describe it as 'habitat desecration' " (UK MAPs).

Further requirements for policy and research

Policy –

- Coherent spatial planning of woodland expansion that recognises geographic specificities, expressed at different scales, which set out pathways and timelines to achieve targets for reducing GHG emissions and enhancing biodiversity.

Research –

- To inform place-based planning, there is a need to understand the types and magnitude of trade-offs required at relevant geographic levels or units, such as in the vicinity of a village

or town, within a landscape unit (i.e. landscape character area), a water catchment or an ownership unit, and from the perspectives of people at each geographic level (e.g. local, regional, national, international).

- Capturing public opinions on woodland expansion, combining quantitative information gathered through Eurobarometers augmented by evidence from qualitative studies that provide insight to community and stakeholder motivations and attitudes towards woodland expansion [Also reflected in recommendations for Section 5.7].

- Understanding barriers to the realisation of future benefits from assets originally secured through initiatives and policies not directly related to climate change (e.g. land reform).

5.2 Education, Training and Reskilling

Increasing human capital across all sectors of society, policy and science is a key requirement for rural areas to plan and deliver pathways towards climate neutrality. A strategic perspective is needed to ensure: i) the design, planning and implementation of an appropriate pipeline of skills required for rural areas; ii) informed decision-making by land managers and rural businesses; and iii) changes in behaviours by rural citizens.

Such a strategy requires joined up engagement between the teams responsible for developing public policy, businesses and organisations responsible for implementing policy (e.g. NGOs, civil society groups), and providers of training and education (e.g. further education colleges, universities, school curriculum), and continuing professional development and life-long learning (e.g. land managers, officers in public agencies) (South Aegean Greece MAP; UK MAPs).

The opportunity to enhance public understanding should be viewed with a long-term perspective, reflecting the magnitude and complexity of the societal challenge, and the various means by which transformations will be required by all citizens. A core aspect should be the progressive integration of climate related topics in the education curricula of schools in line with their governance in each country and region (e.g. Climatically Friendly Villages Czechia MAP, South Aegean Greece MAP, Alqueva Portugal MAP, UK MAPs). This should build on explaining the processes of climate change, its effects across work, life and leisure, and the reasons and mechanisms for its mitigations and adaption, to include the contributions of local actions to those at regional and global levels.

A coherent approach is required to building human capital with concurrent development of the capabilities of agents of knowledge transfer in education, academia and the private sector (e.g. advisors) (Alqueva Portugal MAP), and that of their students and peers. Teachers and trainers have to be equipped with the relevant knowledge and skills to understand and communicate the aspects of the transitions to climate neutrality of relevance to their remits. Beyond their own professional qualification and training, Continuing Professional Development and life-long learning will be of critical importance for developing capacity of those responsible for teaching and training, and the 'peers' providing 'peer to peer' learning. Such life-long learning has the additional benefit of increasing the pathways that can lead to enhanced citizen capabilities and societal understanding (Alqueva Portugal MAP; South Aegean Greece MAP).

The means of education and learning should enable inputs by young people, reflecting their different cultural and geographic contexts (SHERPA conference). This also forms an important element of enabling the just transition to climate neutrality. The approach for children needs to recognise the differences in starting points and pathways through their formal education, eligibility of access at all ages, and approaches that are inclusive of all abilities. This reflects the interactions between climate change and social justice (UK MAPs). Evidence suggests the impacts can be realised in short timescales, particularly on lifestyles and sharing cultural and social values (e.g. recycling, energy use), representing children's roles within families, and the longer timescales of action through responsibilities (e.g. in business, land uses) (e.g. Climatically Friendly Villages Czechia MAP).

Linked to this is the development of social capital, improving networks between peers at equivalent levels of development and implementation (e.g. practices for managing soil carbon), and between levels to facilitate the flow of knowledge between stakeholders with different capacities. Amongst the key actors in facilitating such flows of information are those in AKIS who have pivotal roles as networking and knowledge champions (SHERPA Conference).

All types of actor benefit from mentoring. Such mentoring should be available for staff involved in planning and handling processes of applications for measures of support (e.g. agricultural, rural development), and the recipients of those measures. Mentoring should be provided on a professional basis, with systems of accreditation available for those providing the mentoring. An aim of such accreditation systems should be to provide recipients of mentoring with confidence in the quality of the support received, and to safeguard those providing support (UK MAPs).

The development of human capital is required for the transitions in agricultural systems to contribute to mitigating climate change by reducing GHGs, increase carbon capture in ecosystems and their complementary roles in reversing the loss of biodiversity. Changes in such systems need to be designed to be relevant to each stage in agroecological transitions (e.g. efficiency increase, energy efficiency, input substitution, system redesign). Improved knowledge can be an enabler of initiating such a transition, informing investment in infrastructure, and the uptake of incentive payments for agri-environment schemes, and encouraging the next steps to be taken, in the right place at the right time.

The design and implementation of the strategy would align with an aim of a LTVRA Action Plan flagship under Increasing environmental, climatic and social resilience.

Recommendation for policy

- Funding mechanisms are required to enable the upskilling of all sectors of the workforce in the types of skills required to enable uptake and utilisation of materials made available through open science. Ensuring such lifelong access to the development of new skills is in line with the commitment to training and lifelong learning in the European Pillar of Human Rights, and regional levels (e.g. UK MAPs).

5.3 Measurement, Monitoring, Open Science and Data

To be effective in guiding or achieving behavioral change, information should be easily accessible and presented in a coherent manner. The provision of contemporary knowledge will benefit from the new data and tools which are becoming more widely available in easily understood forms, in multiple languages, as principles of Open Science and Open Data are implemented, such as the Copernicus Climate Change Service, as highlighted in the SHERPA Discussion Paper on Climate Change and Environmental Sustainability (Miller et al., 2021), and the South Aegean Greece and UK MAPs.

Detecting, measuring and reporting physical impacts of climate change and environmental degradation is becoming more common, with investments in digitalisation providing new mechanisms of reporting near real time information for rural areas (UK MAPs). Use is being made of an increasing range of sensors and their means of deployment (e.g. earth observation on satellite, aircraft, drone; on and underground) and infrastructure for enabling the measurement and communication of environmental characteristics (e.g. GHG emissions, soil temperature and moisture). However, there is a lack of scientifically validated data on the actual impacts of interventions on environmental sustainability (e.g. Alqueva Portugal MAP), and the timescales over which they are being created. Providing stakeholders (policy, practice and public) with access to such data could stimulate, or reassure, investment by public, private and third sectors.

There are also gaps in capturing information on human actions, attitudes and behaviours towards

responding to climate change, with a focus on respondents from rural areas. Opportunities could be designed to use new digital tools for capturing information, such as emotional responses towards issues, evidence of impacts of climate change or loss of biodiversity, and suggestions for actions. Those opportunities could originate from citizen science technical and social mechanisms. This is also reflected in Section 5.7 on Public Attitudes.

In some countries there is also a lack of information on technical standards to which environmental management and interventions should adhere to have the desired outcomes (Alqueva Portugal MAP). Adherence to such standards may be in interventions at different levels (e.g. farm, regional), which may require collaboration between actors (e.g. multiple land owners; Climatically Friendly Villages Czechia MAP).

