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Soil natural capital valuation in agri-food businesses

Valuing Nature | Natural Capital Synthesis Report

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Why take a natural capital approach to soil?

Soils are a key natural asset for food production. Soil provides nutrients, water, physical and biological support for plants that are critical to agricultural productivity, and the sustainability of farming, agri-businesses and society. Agricultural soils also provide a range of other services with business and public benefits (Fig. 1)

Yet soils are under threat. The UN's Food and Agriculture Organisation estimates that over 50% of agricultural soils are moderately or severely degraded, and that this percentage is growing.

To secure soils and their benefits, we need to get to grips with the current state of this natural asset and the services it provides, and anticipate how these may be threatened, sustained or enhanced by land management choices.

A natural capital approach is a key element of an integrated and long-term solution. Evaluating stocks of soil natural capital and flows of services (in financial terms or otherwise) helps highlight the value of soils, the risks of degradation and the benefits of investment and action.

The opportunities for sustainable business

Taking a natural capital approach to soils in agri-food businesses, and investing in improving soil natural assets offers five main opportunities:

Figure 1: Soil services and benefits

As well as the direct benefits from supporting food production, soils are key to a range of services from which humans benefit

Soils store and filter water, supporting crops and potentially helping to reduce flood and drought risks and protect water quality

As the largest store of organic carbon on our planet, soils are important in regulating the climate and for climate change

Soils are also a habitat for a vast array of organisms, supporting biodiversity. 25% of all known species reside in soils

1. **Business risk and resilience:** Soil underpins the supply chain. If soil natural capital is degrading then, the business is at risk. Natural capital evaluation can help understand dependencies on soils and exposure to risk, and find means for de-risking.
2. **Reducing costs:** Accounting for soil natural capital can help motivate changes to practice that has win-wins for soil sustainability and saving costs due to improved input efficiency (irrigation, fertilizer and pesticides). The cost of reversing soil degradation is often much higher than prevention.
3. **Increased value:** Increasing soil natural capital stocks increases the value of land and the value of agri-food produce in a market where sustainability is of growing importance.
4. **Co-benefits:** A focus on soils can lead to water, carbon, and biodiversity benefits (Fig. 1) that have value for both business and the wider community that business engages with.
5. **Stewardship:** agri-food businesses have direct or indirect influence on land management. Decision-making that maintains or enhances soils and land is key to responsible business and maintaining licence to operate.

How to evaluate soil natural capital?

To realise the opportunities of soil natural capital valuation, methodologies need to:

1. **Capture the whole pathway** between drivers, supporting processes, soil natural capital stocks, services and benefits (see Fig. 2).
2. **Consider the range of soil benefits** not only crop productivity. The primary services relevant to the agri-business sector are: food production; soil carbon storage; and water regulation.
3. **Recognise both private and public benefits,** whilst acknowledging that public benefits also have private value.
4. **Combine soil data and models** to provide a full evaluation of the soil natural capital pathway. Soil measurements can provide an indication of current stock levels e.g. soil carbon storage. However, data needs to be combined with modelling to understand changes to soil stocks and ecosystem services in response to drivers over time, and the value of management options.

Figure 2: Soil natural capital pathway definitions

Accounting for the whole soil natural captial pathway provides insights not only into ecosystem services, but also changes in soil natural captial stocks, the resilience of the soil system and the economic implications making the business case for change.

