Chapter 6 Theme 5: Natural Resources

"*Our wealth as a nation and our individual well-being depend critically upon the environment. It provides us with the food, water and air that are essential for life and with the minerals and raw materials for our industry and consumption. Less obviously, it provides the processes that purify air and water, and which sequester or break down wastes. It is also in our environment where we find recreation, health and solace, and in which our culture finds its roots and sense of place*".
UK National Ecosystem Assessment, 2011

Accounting for Natural Benefits

6.1 Whether we live in towns or in the countryside, we are dependent on ecological systems (ecosystems) for our health and well-being. The components of the natural environment that provide us with these benefits are known as 'natural capital'. The benefits which society derives from natural capital assets ('ecosystem services') are commonly grouped into four core categories of services:

- **Supporting services** (for example the processes which form soil, cycle nutrients and the essential photosynthetic process in plants).
- **Provisioning services** (for example, woodland that provides timber for fuel, construction and manufacturing; plant communities which sustain populations of insects to pollinate crops).
- **Regulating services** (for example, soils and aquifers that absorb rainfall reducing flooding, and filtering water to give us healthy rivers and clean drinking water).
- **Cultural services (**for example, landscapes, wildlife and cultural heritage that give us a sense of identity, support tourism, offer recreational and learning opportunities, assist our physical and mental well-being and delight the soul).

6.2 The UK National Ecosystem Assessment (NEA 2011). identified that inadequate consideration in decision-making of the full range of natural benefits and services that we derive from the natural environment is a significant factor contributing to the degradation of ecosystems. The Follow-on report (2013) (NEAFO 2013) emphasised that "the natural world, its biodiversity and its constituent ecosystems are critically important to our well-being and economic prosperity, but are consistently undervalued in conventional economic analyses and decision-making"[1] and concluded that embedding knowledge of our ecosystems and their services into project, programme and policy appraisals, is critical for decision-making. While we pay for some ecosystem services, like food and fibre, we are often unaware of the importance of others, such as natural purification of water and air, and the attenuation of flood water. The cost of providing these artificially is considerable. In the years after the highly technical UK NEA reports were published, the environmental campaigner and writer Tony Juniper explained ecosystem services in an accessible and readily understandable format using a series of examples from around the world (in '*What has Nature Ever Done for Us*?') and more recently from around the UK (in '*What Nature does for Britain*'). These illustrate clearly the tendency to under-estimate the value of natural processes and the services and benefits we derive from the natural world. This leads to poorly informed decisions on how to safeguard these functions and utilise natural resources sustainably. The result is pollution, depletion of biodiversity, degraded ecosystems and substantial damage to the processes which are vital to life on Earth. There is a significant financial cost to restore ecosystem functionality or, if it is feasible to do so, to replace such functions with artificial alternatives.

6.3 Just as there are costs to restoring degraded ecosystems, there are benefits and savings from a healthy and naturally functioning environment. Degraded ecosystems present risks to businesses in terms of security of raw materials, waste disposal, insurance rates and brand image. In the North Wessex Downs, there are obvious direct links between ecosystems and the business activities of land-based industries such as farming and forestry (where soil health clearly underpins ecosystem function and the products from the land) and rural tourism. Associations can be less obvious or indirect for other businesses and relate, for example, to supply chains and investment choices.

6.4 In the rural landscape, sustainable agriculture and forestry could deliver widespread positive effects on ecosystems in the area. Grants, subsidies and advice can support and promote sustainable approaches to land use among farmers, foresters and other land managers.

Conserving Resources and Maintaining Ecosystem Function

6.5 Protecting natural resources and the natural benefits arising from them by operating in a way that minimises damaging impacts is part of sustainable development. There is a particular need to conserve soil health, manage water and maintain clean air.

Soils

6.6 Soils are cultivated to produce essential items of food, clothing and fuel. Soils also deliver natural benefits, influencing water flows; storing carbon, and supporting wildlife habitats and nutrient cycling. The Government's strategy for soils in the DEFRA Environmental Improvement

[1] *UK National Ecosystem Assessment Follow-on- Synthesis of the Key Findings*, UNEP-WCMC 2013.