The provision of guidance on standards (e.g. for data capture), tools (e.g. for reporting), and data management (e.g. repositories, cyber-security) should improve the accessibility of materials, and the resilience of the information gathered (South Aegean Greece MAP; UK MAPs). The introduction of new concepts, technologies, and their interpretation need to be trusted, with authoritative and accurate evidence and information. The emergence of new suppliers may also necessitate that users (land managers, communities, policy teams) have the means of checking advice from suppliers to differentiate between sales and marketing of materials and their viability for innovation (e.g. land management practice; digital dataset; model). Enabling access, validation and quality control align with the expectations of a LTVRA Action Plan flagship Rural Observatory, and by Scottish Government in support of the Regional Land Use Partnerships (UK MAPs).

Recommendations for policy and practice

Policy -

- Investment in the provision of observations and monitoring of rural areas should take more account of social and cultural characteristics. Such data and information should be open and accessible by all audiences, in line with principles of Open Data and Science, whilst complying with ethical and cyber-security regulations and considerations (South Aegean Greece MAP).

Practice -

- Easily understood guidance is required on rights of data providers, IPR and ethical considerations in support of widening the basis of provision of data of rural areas (e.g. citizen science), recognising the need for quality control and ensuring the protection of providers and those who, or whose land, are the subject of those observations.

- Update the European Open Data and Science Policy to improve support for citizen science and business models that promote the monitoring of environmental characteristics using digital tools, but tackle inequalities and exclusion from making such contributions (e.g. due to constraints of finance, attitudes, understanding benefits).

5.4 Communications and Engagement

Actions to change land use to mitigate or adapt to climate change, such as peatland restoration and woodland expansion, are subject to interactions with other uses of the land and its management (e.g. managing wild deer, UK). To understand such potential impacts, and plan and implement approaches to achieve the benefits sought for tackling climate change, and the co-benefits (e.g. reversing loss of biodiversity, job creation) necessitates engagement across stakeholders with responsibilities for policy, business, civil society, communities, and providers of training, education and continuing professional development (UK MAPs).

A strategy for communications is required to raise public understanding of the magnitude and

potential impacts of climate change, and motivating actions that achieve outcomes of climate mitigation or adaptation. It needs to enable the tailoring messages to audiences with levels of understanding that range from experts and those involved in well-established actions, to 'new' audiences with sectors not thus far well engaged in the topic or actions (Alqueva Portugal MAP).

Such a strategy requires investment in developing the human capital required to achieve the target of net zero by 2050, delivered by means tailored to specific audiences (e.g. citizens, civil society, business) through credible and trusted sources. An aim should be to foster a sense of attachment to, and responsibility for, the environment for citizens, and facilitating constructive open discussion between rural actors, politicians and researchers. Those investments need to be inclusive, accessible and relevant across gender, age, ethnicity and geography (UK MAPs).

It should also ensure a shared understanding of who constitute the key actors of regional development, define the competences of those actors, identify how to support their activities, and what methodological support and guidance is needed to embed environmental sustainability in plans for regional development.

Recommendations for policy and practice

Policy -

- EU level initiatives require to be harnessed to create momentum for national and regional level mechanisms for facilitating deliberations between or within rural policy, society and science, such as the National Rural Conference in Czechia (Climatically Friendly Villages Czechia MAP), and the Scottish Climate Assembly in Scotland (UK MAPs).

Practice -

- Design of services for informing citizens about issues relating to climate change, mitigation, and adaptation, accessible across a broad range of media to increase prospects of being found and used.

5.5 Governance and Planning

The interlinked nature of crises such as climate change and the loss of biodiversity has implications for the structures of governance, formal and informal. However, as governance structures, economies, and civil society initiatives emerge or evolve to tackle such crises there is a risk of a loss of clarity as to the actors of relevance, and understanding of the authorities and influences of those actors (UK MAPs).

Where models of market and State are inoperable or limited, civil society and community-led actions can be effective in addressing challenges such as climate change, reversing the loss of biodiversity, and the provision of rural services. Empowered civil society and communities can be effective at identifying and implementing opportunities for tackling climate change through social innovations (e.g. direct land management, renewable energy generation, waste re-use), with support growing from EU and national level budgets (UK MAPs). Such a source of leadership places greater emphasis on the third sector and communities through social innovation (UK MAPs), which are providing support for local suppliers, use of local resources, creating new infrastructure and services. Encouraging such social innovation is in line with EU and national policies (e.g. EU European Agricultural Fund for Rural Development; Strategic Framework of the Czech Republic 2030).

A key source of such guidelines is public sector organisations such as regional or sub-regional administrations (i.e. municipalities, local or regional authorities). Local cooperatives, social entrepreneurship or non-profit organizations can take responsibility for the sustainable management of water and greenspaces, produce and distribute energy, and process waste. Such initiatives can stabilize or stimulate local economies, and in some cases reduces costs

(Climatically Friendly Villages Czechia MAP).

However, the motivation and effectiveness of mechanisms for implementing solutions for tackling climate change and reversing the loss of biodiversity through sustainable management of land are inhibited by weak coordination within or across governance frameworks, and limited authority in planning or implementing changes in land use (Climatically Friendly Villages Czechia MAP). The capabilities, human resources and finances of such organisations vary considerably between and within countries, as do the requirements and administrative systems, sometimes as a consequence of previous forms of government. Providing more direct roles of citizens in deciding how budgets are spent could increase the motivation of community inputs, and credibility of policies to involve people in decision-making (e.g. Participatory Budgeting in relation to climate justice and a Just Transition in tackling climate change; UK MAPs).

Greater attention should be paid towards how to scale out or scale up initiatives to increase their collective impacts. Successful initiatives should be used as exemplars of what can be achieved in mitigating or adapting to climate change, within different biophysical, social and cultural contexts. Increased awareness of success stories could stimulate new innovations, or the uptake of existing innovations in areas where pressures of climate change or degradation of biodiversity are triggers of actions (e.g. UK MAPs). The best such exemplars are inclusive across all age groups, gender, faiths and abilities. Key requirements for those initiatives are trust (internally between partners, and between the initiative and their networks), and equality of opportunity in developing human capital. To stimulate and motivate transitions, there is also a need to understand types of pathways that would be required or available to people at different stages of careers, and the differences in contexts that may be due to gender, age, ethnicity and geography (UK MAPs).

Managing projects increasingly requires expertise across several topics for which a small municipality may have limited, or no, human or financial resources for handling the tasks necessary (e.g. reviewing and managing proposals, periodic and final reporting, financial and legal obligations of projects). The development of human capital will require an associated development of social capital to facilitate co-learning and identification of opportunities, particularly amongst communities of place. These are more likely to comprise communities and stakeholders with less access to infrastructure and institutional support. Support will be needed to overcome barriers such as the start-up and organisational resources required for effective and ongoing collaboration (Climatically Friendly Villages Czechia MAP; UK MAPs).

This is consistent with the EU Rural Action Plan of Increasing environmental, climatic and social resilience (European Commission, 2021a). However, in supporting such initiatives, greater attention should be paid to design and promote financial instruments that are inclusive, notably accessible by young entrepreneurs (e.g. South Aegean Greece MAP).