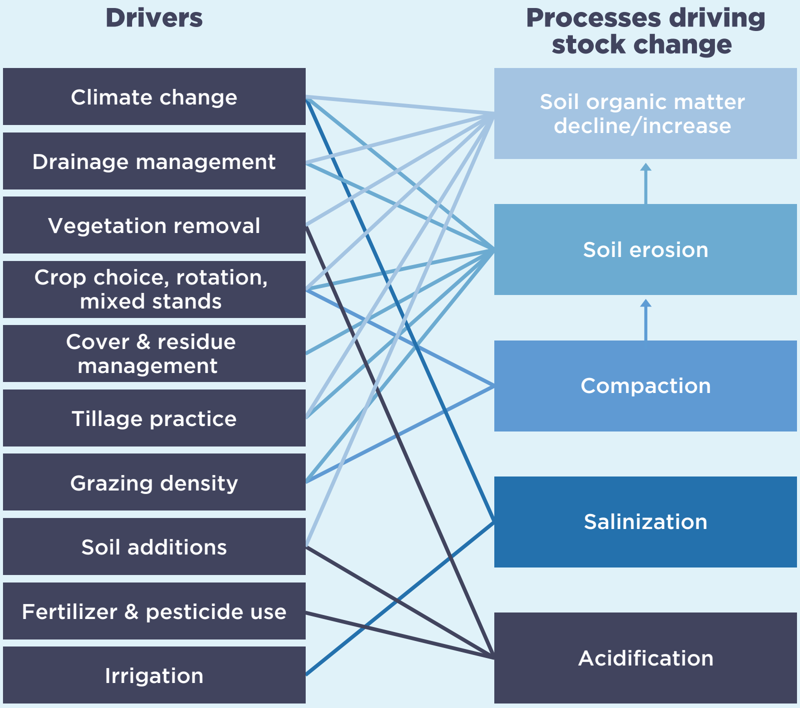
Soil stocks (the amount and quality of the soil) define the capacity of the soil to provide a service of direct human benefit. Soil properties can act as a stock metric.

Supporting processes underpin stocks and services. These can be thought of as supporting services with indirect benefits, and include processes such as nutrient cycling, water infiltration and biological activity.

Drivers are factors that influence stocks and supporting services over time (see Box 1).

Box 1: Key drivers of soil change

The drivers that influence soil processes, stocks and services will vary with what is being farmed, how and where. However, opposite some common drivers that are relevant to many agri-food contexts are highlighted.



How is soil natural capital currently being evaluated?

At present, there are:

- Few natural capital frameworks that specifically address soil as a natural asset;
- Fewer that meet the above criteria for maximising the value of a soil natural capital approach;
- Fewer still that have been applied in agricultural contexts.

Frameworks such as the Millennium Ecosystem Assessment (MEA, 2005) include, but are not specific to soils. Soil-specific frameworks exist but many focus on ecosystem services, without linking to the natural capital stocks that deliver these services. There are a few examples where soil-specific natural capital frameworks have been put into practice[1], but more quantification, investigation of drivers and stock sustainability is needed.

[1] One example of a soil-specific framework that encompasses the whole soil natural capital pathway was presented by Dominati et al (2010). The framework was applied to estimate the current value of a range of ecosystem services provisioning by soils on a dairy farm in New Zealand. Using a process-based model soil ecosystem services were valued at 16,390 $NZ/ha/year (Dominati et al, 2014).

The 'stock adequacy method' demonstrated by Hewitt et al (2015) is an example of how the impact of changing stocks can be assessed by estimating the capability of a soil to provide a service based on a measure of the key natural capital stock that supports the service. As the stock value decreases below and optimum level, service provisioning decreases. The response of the service can be estimated based on observation and/or model data.