Plan sets out a case for improving soil health and protecting peatland by addressing factors such as erosion, compaction and decline of organic matter. The stated policy objective is that "*By 2028 we will bring at least 40% of England's agricultural soil into sustainable management through our new farming schemes, increasing this to up to 60% by 2030.*" [2] Healthy soils are one of the indicators chosen to monitor and evaluate progress.

6.7 Chalk forms the underlying surface geological structure of the North Wessex Downs but the overlying soils influence vegetation cover and land use. Each soil type in the area has its own management requirements.

Sustaining Water Resources

6.8 The main rivers flowing through the Downs – the Pang, the Lambourn and the Kennet – drain eastwards to the River Thames. Watercourses flowing off the northern escarpment into the vales also feed the Thames catchment. The separate catchments of the Hampshire Avon and the Test flow south, draining the Vale of Pewsey and Hampshire Downs respectively. The escarpment in the west around Calne falls into the Salisbury Avon catchment, flowing west.

6.9 The status and condition of both surface waters and groundwater in terms of quality, availability and flow is important to people and to habitats and species in the National Landscape. The North Wessex Downs National Landscape Partnership is committed to supporting the work of Catchment Partnerships, water companies, local planning authorities and other interested groups to help assess, protect and enhance these important assets.

6.10 One in four residential and commercial properties in England is at risk from flooding. Flooding costs the UK economy £2.2 billion a year, with projections indicating a 27% increase by 2050. In the North Wessex Downs, localised flooding of villages in the river valleys in the winter is regular, and climate models indicate that flooding at the scale experienced in January 2024 is likely to be more frequent and have greater impact. The most severe flooding has been caused by a combination of high groundwater, surface water and river flooding. Flood risk management may include the provision of sustainable measures to alleviate future flood risk, for example Sustainable Drainage Systems (SuDS) incorporating biodiverse rain gardens, attenuation basins and wetlands and Natural Flood Management (NFM) schemes involving attenuating surface water runoff from agricultural land, river restoration, river floodplain enhancement and the creation of wetlands. The NFM approach delivers sustainable flood resilience, biodiversity gains, improvements in water quality, carbon capture, and enhanced health and wellbeing for communities. Groundwater flooding is a challenge particular to chalk landscapes and NFM is not usually a solution to this type of flooding, although it can reduce surface water flooding.

6.11 In summer, some rivers suffer from lack of flows because of water abstraction. At its most extreme it leads to dry river beds and the death of aquatic life, but more subtly it leads to a deterioration in water quality and ecological diversity caused, for example, by reduced capacity to dilute inflows downstream from sewage treatment works or to transport silt resulting in its deposition. Pressure for abstraction from the chalk aquifers that feed these rivers is directly related to the rising demand for water, including from new development. Drainage structures and other features modify natural flow regimes. Climate change, the deterioration of assets, as well as continuing pressure to build in areas of high risk flood zones, will contribute to increased risk of flooding affecting local communities. Gradual urban creep from paving gardens, tarmacking tracks and infill development can significantly increase volumes of storm water runoff, leaving drainage networks unable to manage.

6.12 The waters of the chalk aquifers and rivers are a major source of potable water. Ground waters from within the river catchments are abstracted to meet demands for public water supply and for industry, agriculture and aquaculture (watercress and fish farms). The level of abstraction and effect on river flows varies across the area.

6.13 Groundwater abstraction points in the Kennet valley are numerous, The Chalk Stream Restoration Strategy expresses abstraction as a percentage of recharge (A%R) and considers 10% to be a sustainable level. Across the North Wessex Downs abstraction varies from 1.1% of recharge on the Pang to 33% of recharge on the Enbourne., A long-running programme of investigations and licence changes to make groundwater abstractions more sustainable across the National Landscape is still under way, with low flow investigations on the Kingsclere Brook and Upper Kennet in progress. All licence reductions are still dependent on other sources of supply being available. Overall, pressure on rivers from abstraction has reduced in the last 20 years, but it is critically important that new development should not be allowed to reverse these hard won gains.