Recommendations for policy and research

Policy -

- Funds for tackling climate change that can be directed by citizens at national or regional levels (e.g. a component in the EU Cohesion Fund in the 2028-32 funding framework).
- Further measures should be designed to create conditions conducive to local cooperatives, social entrepreneurship or non-profit organizations in rural communities to take responsibility for local delivery of public goods.
- Support for developing governance infrastructures and human capital to enable the design and implementation of citizen-led prioritising of funding for tackling climate change.
- The creation or support for forums or governance structures which focus on place-based and territorial approaches to tackling climate change and environmental sustainability across levels of governance. This is consistent with recommendations by SHERPA for the development of future rural policies (D7.3; Miller et al., 2022b).

- Funding schemes that facilitate community and citizen participation, and actions on-the-ground, tailored to the needs and characteristics of their areas. This is consistent with recommendations by SHERPA for the development of future rural policies (D7.3; Miller et al., 2022b).

- A Communications Strategy for delivery of steps required to achieve net zero.

Research -

- Research into the governance structures and human capital required for enabling citizen led decision-making within the relevant regional and national legal and cultural contexts, and how that can be expanded at EU level.

- Identification of the skills required for delivering each stage of change in land use, and equitable access to such skills locally.

- Opportunities identified for learning from, and supporting, the scaling up and out of successes in community-led initiatives with the aim of broadening the uptake of social, technical and product innovations in rural areas.

- Research into what people who live, work or visit rural areas understand by the term 'net zero'.

5.6 Cooperation and Social Capital

Multiple benefits accrue to biodiversity, landscapes, economic development, and social justice through cooperation between communities and sectors (e.g. volunteer groups, LAGs). Partnership forums that facilitate effective sharing of knowledge between public, private, research and civil society sectors offer considerable potential to inform influencers within institutions (e.g. farmers, public authorities, business and research). Such groupings can be effective in providing points of contact that act as interfaces between national bodies and initiatives of the public, private, third and academic sectors, supporting multiple perspectives on specific topics (e.g. eradicating invasive plants, Climatically Friendly Villages Czechia MAP).

The membership and operation of forums needs to be designed to be relevant to the region, including its land systems (e.g. farming, forestry, natural capital management), the size of businesses (e.g. multi-national, SMEs, micro-business) and communities (e.g. remote rural, rural/urban interface). Their aim should be to share knowledge and foster cooperation that can accelerate the uptake of initiatives and practices that tackle challenges which include transitions to net zero GHG emissions, and associated issues of reversing the loss of biodiversity (Climatically Friendly Villages Czechia MAP; Emilia Romagna Italy MAP, Greenport Gelderland Netherlands MAP; UK MAPs). Such sharing of knowledge should be across levels of governance to ensure consistency in policy and actions at one level with respect to those at another. That requires forums that provide links between governance structures

where responsibilities overlap geographically, to provide clarity on remits and coherence in approaches.

Cooperation is also required across borders to ensure coherent approaches to environmental and social challenges. This recognises that in many cases environmental management requires appreciation of the interactions and impacts in one jurisdiction on the environmental, and potentially social and economic activities in another (e.g. water management, landscapes, habitat networks; Climatically Friendly Villages Czechia). Those jurisdictions may represent political entities (e.g. national or lower levels of administration), natural processes (e.g. water catchment), designations (e.g. natural or cultural heritage areas), ownership or management (e.g. by NGOs, public agencies, communities, private individuals).

The emergence of different types of innovations can be a consequence of, or enhance, cooperation (e.g. social innovations), but can also create pressures on cooperation through complicating understanding of responsibilities (UK MAPs). Where new forums are created, they should respect the remits and authority of existing groupings, and avoid adding complexity to governance, with attendant risks of mixed messages to residents, businesses and stakeholders.

Further requirements for policy and research

Policy -

- Clarification of the governance of plans for achieving net zero GHG emissions, and ensuring consistency between overlapping geographic areas of responsibility, and across sectors (UK MAPs).

- Measures should enable the creation and maintenance of networks that inform or support cooperation, with a particular emphasis on building, or rebuild, short supply chains and local markets in the post pandemic phases of COVID-19 (Climatically Friendly Villages Czechia). This is consistent with an aim of the LTVRA Action Plan Highlight the role of Producer Organisations in rural development.

- Mechanisms should be designed to learn from experiences of withdrawal from industrial activities in rural areas, with environmental, economic and social consequences. Examples could be mapped onto a conceptual framework of transitions and interpreted in terms of their characteristics of a just transition. (UK MAPs).

Research –

- As different types of cooperation, sharing of knowledge, and the development of social capital evolve so there is a need to understand the pathways of that evolution, and the key moments when barriers to uptake could have greatest adverse impacts, and when enablers could be most beneficial. This would also be consistent with recommendations by SHERPA for future research agendas in rural areas (D7.2, Chartier et al., 2022).

5.7 Stakeholder and Public Attitudes

The Eurobarometer (European Commission, 2021c) reports that, for the first time in its surveys of attitudes of European citizens, climate change ranked first as the most serious problem facing the world as a whole. Climate change was cited by 18% of respondents, and the deterioration of nature by 7%. It should be noted that fieldwork for the survey was in the first year of the COVID-19 pandemic (spread of infectious diseases ranked 2nd, 17% respondents), and before conflict in Ukraine February 2022 (4% cited armed conflicts).

The majority of respondents consider it very important that the EU (53%) or national governments (51%) set ambitious targets to increase the amount of renewable energy used by 2030, ranging from 32% (Latvia) to 74% (Portugal). There is significant support for the belief that the costs of

damage due to climate change are greater than the level of investments needed for a green transition (74%). To aid the process of transition to clean energy, 81% Totally Agreed, or Tended to Agree there should be more public financial support. The majority of respondents also expressed positive responses to questions about adaptation to climate change. For example, when asked about attitudes towards adapting to climate change, 62% of respondents either Totally Agree (23%) or Tend to Agree (39%) that "adapting to the adverse impacts of climate change can have positive outcomes for citizens in the EU". Similarly, the majority of respondents (78%) either Totally Agree or Tend to Agree that taking action on climate change will lead to innovation that will make EU companies more competitive.

Changes in attitudes and behaviours of citizens in rural areas, and activities which take place in rural areas by those from urban areas (e.g. employment, recreation) will be necessary to achieve targets of climate neutrality and reversing the loss of biodiversity. Sixty-four percent of respondents across the EU declare they had taken some personal action to fight climate change (November 2020 to April 2021), up from 60% the previous year, ranging from 83% in Portugal to 31% in Romania. However, the headline proportions for 10 out of 15 options of actions were down in 2021 compared to 2019, including consideration of the carbon footprint when planning transport (11% in 2021, 12% in 2019), and when purchasing food (16% in 2021, 18% in 2019). Indications of further actions by consumers regarding preferences and diets are indicated by those who would eat more organic food (32%), with responses varying nationally between 12% (Hungary) and 49% (Slovenia) and buying and eating less meat (31%), with responses varying nationally between 12% (Romania) and 55% (Netherlands).