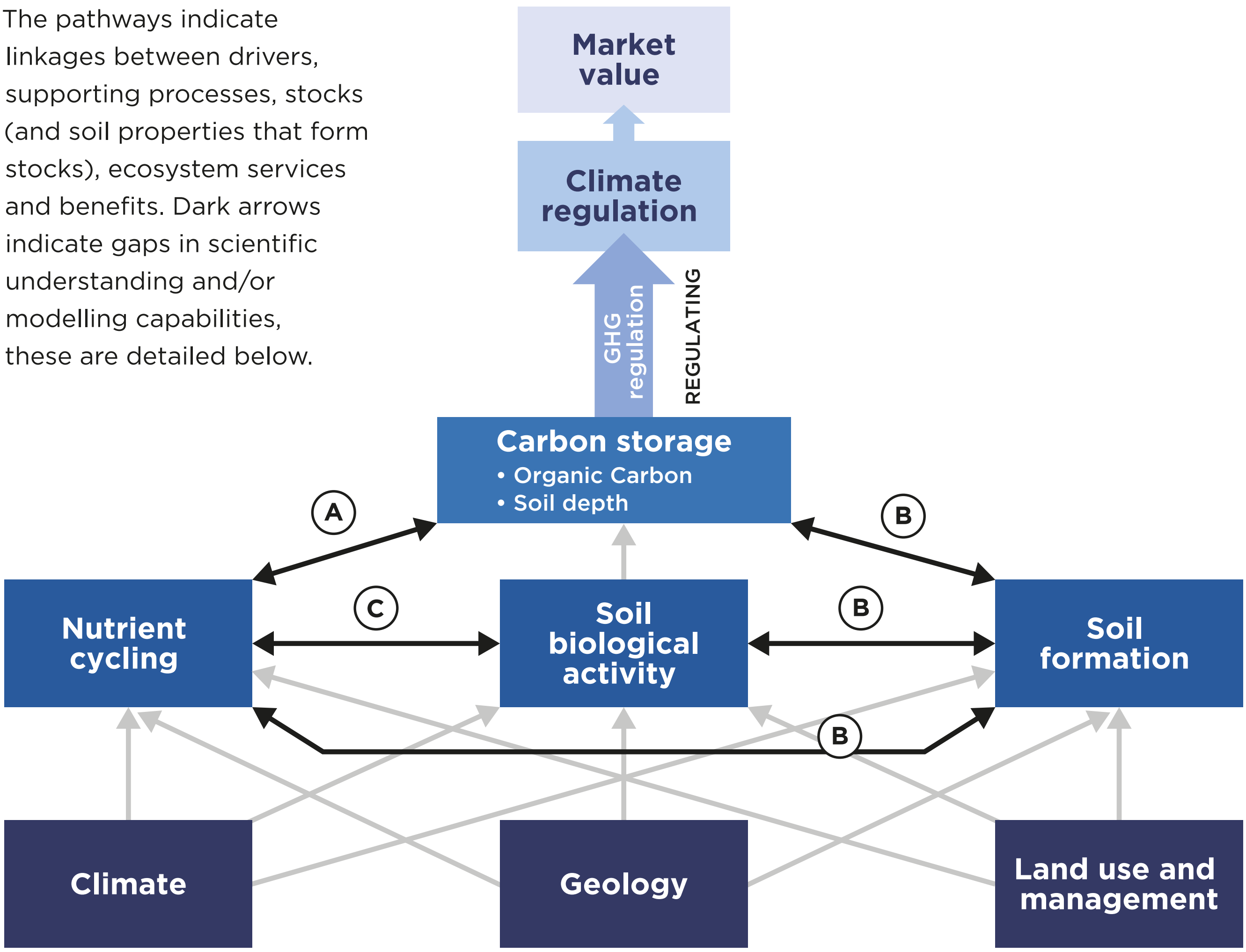
Soil natural capital pathways and gaps

The soil natural capital pathways for the three primary services relevant to agri-business — food production, soil carbon storage, and water regulation — are outlined here as an illustration of what needs to be considered in a soil natural capital approach.

Gaps in our knowledge and valuation capabilities along the pathways are highlighted to help provide a roadmap for developing our ability to value soil natural capital.

Soil carbon storage natural capital pathway

The pathways indicate linkages between drivers, supporting processes, stocks (and soil properties that form stocks), ecosystem services and benefits. Dark arrows indicate gaps in scientific understanding and/or modelling capabilities, these are detailed below.