6.14 At the same time, the operational requirements of the Kennet and Avon Canal have an effect on the Kennet. Between Bath and the summit at Crofton Pumping Station the Canal is fed by the Bristol Avon; between the summit and Kintbury by the River Dun, a tributary of the Kennet; and between Kintbury and Reading by the Kennet. In-flows into the Canal from these river sources can result in less than optimum flows in the rivers, particularly in the summer months and in drier years. When the combined section of canal and river diverge, this can result in high levels of turbidity in the river. Small tributaries including the Pear Tree Bottom and Inkpen Streams are known to bring high volumes of sediment into the slow-moving canal.. There has been significant progress amongst the various parties to minimise the impacts of the canal on the river and vice versa, including the construction of bypass weirs at canal locks west of Hungerford to reduce canal water spilling over into the River Dun. Wet winters in 2024 and 2025 have tested these beyond their design limits and canal overflows remain a challenge for the river. It is a clear objective of the Canal and River Trust to optimise the use of water resources in the Canal and to use back-pumping to conserve water in the 'artificial' section between Bath and the Canal summit. It is a clear objective of the Kennet Catchment Partnership to minimise the impact of the canal on water quality in the river.

[2] *Environmental Improvement Plan 2023 - First revision of the 25 Year Environment Plan*, DEFRA 2023

6.15 Under the Nitrates Directive, the majority of the North Wessex Downs National Landscape is designated as a Nitrate Vulnerable Zone (NVZ). Within these zones, farmers are required to limit the application of manures and nitrogen fertilisers, subject to a closed season for the application of certain manures. They are also required to keep records of cropping, stocking and the application of nitrogen fertilisers and manures. As a consequence of post-war farming practices, nitrate level in groundwater is high across the North Wessex Downs, rendering some groundwater sources of drinking water unuseable without treatment or dilution.

6.16 Further control of diffuse pollution is a requirement of the EU Water Framework Directive. There is an obligation to manage river basins to deliver good environmental outcomes in both surface waters and groundwater. Agriculture is recognised as one of the main sources of diffuse pollution of water courses and groundwater. DEFRA encourages Catchment Sensitive Farming (CSF) as a key approach to resolving this by managing land in a way that is sensitive to the ecological health of the water environment. While farming is not the sole cause of diffuse pollution, it does contribute approximately 60% of nitrates, 25% of phosphorus and 70% of sediments along with other pollutants which enter our surface waters.

6.17 Sewage treatment works serving communities in the North Wessex Downs discharge both treated and untreated sewage effluent into our rivers. Marlborough Sewage Treatment works was the first in the country to benefit from phosphate-stripping, and the long-term data show the benefit in reducing phosphate levels in the Kennet as a consequence. Across the North Wessex Downs there are more than 100 storm overflows, which spill untreated sewage into rivers for tens of thousands of hours every year when groundwater is high or after rain. Chalk streams have been prioritised in water companies' storm overflow reduction programmes but no real improvement is expected until 2030. Some rural communities within the National Landscape are served by private septic tanks, which do not provide a reduction in phosphate and require management and maintenance to function effectively.

6.18 Untreated run-off from roads drains into rivers in the protected landscape. For example, the M4 motorway drains directly to both the Lambourn and the Pang. This storm water carries complex chemicals known as per- and polyfluoroalkyl substances (PFAS), as well as hydrocarbons which both bioaccumulate and are carcinogenic. There is little research and no regulation regarding these pollution but it is an emerging threat to the health of rivers and communities.

Maintaining Air Quality

6.19 A variety of air pollutants have known or suspected harmful effects on human health and the environment. In most areas of Europe, these pollutants are principally the products of combustion from space heating, power generation or from motor vehicle traffic. Pollutants from these sources may not only prove a problem in the immediate vicinity but can travel long distances, chemically reacting in the atmosphere to produce secondary pollutants such as acid rain or ozone. The nearest monitoring site to the North Wessex Downs is at Harwell. Other sites are in Reading Town Centre, Newbury, Thatcham, Bath and Oxford. Pollution is low but there may be local issues, such as environmental quality relating to traffic pollution.

Climate Change

6.20 There is clear and mounting evidence that global climate change is accelerating, primarily due to human activity, including use of fossil fuels for transport and energy, deforestation, changes in land use and industrial processes. The Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (2021) confirms that human influence has unequivocally warmed the atmosphere, ocean, and land, with significant consequences for biodiversity, agriculture, water resources, and communities. In response, the UK Government has committed to achieving net zero greenhouse gas emissions by 2050, as set out in the Climate Change Act 2008 (amended 2019).