Not all actors agree with the nature of the changes required, or the actions that may be required of them or their sectors (Climatically Friendly Villages Czechia MAP). In some areas proposals for changes in land use that contribute to mitigating climate change meet with disapproval such as where there are policy aims of increasing woodland cover but where locally such a land use is already extensive (e.g. UK MAPs).

In some areas and sectors there is evidence of a lack of awareness amongst audiences in policy and society of the types of interventions which can create the most significant impacts in addressing issues of climate change and environmental sustainability, such as the role of agriculture in mitigating effects of climate change whilst maintaining food production (e.g. Alqueva Portugal MAP). Examples are in waste management, developing a circular economy, and specific benefits accruing from blue and green infrastructure. Amongst explanations of this lack of awareness is the limited coverage of topics in the traditional mass media (Climatically Friendly Villages Czechia MAP). An associated need is to understand land manager attitudes towards the benefits of monitoring, and their understanding and effective use of the data generated within their businesses, and for wider public good.

An aim of strategies for informing actions and interventions by citizens, should be to make knowledge about impacts of climate change or environmental degradation relevant to individuals. Information should be framed in relation to ways of working (e.g. travel), lifestyle (e.g. holidays, recreation, consumption), and in relation to places (e.g. to where people have attachments or familiarity through holidays, sports events, media coverage). Such information could be brigaded across Europe, and further afield, by exploiting the capabilities of relevant EU institutions such as European Environment Agency, and the EU Copernicus Programme and Copernicus Climate Change Service (C3S) database.

Public belief in the Climate Emergency is greatest amongst the younger age group (69%, for aged under 18), and lowest amongst the oldest group (58%, for aged 60 and over) (UNDP, 2021). The evidence from COP26 is of how effectively young people can contribute to providing visions for the future, and the moral obligation to include them in creating those visions and the actions required (UK MAPs). This suggests there is a credible prospect of realising a target of Goal 10 Sustainable Green Europe, of achieving "a society in which all young people are environmentally active, educated and able to make a difference in their everyday lives." Two targets for achieving this goal are to: "Empower the entire society especially young people to act as agents of change for environmental and sustainable development", and "Ensure everyone especially young people have access to eco-friendly infrastructure for living a more sustainable lifestyle."

Success in achieving these targets would be in line with Principle 1 of the European Pillars of Social Rights, of Education, Training and life-long learning, in particular the element of maintaining and acquiring … "skills that enable them to participate fully in society and manage successfully transitions in the labour market." At an EU level, the strategy would contribute to the EU Youth Strategy, building "a bridge between the EU and young people to regain trust and increase participation." (European Union, 2018).

Further requirements for policy and research

Policy -

- The series of snapshots of public attitudes towards climate change, at international, EU and national levels provides valuable insights to changes in those attitudes over time. Maintaining this series is a key requirement for interpretation of trends over time, and for communicating information about climate change, greenhouse gas emissions, and interventions of policy and practice.

- Credible plans are required that lead to transitions to net zero from changes in personal behaviour. Such plans need to be clearly understood by citizens and stakeholders, at each step in a transition, and any barriers or incentives to their adoption recognised.

Research –

- Greater public understanding is required of the links between specific actions or interventions and the GHGs mitigated, and how they contribute to limiting changes in climate (e.g. temperature). This needs knowledge and research into influences on public attitudes towards actions and interventions, and identification of barriers to those actions and how they can be overcome.

- To understand changes in public associations of land management practices with cultural heritage with an aim of identifying approaches to addressing potential resistance to new regulations or best practices (e.g. use of peat and peatlands; expansion of woodlands; water usage).

5.8 Legislation and Regulations

International aims of achieving net zero GHG emissions and reversing the loss of biodiversity are set out in conventions and agreements (see also Section 4). The design, implementation and monitoring of impacts of policies and measures relevant to achieving those aims operate under different regulatory and administrative systems and geographic levels (e.g. European, national, regional). They are also codified in ways that carry different levels of authority such as legislation, agreements, protocols, guidance and best practice. There requires to be coherence between policies and measures at different levels whilst accommodating local circumstances through derogations (e.g. reflecting traditions such as peat burning for domestic purposes) (UK MAPs).

Conditions for success require to be understood, at different levels (i.e. international, EU, national, regional, local), and the share of outcomes between actors including benefits (e.g. financial, human, environmental) and liabilities (e.g. for adverse outcomes). A significant influence on motivations to transitions in practices or behaviours is to whom the benefits accrue and how. The mechanisms for influencing changes in the use or management of land vary by jurisdiction. The influence of public authorities is moderated by the types of land ownership or tenure (e.g. public, NGO, private; land consolidation system), systems of planning, motivations to change (e.g. the delivery of public and private goods), and mechanisms to promote or support change (e.g. Climatically Friendly Villages Czechia MAP; UK MAPs). Differences between planning authorities

within countries, such as priorities or means of providing support, can skew investments towards those for which there is local societal acceptance or least opposition (e.g. onshore wind energy, solar farms; UK MAPs).

No one approach will suit all combinations of circumstances. Some areas have needs that are more pressing than in others such as tackling extreme weather events as a consequence of climate change. Approaches need tuned to the contexts and circumstances of regional and local needs commensurate with the levels and types of threats, the appropriateness of strategies of mitigation and adaptation, and sensitive to social and cultural values. Such tailoring requires mechanisms for providing feedback that informs reviews of regulations and measures against their potential to achieve the impacts intended, and the modification of regulations and measures if and when the level or nature of impact changes (e.g. rate of reduction of GHG emissions).

The complexity of regulation can create significant obstacles for implementing measures for sustainable land management by micro- and small businesses and communities. Maintaining awareness and understanding and implementing regulations (e.g. eligibility for support measures) can also be challenges for bodies responsible for managing the distribution of funds, including public bodies, civil society and business support. Complexities in processes (e.g. application forms for seeking support) may result in unsuccessful bids due to accidental errors in documentation, errors in the handling of applications, and prospectively limit progress in achieving the aims of public policy through demotivation of applicants. Processes for applying and monitoring support measures require to be simplified whilst still ensuring protection against the misuse of public money or fraud. For example, smaller municipalities and organisations would benefit from greater opportunity to use flat rates of funding for personnel costs and lump sums for project funding. This would be consistent with the reporting on the pilot schemes with the use of lump sum funding, albeit as it applies to SMEs and small research consortia, European Commission, 2021d).

Systems of regulation and delivery require support to develop the necessary human capital and infrastructures. Organisations with regulatory responsibilities need to acquire and develop knowledge and skills to ensure they make accurate assessments of eligibility for funds and ensure compliance of recipients of funds with their legal obligations. This necessitates efficient means of processing applications, sufficient staff numbers and finances to support measures. There is also a need for such organisations to be able to provide or direct applicants and awardees to sources of suitable advice. Increased efficiency is likely to arise from the adoption of digital solutions that are designed to tackle specific tasks. However, care should be taken not to disconnect those providing advice with knowledge or understanding of the rural areas to which it is being offered (e.g. concentrating staff in urban centres).