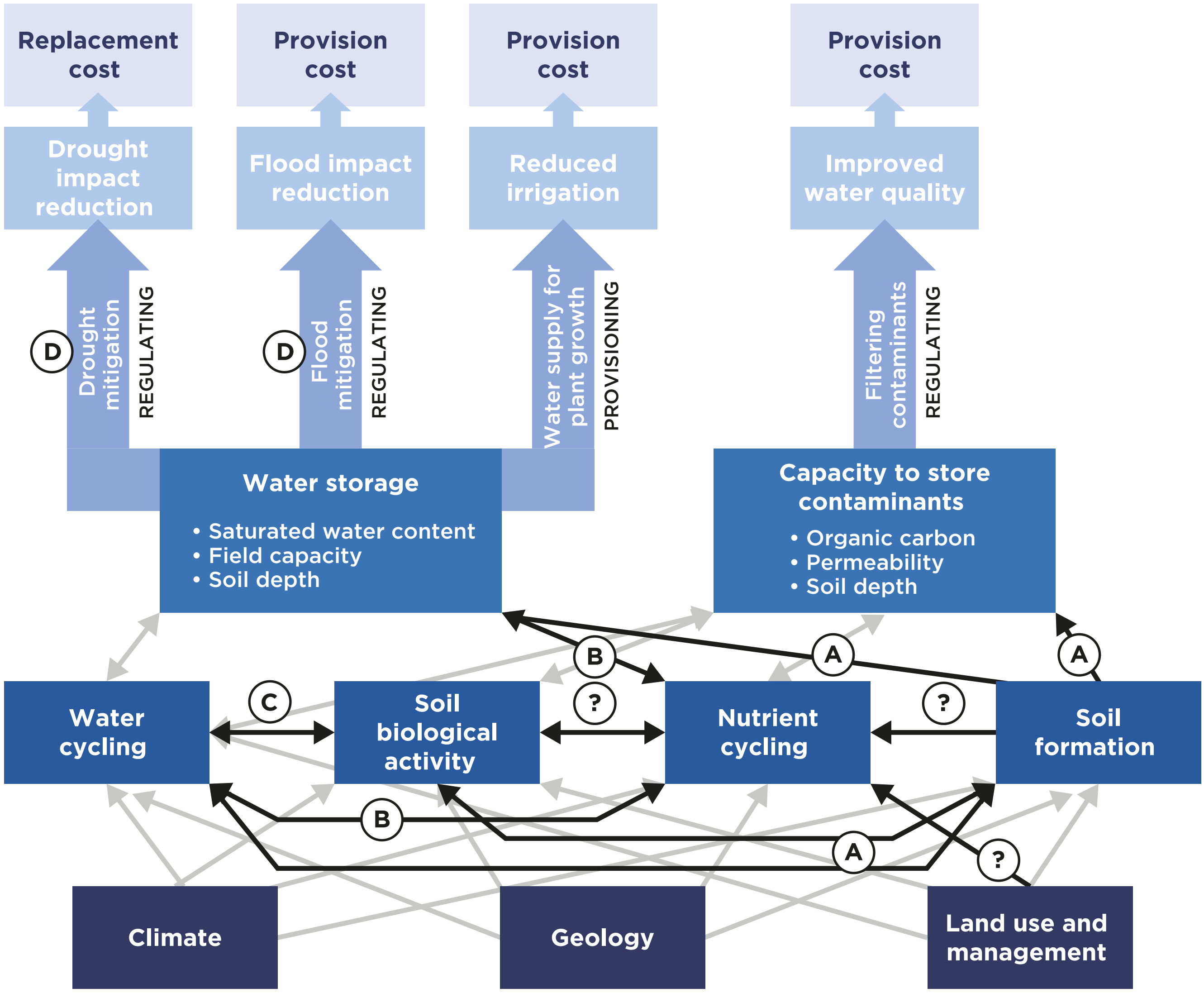
Key gaps in knowledge and capabilities

A. **Nutrient cycles in agricultural soils:** Soil carbon is the focus of many datasets and models, but carbon is closely coupled to other macronutrients such as nitrogen and phosphorus which are highly modified in agriculture. Increasingly models link carbon and nitrogen cycles, but more data and models are needed for linkages with phosphorus.

B. **Soil depth and density:** Soil depth can change due to erosion or mineral and organic accumulation. Soil density can increase in mechanized agriculture and reduce in no-till system with high organic matter input. Data or models that enable us to understand how soil depth and density is changing, and incorporating these changes within supporting processes is a key gap.