6.21 The UK Climate Projections 2018 (UKCP18) provide the most up-to-date assessment of expected climatic shifts. For southern England, these include:

- hotter, drier summers, increasing risks of drought and water scarcity;
- milder, wetter winters, leading to greater flood risks and soil erosion; and
- more extreme and unpredictable weather events, including storms, heatwaves, and seasonal shifts.

6.22 These changes will affect land use, biodiversity, water resources, ecosystems and community resilience in the North Wessex Downs. While some shifts may be gradual, many impacts require urgent action due to the time needed for implementation.

Impacts on the North Wessex Downs

1. Water Resources and Hydrology
    - Increased winter rainfall may cause more flooding and soil erosion, damaging historic landscapes and increasing sediment and nutrient runoff into rivers.
    - Drought conditions in summer will contract the chalk stream network, with some perennial streams becoming seasonal winterbournes, threatening freshwater biodiversity.
    - Changes in rainfall patterns will affect groundwater recharge, putting additional pressure on water availability for agriculture, wildlife, and local communities.

2. Biodiversity and Habitat Shifts

- Warmer temperatures and changing conditions will alter tree species composition, with the impact of ash die-back continuing, oak showing some resilience to climate change, whilst beech, which remains vulnerable to drought and storms associated with climate change, may decline. More drought-tolerant species like sweet chestnut and sycamore may become more prominent.
- Species distributions will shift, with some populations contracting, expanding, or migrating in response to climate pressures.
- The increased prevalence of invasive species and diseases (e.g., ash die-back, oak processionary moth, bluetongue virus) has the potential to threaten native species and ecosystems.

3. Agriculture and Land Use
    - Farmers may adapt their crop choices, incorporating drought-resistant varieties and possibly increasing biofuel cultivation.
    - Livestock may face greater risks from heat stress and emerging diseases, requiring changes in herd management and pasture practices.
    - Soil degradation risks will increase due to heavier winter rainfall and drought-stressed soils, necessitating better land management practices.
    - Whilst renewable energy sources are essential, the integration of wind turbine and solar technology needs careful consideration to avoid negative visual impacts on the landscape, natural beauty, and ecological assets of the North Wessex Downs

4. Recreation and Tourism
    - Warmer summers may increase visitor pressure on sensitive landscapes, particularly waterways and shaded woodland areas.
    - Seasonal patterns of tourism may shift, requiring adaptive management to balance conservation and public access.

6.23 Based on the UK Climate Projections 2018 (UKCP18), the UK's third Climate Change Risk Assessment (published in 2022) and the National Adaptation Programme 2023-2028 are key initiatives that define climate change impacts and adaptation strategies. The North Wessex Downs Partnership is keen to refine its understanding of the impacts of climate change and develop strategies for adaption to these effects.

6.24 'Making Space for Nature' outlined four key ways that we can adapt our ecological networks to a changing climate:

- Ensure that all parts of the network are in the best possible management.
- Increase the population sizes of vulnerable species.
- Reduce the risks of local extinction.
- Provide colonists for new sites.

6.25 The 'Making Space for Nature' principles remain relevant, with the Environment Act 2021 and the Environmental Improvement Plan (2023) further emphasising the need for nature recovery and increased ecological resilience.

6.26 The North Wessex Downs Partnership is committed to refining its understanding of climate change impacts and developing effective adaptation strategies, in line with the latest scientific evidence and national policy frameworks.

6.27 To do this we must:

- Allow species to adapt by shifting their distributions naturally to stay within their preferred 'climate envelope' through increasing connectivity (habitat patches and corridors and a network of protected sites to provide a more permeable countryside).
- Enhance the opportunities for species to stay within their climate envelope through small-scale local movements (as opposed to being forced into long-distance dispersal) by promoting landscape level heterogeneity within the National Landscape.
- Promote nature-based solutions, such as rewilding, habitat corridors, and wetland restoration.
- Enhance soil health and regenerative farming practices to reduce erosion and carbon loss.
- Increase tree and hedgerow planting to mitigate temperature extremes and capture carbon.
- Improve water conservation measures and encourage sustainable land management.
- Strengthen biodiversity networks through the principles of 'Making Space for Nature', ensuring species have the ability to adapt and migrate as needed.
- Value the crucial role the extensive grasslands of the North Wessex Downs plays a in carbon sequestration and maintaining water quality, further supporting the vital ecosystem services within the landscape.
- Prioritise nature based solutions to climate change, such as tree planting, species re-introductions and regenerative farming.
- Prioritise climate change mitigation and adaptation responses that are landscape-led and enhance the characteristics, qualities, and distinctiveness of the North Wessex Downs