Further requirements for policy

Policy -

- Adopting a principle of the wording of regulations being subjected to a plain language test the aim of which would be to improving adherence and enhancing uptake of measures.

- Simplification of the administrative complexity of applications, progress and financial reporting. Investment is also required in mechanisms that build capabilities of prospective applicants and project management teams. Such mechanisms should include effective means of online help, mentoring and training, tailored to the intended audiences and the differences in their levels of capability.

5.9 Enabling Environmental Sustainability

The effective management of natural resources and landscapes is essential for achieving aims of climate neutrality and enhancing biodiversity in Europe, and the sustainability of rural areas. The natural resources of rural areas provide opportunities for innovative management and benefits accruing for communities of place and of interest. Designing and realising those opportunities requires a suitable portfolio of landscape planning tools that can be deployed to protect, recover and enhance the quality of natural resources such as water, air, soil, vegetation, and the socio-economic contexts within which they are managed. There is also a need to understand how environmental sustainability can be embedded in rural and regional development, taking account of the socio-economic circumstances of those who live, work or visit rural areas.

Suitable conditions can and should be created for the effective management of land and water by enabling the effective planning and arrangement of land parcels in ways that take account of factors such as erosion and flood control. Therefore, collective benefits can accrue by designing environmental sustainability into the infrastructure of processes of allocating land (e.g. the Complex Land Consolidation, Climatically Friendly Villages Czechia MAP).

Integral to the management of natural resources are the types of land tenure and governance structures, and the authority with which technical, economic and social investment can be made in the future uses of the land. The form of land tenure may influence who benefits from investments in interventions, and thus the motivations to makes such investments.

Water supply management presents a particular challenge for many areas of Europe. In some there are severe problems of water supply and droughts, in turn causing high energy consumption for the production and collection of water from various sources (e.g. desalination, drilling, transport of water by tankers) (e.g. South Aegean Greece MAP). All types of user should be advocating, encouraging and demonstrating innovative and responsible uses of water (e.g. harvesting rainwater; re-use of wastewater, e.g. Climatically Friendly Villages Czechia MAP). This can contribute to win-win situations of reducing waste, reducing the use of landfill, alongside developing circular economies and associated opportunities for the creation of new businesses and economic development in rural areas. For example, the increase in recycling centres, sorting of waste, and enabling handling of items such as biowaste and cooking oil, is creating new sectors of employment in tackling waste and introducing new products into supply chains. Delivering such new opportunities, in line with principles of a circular economy, fuelled by and providing raw materials for renewable energy, offers potential lines of development for smart villages (Climatically Friendly Villages Czechia MAP).

The concept of Blue-green infrastructure and design and implementation of nature-based solutions are important elements in mitigating the effects of climate change (reducing risks of flooding particularly fluvial, sequestering GHG emissions) and making positive contributions to improving habitats and biodiversity. However, there is evidence of authorities and stakeholders unwilling to commit to long-term water retention or flood prevention measures (e.g. Climatically

Friendly Villages Czechia MAP), and a lack of understanding amongst the responsible authorities of the potential benefits of nature-based solutions.

Maintaining and introducing features to landscapes, particularly those which are intensively managed, are a valuable way of maintaining or enhancing habitat structures that support biodiversity in terms of flora and fauna. Such features can be natural (e.g. woods, hedges, treelines) or man-made (e.g. stone walls, animal shelters, water bodies, 'insect hotels'), designed to contribute to natural and cultural aspects of the landscape and positioned to maximise their beneficial impacts. Of particular significance is to recognise the interactions between habitats and habitat management actions at place and landscapes, and potential threats to and impacts on areas that are spatially adjacent or downstream, including aquatic ecosystems (Alqueva Portugal MAP). The planning of interventions should also take account of genetic diversity of plants and crops, their importance to natural and cultural heritage through agro-biodiversity (as per the EU Biodiversity Strategy 2030; European Commission, 2020b), and the opportunities they offer for economic development.

The European Green Deal (European Commission, 2019), proposed EU Mission on a Soil Deal for Europe, and Horizon Europe Partnership on Agroecology (and related H2020 projects ALL-Ready and AE4EU), envisage transitions to agro-ecological farming systems offering significant potential for carbon sequestration and other sustainability benefits such as reduced water use, pesticide inputs, managing Nitrogen and Phosphorus runoff and within their lifecycles (EU Farm to Fork Strategy). This would deliver on aims of the EU Soil Strategy (European Commission, 2021b) on topics such as land-based approaches to achieved climate neutrality, the EU Biodiversity Strategy 2030, and the EU Circular Economy Action Plan.

Further requirements for policy and research

Policy -

- Respecting the rights of all actors in just transitions of farming systems, ensuring that no one is left behind in transitions to new land management practices and structure of land systems.
- Mechanisms that support the reintroduction of landscape features which enhance thequality of public goods (e.g. reduced flood risk, landscape aesthetics, air quality, pollinators).
- Empower public procurement towards the circular economy through the purchasing of re-used, refurbished and remanufactured products, to aid in the creation of circular economy markets in rural areas.
- Design fiscal policies that motivate changes in production processes towards those which are consistent with achieving net zero greenhouse gas emissions, with zero or with low environmental footprints.

Research –

- The identification of principles to guide the spatial planning of land use that would support environmentally beneficial outcomes, and which are consistent across geographic levels (e.g. future proofing land use options against climate change), across jurisdictions and equitable for all stakeholders in their responsibilities and the benefits they accrue.
- Development of modelling of the hydrological properties of soils and capability to transmit water vertically and horizontally, mapped spatially (e.g. adapting the Hydrology of Soil Types Classification for Great Britain). The aim of the research would be to provide guidance on water retention at times of rainfall and flooding events, and on the characteristics and quantity of water supplies.

- Understanding the differences in attitudes and actions of rural citizens towards environmental sustainability with respect to life courses (e.g. socio-economic status in early-life compared to later life).
- Understanding the potential of re-used, refurbished and remanufactured products in relation to different sectors of rural economies.
- Develop and test models of environmental restoration that are tailored to rural areas and can be scaled up or out.
- Quantification of the benefits of land management practices that promote biodiversity, and the relationship between wild biodiversity and ecosystem services. Research would entail modelling of the impacts of effects associated with re-naturalisations in extensive rainfed areas, such as increased risk of forest fires and loss of habitats associated with steppe birds.

6. Perspectives of the SHERPA EU Multi-Actor Platform

The EU-level MAP met to discuss the topic of climate change and environmental sustainability, informed by the results of the SHERPA Position Papers of SHERPA national and regional MAPs. Members of the EU-level MAP reflected on the recommendations developed by the national and regional MAPs and discussed how these recommendations, regarding rural policies, interventions, and research gaps related to climate change and environmental sustainability, can be supported at the European Union (EU) level. Those reflections are summarised below.

6.1 Understanding the Urgency Related to Climate Change

As highlighted during the United Nations Climate Change Conference 2021 (COP26), there is an urgent need to implement mitigation and adaptation measures to fight climate change, and to build environmental sustainability. This sense of urgency should be embedded in measures supporting climate change and environmental sustainability in rural areas. At the EU level, there is a need to determine which characteristics of rural areas require the protection most urgently, and how they can be supported. It is also imperative to identify which rural areas are most vulnerable to the effects of climate change, and to enact measures to protect them.