C. **Biological activity and the links to nutrient cycling:** Biological activity influences soil decomposition rates and nitrogen fixing – key elements of nutrient cycling. Knowledge of soil biology is rapidly expanding, but more science and models are needed that link changes in the key agri-soil drivers with biological activity changes, and the subsequent effects on other supporting processes and stocks.

Water regulation natural capital pathway



Key gaps in knowledge and capabilities
(in addition to those mentioned previously)

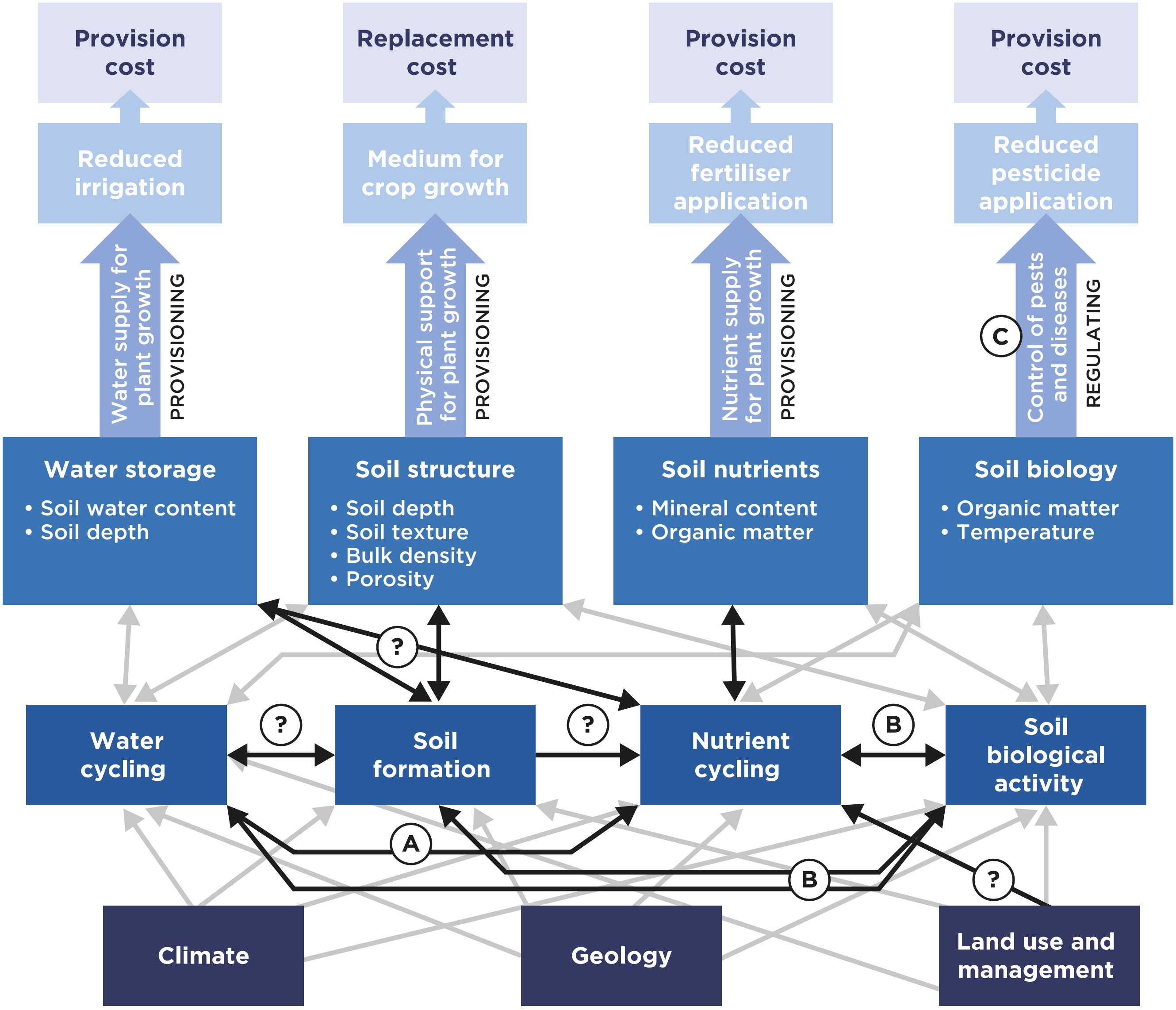
A. **Change in soil depth, density and soil organic** matter influence stocks of water storage and capacity to store contaminants. Several models of water cycling simulate soil erosion, but lack soil depth and soil density change or changes in organic matter content.