6.28 In accordance with the UK government's third National Adaptation Programme (NAP3), the North Wessex Downs National Landscape will develop a dedicated Climate Change Adaptation Plan by 2028. This plan will be embedded within and directly linked to this Management Plan. It will outline specific, measurable, achievable, realistic, and timely actions and objectives designed to adapt the National Landscape to the impacts of climate change, encompassing nature, people, and place. This Adaptation Plan will be reviewed and updated on a five-yearly cycle, aligning with future iterations of the Management Plan, ensuring a proactive and adaptive approach to climate change resilience.

National Landscape Valued Qualities: **Natural Resources**

6.29 Cretaceous, Tertiary and Quaternary **geological history,** with features such as Sarsen Stones.

6.30 This geology in turn influences the main **soil types** of the North Wessex Downs:

- Thin chalk soils of the open downland, now primarily under arable production.
- The capping of Quaternary Clay with Flints over the chalk found as pockets of reddish-brown clay containing flint pebbles. These areas are particularly characteristic of the Downland with Woodland and Wooded Plateau Landscape Types.
- Quaternary Coombe deposits found where accumulated frost-weathered debris was carried down slope by melt waters at the end of the last glaciation. These have created till deposits in the dry valleys of the downs providing richer pockets of soil, often under arable production.
- Deep well-drained loamy soils over Greensand and river alluviums in the Vale of Pewsey, traditionally under pasture with large areas forming winter flood meadows.
- A mixed soil mosaic to the east of Newbury with nutrient-poor acidic soils over plateau gravels intermixed with fertile loamy soils overlying the London Clay, characterised by the Medieval landscape of the Lowland Mosaic Landscape Type.

6.31 Carbon storage in the characteristic habitats of the North Wessex Downs such as chalk grassland and broadleaved woodland.

6.32 Rivers with shallow sloping banks, clean shallow 'washed' **river gravel beds** (riffles) contrasting with deeper shaded pools.

6.33 Often a complex pattern of **river channels** (as on the Kennet downstream of Marlborough) reflecting the past use of the river to supply water to an extensive network of water meadows and mills, most of which are now disused. Upper winterbourne sections and winterbourne tributaries, flowing only during winter and spring when groundwater levels are at their highest.

6.35 **Clear natural water** fed from the chalk aquifer by springs which issue in the valleys of the chalk dip slope at the point where the water table comes to the surface. Limited fluctuations in water temperature throughout the year, resulting from the filtration of groundwater as it percolates through the chalk.

Natural Resources: Key Issues, Priorities and Policies

6.36 **Key issues** with the potential to have significant influence on the National Landscape's Natural Resources Valued Qualities:

a. Lack of agreement on the levels of acceptable environmental limits within the National Landscape.

b. The need to raise awareness of water quality issues.

c. Accelerated water run-off and soil erosion, especially on steeper slopes and under 'open' arable crops, such as maize.

d. Opportunities to encourage minimum tillage and careful application of inputs,

e. Overall air quality is generally good but activities outside the National Landscape can have a significant effect across the area; impacts of air pollution from road traffic and agriculture on ecosystem health is of concern.

f. [*Over abstraction of groundwater]*

g. Increasing water demand, especially during the summer months, as a result of climate change and changing lifestyles.

h. Increasing water demand for crop irrigation as a result of climate change and more erratic weather patterns resulting in prolonged dry periods and intense summer rainfall.

i. The influence of climate change on groundwater recharge patterns, overall water availability and elevated temperatures in chalk streams.

j. Increasing water demand as a result of major development in the urban areas in and around the North Wessex Downs, also sometimes leading to export of water out of the National Landscape catchments.

k. Loss of river habitats as a result of historical land drainage and channel modifications associated with past flood alleviation works and past industry (although some man-made features, e.g. mill leats, are of considerable historical importance).

l. Need to maintain wild fish stocks and quality of fisheries.

m. Excessive removal of bankside vegetation (on occasion associated with fisheries management).

n. Watercourse maintenance to conserve habitat, and a need for a change in emphasis from dredging to slowing the flow.