It is important to consider the unexpected consequences of actions on mitigation and adaptation on rural communities and rural areas. Research findings should inform a systems perspective and cross-sectoral approach, accounting for trade-offs between climate mitigation/adaptation measures, and with an inbuilt understanding of how they would affect rural areas and rural communities.

6.2 Facilitating Climate Mitigation and Adaptation Measures on the Ground

There is an urgent need to implement measures to mitigate the effects of climate change. Regional agencies and local public authorities are often best positioned to swiftly execute such actions 'on the ground', because they are already familiar with the most urgent local needs and appropriate, tailored climate adaptation measures. EU funding is available to support and facilitate such measures. The majority of relevant EU programmes and funds are accessible by regional and local authorities, as long as the measures supported also contribute to fulfilling the collective targets set by the Member States and the EU, such as green and digital transitions, and comply with obligations for any Member State contribution.

The EU offers an enabling framework built on various policies, such as the Common Agricultural Policy (CAP) and Cohesion Policy, with a range of specific funds, such as the European Regional Development Fund (ERDF). These funds can be used to facilitate swift decision-making and the implementation of climate adaptation actions (e.g. the insulation of houses) on the ground by national, regional, or local authorities. Aside from the provision of policies and funding, the EU has also made multiple examples of good practice in climate change mitigation and adaptation measures available. Public authorities can use these examples as inspiration to design and deliver measures in their rural areas.

Measures taken must follow the principles of a just transition (no one or place being left behind, 'how' to achieve net zero by 2050, and engagement with those directly affected), recognising the interconnectedness of the climate crisis and the biodiversity crisis, and the close links between climate justice and social justice. The EU Just Transition Mechanisms provide €55 billion over the period 2021-2027. The uptake and impacts of those funds will become apparent over the coming few years. However, although progress is being made on adopting principles for just transitions (e.g. UK MAPs), there is a lack of specific plans of an appropriate level of granularity in how transitions take place, recognising sequences, timing, overlaps in actions, and the nature of closure or cessation of activities. Interests representing rural areas should identify opportunities to influence the contents of the Territorial Just Transition Plans of the Member States, facilitating action via climate education and training.

The need for swift climate change and environmental sustainability mitigation means that it is important to increase awareness among multiple relevant stakeholders in rural areas, such as farmers, rural inhabitants, and rural politicians. These stakeholders, who are central to decision-making in rural areas, should be aware of and recognise the need for both short-term and long-term actions. Climate education and training, delivered by credible existing providers (using accessible evidence and demonstrations of what can be achieved), or emerging as new businesses, would encourage actors in rural areas with key responsibilities to take effective steps.

The EU already provides various programmes and frameworks that can be used to finance and design education and training offers, and so raise awareness of the challenges and solutions at hand. The ERDF and the European Social Fund Plus (ESF+) can be used to finance training, education, and information dissemination efforts. The EU Mission on Adaptation to Climate Change also supports the creation of citizen awareness and engagement programmes. CAP funds can also support training for farmers, foresters and rural communities, as can the LEADER/Community-Led Local Development (CLLD) instrument.

6.3 Roles of Transdisciplinary Approaches and Open Science

Achieving the aim of net zero greenhouse gas emissions by 2050 necessitates transdisciplinary approaches with inputs from across the full breadth of stakeholders, including policy, science, engineering and society, including mechanisms for learning and motivating actions (e.g. from arts and humanities). Implementation of the principles of Open Science should enable access to contemporary knowledge and data, and understanding of its uses, in line with strategies such as the EU Soil Strategy of widening 'the access to and use of results from research activities (European Commission, 2021b). The Open Science approach delivers on objectives of the European Green Deal" (European Commission, 2021a), and proposed in the 'Next Generation European Union', including "advancing climate action and promoting environmental and biodiversity protection" and a "greener, more digital, more resilient and better fit for the current and forthcoming challenges".

Sensitivity to local circumstances (e.g. cultural contexts) will be enhanced through the involvement of regional and local researchers in climate change and environmental sustainability responses. This should be encouraged as part of the empowerment of local communities, exploitation of local expertise, and mobilisation of the individuals directly affected. Such empowerment should enable the design and implementation of new and innovative mitigation measures to fight climate change and enable environmental sustainability in rural areas, encouraging bold changes which help traditional ways of thinking and acting in rural areas to evolve and adapt.

One example of a focus for local empowerment is the rethinking of local food systems in rural areas, and how such systems can contribute to mitigating and adapting to climate change, while avoiding adverse indirect effects or spillovers into other areas of rural economy and society. However, the transformation of food systems also needs insights to public attitudes towards climate change, actions in policy and practice, and a willingness of individuals, businesses and public bodies to take actions that can make a difference. Evidence from the series of Eurobarometers (e.g. Number 513), shows recognition of climate change as a very serious problem, but considerable diversity is attitudes on the level of urgency, and the types of interventions required for tackling climate change (e.g. change in diet, renewable energy, land use change).

As the implementation of policies evolve, and evidence emerges of the impacts on GHG emissions, so there is a need for surveys and understanding public attitudes which enable a more tailored set of messages and sensitivity to local and cultural issues that may inhibit the pathways to climate neutrality. In turn, the findings from those surveys should contribute to the evidence base made available through open science and communicated in ways that are meaningful to communities at local through to continental levels.

7. Recommendations

To achieve the target of net zero GHG emissions and environmental sustainability will require the innovation and initiatives of all public, private and third sectors. The SHERPA MAPs have developed recommendations for policy, practice and future research relevant to

tackling climate change and facilitating environmental sustainability which are summarised below.

7.1 Recommendations Regarding Policies and Practices Relevant to Rural Areas

Tackling climate change and enhancing environmental sustainability requires policy direction and mechanisms that can enhance the prospects of achieving climate neutrality and reversing the loss of biodiversity, priorities for which are summarised below.

Planning

The role of multi-level spatial planning of land use should be developed, aiming to optimize outcomes of multiple benefits for mitigating or adapting to climate change, and enhancing biodiversity. Such spatial planning should be coherent across scales, recognising geographic specificities, and future proofed for changes in biophysical conditions and considering social and economic implications of those plans. They should be accompanied by pathways and timelines to achieve targets for reducing GHG emissions and enhancing biodiversity, and details of the governance of plans for achieving those targets and ensuring consistency between overlapping geographic areas of responsibility, and across sectors (UK MAPs).

Experience from COP26 in 2021 showed how initiatives delivering a common message can be coordinated at multiple geographic and administrative levels, business, civil society and citizens. The momentum created by COP26 requires to be translated into continuous actions, supporting new forums and mechanisms for deliberation and decision-making.

Forums should be developed and supported which have a recognised authority and remit for developing place-based and territorial approaches to tackling climate change and environmental sustainability across different levels of governance. An output from those approaches should be spatial plans for their areas of responsibility, with clear mechanisms for the involvement of citizens, civil society and business. The authority of such forums will be required to align with existing national or regional governance structures. This recommendation aligns with proposals by SHERPA for developing future rural policies (D7.3; Miller et al., 2022b).