B. **Linkages between nutrient and water cycling:** Soil organic carbon increases water storage capacity and soil moisture influences decomposition. These links are not commonly represented in models simulating water processes.

C. **Links between biological activity and water cycling:** Soil biota play a key role in soil structure and aggregate formation, influencing water movement through soils. Means for understanding and predicting the pathways between drivers, biological activity and water stocks and services are a gap.

D. **Flood and drought mitigation services:** how soil stocks influence drought mitigation and flood mitigation services is an under-explored area at present, but the role of soils in natural flood management is a rapidly expanding area of science.

Food production natural capital pathway



Key gaps in knowledge and capabilities
(in addition to those mentioned previously)

A. Plant and soil micronutrients: Few models simulate soil micronutrients, which are of high relevance for agri-food purposes. Soil micronutrient effects on supporting processes are also under-explored.

B. Linkage between biological activity and supporting processes: to simulate stocks of soil biology improved understanding of habitat change through coupling models of nutrient and water cycling is required.

C. Models of soil biological activity: Observational data relating to soil biota and plant health exist, yet there is a lack of simulation models to represent the of control of pests and diseases by soils.

A roadmap to soil natural capital valuation in agri-businesses

Gaps in soil science understanding

Clearly soils are critical for agricultural outputs. But if we are to understand the broader value of soil and its suite of co-benefits, the risks presented by degradation, and make the business case for investment then more integration of knowledge and capabilities is needed.

A wealth of knowledge exists around individual drivers and supporting processes, but new science that integrates these is needed. Many of the gaps identified in the pathways described stem from the fact that science to date has focused on individual (or relatively few) drivers and supporting processes (e.g. carbon cycling, biological activity, water cycling and soil formation). To understand and predict changes in soil stocks, and in turn services, to climate and land use management, we need to consider the soil system as a whole.

A second shared gap across the three soil natural capital pathways is the lack of comprehensive data and models that allow us to evaluate the range of management options that agri-businesses and farms have at their disposal. Science that focuses on how the suite of land management options influence the key soil stocks and services is needed.

Bridging the science-business gap

Whilst the pathways discussed in this report highlight the complexity of soils and the gaps in our current understanding and capabilities, we know enough about soil processes to start making science-based natural capital assessments using existing data and models. But to achieve this, we need to bridge the gap between science and business. To address this, we need:

1. **Closer partnerships between business and science** to develop a clearer understanding of the needs, issues and options agri-food businesses have, and establish specific datasets and tools to address these issues. Stronger partnerships can guide the development of relevant science and future of soil monitoring and management practices.

2. **More funding mechanisms that allow science-business co-creation.** Funding that allows co-development of science-based soil natural capital valuation methods and road-testing in real business settings is needed. This goes beyond consultancy – new scientific discoveries that achieve real practice change needs funding structures that facilitates both goals.

3. **To develop a community of practice around soil natural capital** including academia, business, and the wider set of stakeholders that benefit from soil ecosystem services. Sharing data, methodologies and applications is key to ensuring the sustainable management of soil natural capital, and the continued provision of vital soil ecosystem services.

With thanks

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The Valuing Nature Programme is a 5 year £7M research programme which aims to improve understanding of the value of nature both in economic and non-economic terms, and improve the use of these valuations in decision making. It funds interdisciplinary research and builds links between researchers and people who make decisions that affect nature in business, policy-making and in practice. See **www.valuing-nature.net**

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