THE ENVIRONMENT STRATEGY FOR SCOTLAND

DELIVERING THE ENVIRONMENT STRATEGY OUTCOME ON SCOTLAND'S GLOBAL FOOTPRINT: EVIDENCE BASE AND POLICY LEVERS

Independent report by Global Footprint Network

Global Footprint Network
Advancing the Science of Sustainability

Scottish Government
Riaghaltas na h-Alba

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Disclaimers

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Global Footprint Network
Advancing the Science of Sustainability

Global Footprint Network, an international nonprofit organization founded in 2003, envisions a future where all can thrive within the means of our one planet. We enable our vision through our mission: to help end ecological overshoot by making ecological limits central to decision-making.

Our Partner Network comprises more than 70 organizations around the world. This helps guide our research agenda and contributes to the development of the Footprint methodology and standards. Our work with business, government and individuals helps to ensure the Footprint is relevant and practical.

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1. Abstract

This report discusses pathways for achieving Scotland's goal of being responsible global citizens with a sustainable international footprint. First, it gathers evidence. Then it explores response options.

Section 1 responds to Research Question 1 - what does evidence tell us about the impact of Scotland's consumption and production on the natural environment in other countries around the world, and the extent to which this is sustainable? It introduces the framework for measuring Scotland's international footprint - using the lens of biological regeneration, since in the Anthropocene, this is the world's most limited material resource. The report finds that 47% of Scotland's demand on biological regeneration - its Footprint - is placed overseas. It also shows that, per person, Scotland's Footprint currently exceeds what its territory's ecosystems can regenerate - its biocapacity - by 25% i.e. Scotland is operating with a biocapacity deficit.

Section 2 responds to Research Question 2 - what policy levers could be used most effectively to improve the sustainability of Scotland's international environmental impact? It addresses the need for a systemic approach to managing nature's budget, given we live now in the Anthropocene. To minimise impacts abroad, it highlights the importance of reducing overall consumption demand. For effective adoption of such measures and avoiding policy conflicts, it also suggests prioritising interventions that simultaneously advance wider societal goals. Further, by considering policy levers, interventions and examples of international best practice, the report proposes how impact reduction policies can be integrated into current government activities.

2. Executive Summary

2.1 The questions this report tackles

With clear evidence of the interlinked global climate and nature emergencies, and growing resource constraints, the Scottish Government is inquiring how Scotland can most effectively face this emerging reality. Scotland's Environment Strategy aims to support a whole-of-government approach to playing Scotland's part in tackling these crises, recognising that this will rely on transformations in Scotland's economy and society.

As part of this effort, Scotland wants to understand its overseas environmental impacts and how it can manage (and, ultimately, minimise) them. This is enshrined in one of the Environment Strategy's six outcomes: 'We are responsible global citizens with a sustainable international footprint'. The Scottish Government is developing a 'pathway' for achieving this outcome, identifying actions and priorities across government for improving the sustainability of Scotland's overseas impact.

This report helps to provide the evidence base for informing the development of this pathway. It addresses two research questions:

1. What does evidence tell us about the impact of Scotland's consumption and production on the natural environment in other countries around the world, and the extent to which this is sustainable?
2. What policy levers could be used most effectively to improve the sustainability of Scotland's international environmental impact?

Section 1 addresses Research Question 1 on evaluating the sustainability of Scotland's overseas impact. This section of the report recommends how to think about the challenge of measuring and evaluating ecological impacts of a nation outside its boundaries, and what tools are most relevant for that task. Therefore, it proposes a metric and starts by explaining why this metric is best suited for quantifying Scotland's international Footprint (called "overseas Footprint" in this report). Effective metrics must respond to the current context, particularly as humanity has entered the epoch of the Anthropocene. This new time is characterized by humanity becoming the dominant geological force on the planet, largely through persistent global overshoot i.e. human demand exceeding what the planet's ecosystems can renew.

2.2 Overshoot as the overarching driver

Overshoot is the demand on ecological resources that exceeds what the ecosystems can regenerate. During overshoot, the planet's ecological regeneration becomes the most limiting physical bottleneck for economies. Even fossil fuel is most severely limited by ecological regeneration, as this energy source is more constrained on the waste end (the finite amount of greenhouse gas emissions that ecosystems can assimilate) than by the remaining stocks underground.

Therefore, using regeneration as the metric's lens is the most effective way to systemically track the ecological performance of a city, a country, a company or even humanity as a whole.

By now, the sum of all human activities competing for our planet's "regenerative budget" is so large that only portions are renewed, and the rest depends on depleting the planet's ecosystems. As explained in the report, regenerating humanity's total demand would currently require more than 1.7 Earths. The situation is even tighter than this number may suggest, because some portions of Earth would need to be set aside for biodiversity to stop its decline. Some advocate for the goal of not using more than ½ Earth, which is more than three times less than humanity's current biological resource demand.

The ratio between human demand and regeneration can be quantified by mapping both demand and availability of biologically productive land required to provide for this demand. This is the reason comprehensive Ecological Footprint and biocapacity accounting is chosen as overarching metric for Research Question 1.

2.3 What Ecological Footprint accounts reveal about Scotland's overseas impact

The Ecological Footprint represents the **demand** side – the sum of all the productive areas needed to regenerate what is being taken, such as forests, pasture, crop area or fishing grounds. Biocapacity represents the **availability** – the sum of all these productive areas that exist to provide regeneration. Tracking these through the same lens then allows analysts to compare demand against availability. This then shows the levels of deficits and overshoot.