Measures and interventions

Achieving the aims of policies such as those of the EU Green Deal, EU Fit for 55, and Biodiversity 2030 requires measures that motivate and enable actions to be taken by relevant actors in public, private and third sectors, as well as citizens. The design and implementation of measures should include utilising the role of the public sector as major purchasers and users of goods. As such, public procurement rules should be aligned in ways that support transitions to a circular economy, such as through the purchasing of re-used, refurbished and remanufactured products, to aid in the creation of circular economy markets in rural areas.

To create the positive impacts intended of measures to deliver on public policy requires addressing barriers to applications for funding. Mechanisms are required to build capabilities of prospective applicants and project management teams, which should include effective means of online help, mentoring and training, tailored to the intended audiences and the differences in their levels of capability. They should be accompanied by simpler application forms, and for progress and financial reporting, presented in clearer language.

At a municipal level, support should be directed towards building, or rebuilding, short supply chains and local markets in the post pandemic phases of COVID-19. This should include prioritising the needs of local producers of goods and services, such as the provision of space for community level activities such as farming and gardens. This is in line with an aim of the

LTVRA Action Plan Highlight the role of Producer Organisations in rural development.

Communities and networks

Building on successes of community-led initiatives, such as social innovations, as effective means of delivering actions on the ground, such as environmental restoration, funding schemes continue to be required to facilitate community and citizen participation, and actions on-the-ground, tailored to the needs and characteristics of their areas. Such schemes should enable citizen led decisions on the allocation of funds (e.g. participatory budgeting) within suitable existing, or newly formed, governance structures. The allocation of funds could form a component in the EU Cohesion Fund in the 2028-32 funding framework. This is consistent with the recommendations by SHERPA for the development of future rural policies (D7.3; Miller et al., 2022b).

Tackling climate change and progressing towards net zero GHG emissions and environmental sustainability necessitates changes in personal behaviours. Guidance on steps in a transition need to be credible and understandable by citizens and stakeholders.

A Communications Strategy should be designed for explaining the reasons for a target of net zero GHG emissions by 2050, how that can be achieved by all sectors and citizens and the impacts of individual measures. The communications channels should facilitate how progress towards the target can be tracked both by communities of place and of interest (e.g. in a variation of the EU Biodiversity Strategy Dashboard).

Open data, knowledge and skills

European Open Data and Science Policy should be updated to improve its support for citizen science and business models that promote the monitoring of environmental characteristics using digital tools, whilst taking account of differences in cultural characteristics or inequalities that could inhibit contributions to such monitoring. In support of such an aim, easily understood guidance should be developed on the rights of data providers, IPR and ethical considerations, recognising the need for quality control and cyber-security, and ensuring the protection of providers and those who, or whose land, are the subject of those observations.

The emergence and adoption of new concepts, practices and technologies are enabling or accelerating transitions to climate neutrality and environmental sustainability. For these to be effective, there is a need to identify the skills required for delivering each stage in relevant transitions (e.g. in peatland restoration; land systems that are new to an area) and ensure equitable access to such skills local to where they are needed. There is also a need for funding mechanisms for upskilling all sectors of the workforce, at all stages of life course, to enable the uptake and utilisation of materials made accessible through Open Science.

7.2 Recommendations Regarding Research Gaps and Needs

Tackling climate change and enhancing environmental sustainability requires the provision of knowledge, data and methods for use by relevant types of actors with remits relating to rural areas. A summary of principal areas of research requirements identified through the relevant SHERPA MAPs follows.

Planning

As noted in the SHERPA Discussion Paper on a long term vision for rural areas (Féret et al., 2020), place-based management can contribute to achieving a balance between the multiple services provided by land. As the mix of benefits sought from land evolve so there is a need to understand the types and magnitude of trade-offs required to achieve climate neutrality and

environmental sustainability, assessed at different geographic levels, over different timescales, and from the perspectives of communities of place and of interest. Such understanding should be accompanied by the identification of principles to guide the spatial planning of land use which are consistent across geographic levels, across jurisdictions, and equitable for all stakeholders.

Public attitudes and behaviours

To progress towards net zero GHG emissions by 2050 requires understanding of public attitudes towards climate change, the types of interventions or changes in behaviours required, and identification of barriers to those actions and how they can be overcome. The Eurobarometer series of snapshots of public attitudes towards climate change, at international, EU and national levels provides valuable insights to changes in those attitudes over time. Maintaining this series is a key requirement for interpretation of trends over time, and for communicating information about climate change, greenhouse gas emissions, and interventions of policy and practice. However, more in-depth research is required into public and stakeholder understanding and attitudes regarding:

1. The terminology used in discussing targets and interventions for tackling climate change. For example, what do people who live, work or visit rural areas understand by the term 'net zero'?

2. Woodland expansion and barriers amongst some land managers and communities in the vicinity of prospective large scale woodland planting. Research should combine quantitative information gathered by surveys such as the Eurobarometers, and evidence from qualitative studies that provide insight to community and stakeholder motivations and attitudes towards woodland expansion [Also reflected in recommendations for Section 5.7].

3. The approaches to address resistance to new regulations or best practices (e.g. use of peat and peatlands; expansion of woodlands; water usage) through better knowledge of public associations of land management practices with cultural heritage.

4. Understanding the differences in attitudes and actions of rural citizens towards environmental sustainability with respect to life courses.

Social, technical and product innovation

Identifying, documenting and disseminating information about successful examples of scaling up and scaling out social, technical and product innovations in rural areas that contribute to tackling climate change is likely to assist within broadening their uptake and impacts. A resource with such examples could be used to inspire innovations in a rural circular economy by small and micro-businesses and communities, such as understanding the potential of re-used, refurbished and remanufactured products in different sectors.

There is also a need to understand barriers to mainstreaming measures to prevent and mitigate adverse effects of climate change, especially on agricultural production. Innovation in crop breeding is leading to varieties with increased resistance to threats of plant disease and water scarcity, with considerable potential offered by gene editing technologies. However, the development and uptake of such product innovations is influenced by factors of regulatory approval and social acceptance as well as economic benefits. There is also a need to understand the potential and uses of indigenous genetic resources of crops, and the technological and economic valorisation of their use in primary production and agri-food sectors, and barriers to their adoption.

Identifying when barriers to uptake could have greatest adverse impacts, and when enablers could be most beneficial, is also relevant in the evolution of social innovation. As different forms of cooperation and governance structures emerge, in different socio-economic contexts, so there is benefit from understanding the pathways of their evolution, and key moments when social innovations can be threatened. #

Research in these topics would contribute to delivering the aims of the EU LTVRA Action Plan of supporting economic diversification in rural areas, the facilitating the use of traditional varieties of crops and breeds as per the EU Biodiversity Strategy 2030, and updating the EU Farm to Fork Strategy in relation to legislation that takes account of whether products have the potential to contribute to sustainability. They would also be consistent with recommendations by SHERPA for future research agendas in rural areas (D7.2, Chartier et al., 2022).