o. Loss of winterbourne channels through agricultural cultivation, or destruction of character of winterbourne channels by dredging.

p. Increasing lock movements on the Kennet and Avon Canal taking water from the River Kennet and its tributaries.

q. Pollution of rivers from point sources, including public and private domestic sewerage systems (with phosphorus discharges a particular problem), agriculture, commercial watercress beds, and fish farms.

r. Impacts on ecology of rivers from diffuse sources of pollution - often individually minor but collectively significant - including run-off from roads, houses and commercial areas, run-off from farmland, and seepage into groundwater from developed landscapes of all kinds, resulting in raised nutrient levels and toxic algal blooms.

s. Pollution pressure on the River Kennet generated by poor water quality and boat traffic on the Kennet and Avon Canal.

Natural Resources Priorities

1. Action to ensure that chalk rivers and streams in the National Landscape achieve and are maintained at good ecological status including, for example, appropriate riparian planting to mitigate elevated water temperatures predicted as a consequence of climate change.

2. Collaborative landscape-scale action to mitigate and adapt to the effects of climate change, for example through nature-based solutions (NbS).

3. Develop a Climate Change Adaptation Plan for the North Wessex Downs National Landscape

4. Ensure that all landscape interventions recognise and address the implications of climate change for the valued qualities of the North Wessex Downs and its setting.

5. Secure full recognition by decision makers of the importance of the North Wessex Downs landscape for the value of its natural capital and the environmental goods and services it provides to the economy and society as a whole, including heritage, water quality, healthy soils, food production, wildlife, flood management, carbon storage, recreation, health and well-being.

Natural Resources Policies

NR 01 Support co-ordinated action, guidance and measures on soil health issues.

NR 02 Promote and encourage initiatives for the sustainable management of soil by farmers and other land managers to minimise soil degradation through erosion, compaction, pollution and impoverishment, particularly in the case of the thin chalk downland soils.

NR 03 Support landscape awareness and understanding among catchment partnerships in and around the North Wessex Downs, and encourage collaborative research, projects and management to protect and improve watercourses and catchments.

NR 04 Encourage all partners to take water demand and its consequences for landscape, ecology and fisheries fully into account in decisions regarding development, changes to land use or cropping patterns within the North Wessex Downs.

NR 05 Support the introduction of demand management measures for water use in those settlements that draw on the aquifers of the North Wessex Downs, and measures to monitor and reduce water wastage.

NR 06 Encourage action to identify and address the sources of diffuse and point pollution within the North Wessex Downs.

NR 07 Encourage co-ordinated remedial action through the Catchment Sensitive Farming programme and other partnership schemes to restore and enhance degraded river sections within the North Wessex Downs.

NR 08 Support measures to reduce abstraction and help businesses adopt new mitigation measures.

NR 09 Promote well designed Sustainable Drainage Systems (SUDS) which achieve benefit to water quality, water quantity, biodiversity and amenity in urban areas. Promote natural flood management initiatives, particularly upstream in the catchment. to maximise multiple benefits, to benefit people and wildlife.

NR 10 Promote restoration and continued maintenance of rivers and river corridors to further biodiversity and amenity objectives – re-creating natural river channels and re-linking rivers with their floodplains where this would not damage artificial channels of historic and cultural importance.

NR 11 Develop a better understanding of the likely implications of climate change on the environment and economy of the North Wessex Downs.

NR 12 Support reductions in greenhouse gas emissions, such as carbon dioxide, nitrous oxide and methane, from all possible sources.

NR 13 Support climate mitigation measures including nature-based solutions, energy efficiency improvements, better on-farm management of fertiliser and animal waste, biomass heating from local fuel stocks and small-scale renewable energy generation consistent with conserving and enhancing the natural beauty of the landscape.

NR 14 Engage with opportunities to improve the availability and accessibility of sustainable modes of transport (e.g. bus and rail services, cycling) recognising in particular the health benefits of active modes (walking, cycling, riding etc) and promote use their use.

NR 15 Encourage greater use of timber from sustainable woodland, and in particular short local supply chains to support forestry, woodland and wood products businesses in the National Landscape.

NR 16 Promote carbon sequestration as an objective and benefit of habitat creation and management of woodland and permanent grassland.

NR 17 Encourage simple greenhouse gas and carbon accounting to monitor the effectiveness of changes.