Environmental data and monitoring

Land management practices can create pressures on natural resources but can also be used to reverse damage to such resources. Access to contemporary data on characteristics of the environment is an important asset for interpreting the impacts of pressures on natural resources and the uses of land in rural areas. Increasingly, such data are available in near real time through drones and digital sensors deployed on and below ground. However, areas of research needs identified are:

1. Links between specific interventions and the GHGs mitigated, and how those savings contribute to limiting changes in climate.

2. Identification of characteristics of natural and managed environments that can be monitored using digital solutions, outputs from which are data for informing management that mitigates impacts of climate change, alerts stakeholders to threats (e.g. water saturation of soils), and opportunities for enhancing biodiversity (e.g. introduction of landscape features as components of new land systems).

3. Testing and evaluating the deployment of digital sensors to understand their operational use in different types of biophysical and socio-economic contexts across Europe, requirements for infrastructure (technical and human), and mechanisms for enabling the data collected to be interpreted in an easily understood manner. Consideration of such mechanisms should include institutional issues relating to data sharing (e.g. regulatory, ethical, commercial), and for wider exploitation (e.g. through the Copernicus Climate Change Service).

Research in this topic area could contribute to the LTVRA Action Plan flagship Rural Observatory,

Modelling tools can be used to understand what land management approaches may be most effective in planning and managing the environmental sustainability of rural areas. Three priority areas for such increased understanding are:

1. Modelling the quantification of the benefits of land management practices that promote biodiversity, and the relationship between wild biodiversity and ecosystem services. This could entail modelling the impacts of effects associated with re-naturalisations in extensive rainfed areas, such as increased risk of forest fires and loss of habitats associated with steppe birds.

2. Modelling the hydrological properties of soils and capability to transmit water vertically and horizontally, mapped spatially (e.g. adapting the Hydrology of Soil Types Classification for Great Britain). An output from this research would be guidance on water retention at times of extreme rainfall and flooding events, and on the characteristics and quantity of water supplies.

3. Developing and testing models of environmental restoration that are tailored to rural areas and can be scaled up or out.

Research in these areas would contribute to the proposed LTVRA Action Plan flagship Rural Observatory.

8. Concluding Remarks

All stakeholders are in need of assistance in navigating their ways along pathways to climate neutrality by 2050. Actions are required throughout the supply and value chains (natural resource management, farming, processing, consumption), by across all sectors of society in their employment and lifestyles, and the infrastructure provided by the public, private and third sectors. However, lessons should be learnt from experiences of withdrawing from industrial activities in rural areas, and the consequential environmental, economic and social impacts. Transitions to climate neutrality and environmental sustainability should be follow the principle of respecting the rights of all actors, with no one or place left behind in transitions to new ways of working and living. As such,

A concluding observation from a member of the UK MAP on the challenge being faced is that ...

"We have done very well out of cheap energy, food and resources without paying the real costs. It will not always be the government or taxpayer who foots the bill. Everyone has to help pay the bill, and not pass it on to future generations."

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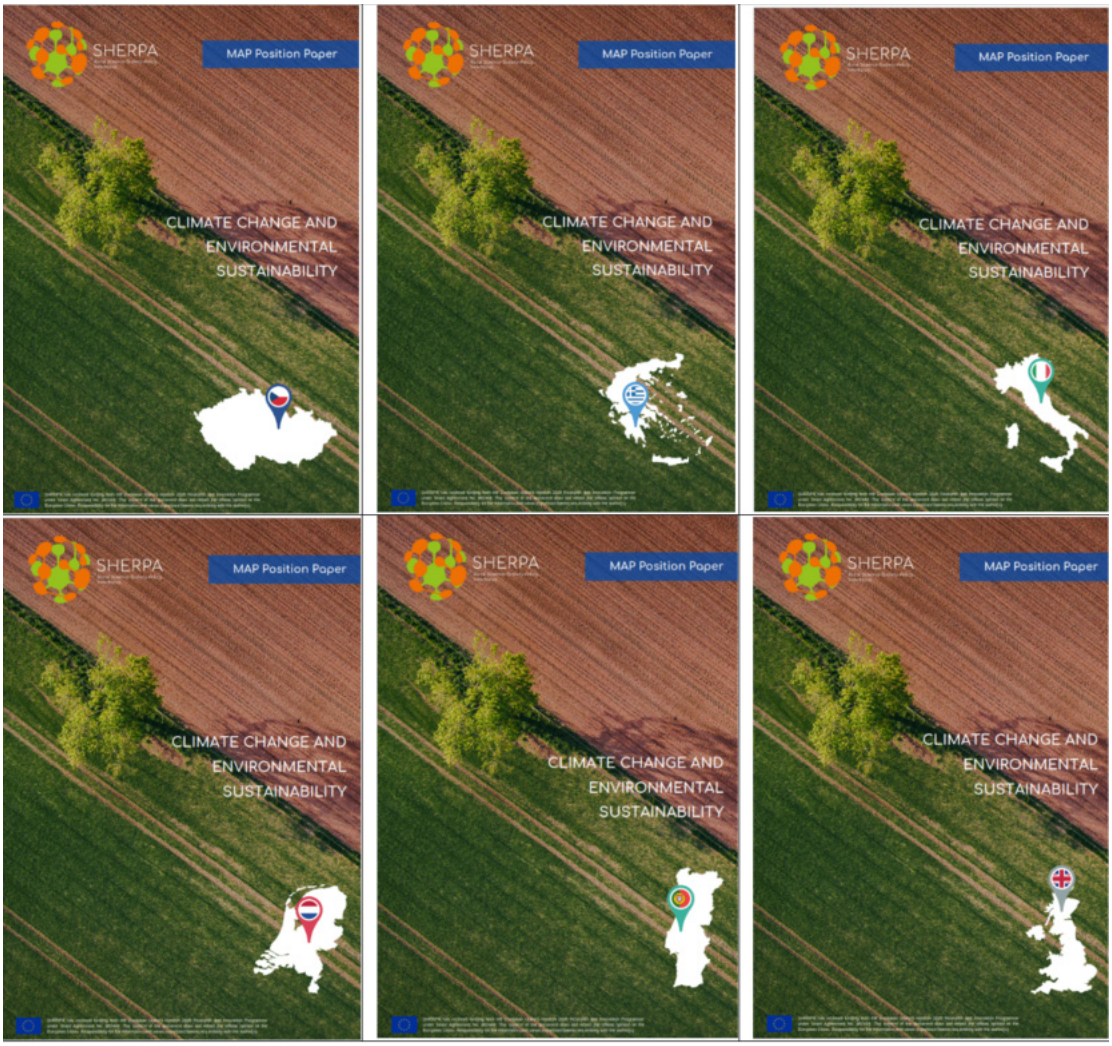
Appendix 1. Position Papers of SHERPA Multi-Actor Platforms on Climate Change and Environmental Sustainability

The SHERPA Position Paper on Climate Change and Environmental Sustainability was developed from the evidence and positions set out by the Multi-Actor Platforms of Emilia Romagna (Italy), South Aegean (Greece), Greenport Gelderland (Netherlands), Alqueva (Portugal) Climatically Friendly Villages (Czechia), the River Dee Catchment (UK) and Rural Scotland (UK).



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