The consequences of overshoot include climate change, biodiversity loss and resource depletion. These impacts also motivate Scotland's interest to address its overseas Footprints. Managing such impacts requires metrics that can track them, both from the perspective of demand on, as well as availability of, ecological regeneration. Such a metric also helps inform what could be considered "responsible" and "sustainable", thereby supporting the implementation of goals for climate and nature.

More specifically, through the research for this report, this resource accounting approach found that:

- **Scotland's demand on regeneration, i.e. its Ecological Footprint of consumption, stretches to 4.3 global hectares per person**, slightly higher than the UK average of 4.2 global hectares per person.
- **Scotland's Ecological Footprint of consumption currently exceeds by about one quarter what its territory's ecosystems can renew i.e. its biocapacity**. Compared to the UK's biocapacity, which is only 1.1 global hectares per person, Scotland's biocapacity per person (3.5 global hectares) is over three times larger. Still, with a Footprint of 4.3 global hectares per person, Scotland runs a biocapacity deficit. This biocapacity deficit can be met without over-drawing on local ecosystems, for instance by importing goods and services or using global commons such as the atmosphere or international waters. But since humanity's Footprint already exceeds the planet's biocapacity by at least 70%, demand beyond the available biocapacity inevitably leads to depletion somewhere on the planet.
- **An estimated 47% of Scotland's consumption originates from countries outside the UK**. Food comprises the largest overseas Footprint among all consumption categories. Goods have the largest portion of their Footprint originating overseas – over 70%. Housing is on the other end of the extreme with only one quarter sourced from overseas.

At the core of the analysis provided in Section 1 is a table, summarized just below, and with the full details in Appendix A. This table, called the Consumption Land-Use Matrix (or CLUM), provides a breakdown of a country's consumption in 50+ categories by 6 land area types. Below, the CLUM is further divided to show consumption that originates overseas (due to data and scope limitations, we could not determine how much comes from UK versus Scotland, so overseas refers to outside of the UK). CLUMs can also distinguish for each category how much is consumption for building stocks (called "Gross Fixed Capital Formation") versus for

short term use. Short term consumption is divided into that paid for by governments (such as policing, education, social services) or directly purchased by households.

The summarized CLUM below shows the rough distribution, in global hectares per person, of Scotland's total consumption, and breaks down how much of these demands is satisfied by biocapacity from overseas (in yellow) versus from Scotland and the rest of the UK. It also breaks down Scotland's consumption into carbon versus non-carbon Footprints.

	Total			Non-Carbon		Carbon	
Ecological Footprint of consumption (in gha per person)	Total	From Scotland and rest of UK	From overseas	From Scotland and rest of UK	From overseas	From Scotland and rest of UK	From overseas
Total Ecological Footprint	**4.33**	**2.30**	**2.03**	**0.87**	**0.87**	**1.43**	**1.16**
Direct household spending	**2.95**	**1.53**	**1.42**	**0.58**	**0.66**	**0.95**	**0.76**
Food	0.85	0.43	0.42	0.32	0.33	0.11	0.09
Housing	0.47	0.34	0.13	0.04	0.03	0.30	0.10
Personal Transportation	0.70	0.35	0.35	0.03	0.06	0.32	0.29
Goods	0.44	0.12	0.32	0.04	0.14	0.08	0.18
Services	0.49	0.28	0.21	0.15	0.10	0.13	0.10
Government spending	**0.78**	**0.46**	**0.32**	**0.16**	**0.11**	**0.30**	**0.21**
Gross Fixed Capital Formation	**0.60**	**0.32**	**0.28**	**0.13**	**0.10**	**0.19**	**0.18**

Table: The Consumption Land-Use Matrix (or CLUM) for Scotland, expressed in global hectares (gha) per person, shows the sum total of Scotland's consumption split up by land-area type, by consumption area, by origin, by short-term versus long-term etc. Thereby, it puts all consumption demands in context with each other. Since managing our environmental impact in the Anthropocene requires a budgeting approach, this tool enables us to see "environmental expenditures" as a whole, and from a number of cross-sectional perspectives. Data representing year 2018 (Consumption Land-Use Matrix 2022 edition, Global Footprint Network, 2023).

This table, for instance, reveals that 0.42 global hectares (gha) per person from overseas are occupied to feed, on average, a Scottish resident. It also shows that about half of the capacity used for capital formation, which in itself contributes about 15% to Scotland's Footprint (0.6 gha/person out of 4.3), stems from overseas.

Recognising these large resource dependencies and their geographic origins from an all-encompassing perspective illustrates how global overshoot reduction is central to combatting climate change and ecological depletion.

Nearly 60% of Scotland's total Ecological Footprint comes from its carbon Footprint i.e. the area of forestland required to absorb the carbon emissions from Scotland's consumption (in excess of what the oceans already absorb). However, as consumption emissions already being considered through the Scottish Government's climate change policies, this research project focuses on Scotland's non-carbon Footprint. Within this, it addresses **the portion of Scotland's non-carbon Footprint that originates from overseas.** The table shows that the consumption areas which make the greatest contribution to this Footprint are **food** and **goods**. In turn, the contribution from goods is dominated by **clothing**, as shown in the more detailed CLUM in Appendix A.

2.4 How to deal with overseas impacts, given we live in the Anthropocene

Section 2 addresses Research Question 2 by examining what policy options exist to respond to the findings presented in Section 1. In other words, it discusses the strategies and opportunities to reduce what we call here Scotland's "overseas Footprint". This section of the report recommends how to think about the challenge of developing effective policies that would lead to lasting impact reductions abroad.

In the past, it would suffice to directly address specific impacts. However, in the epoch of the Anthropocene, with persistent overshoot, **impacts have become systemic**. Therefore, it now requires managing economies' overall demand on "nature's budget": reducing overuse in one place without reducing demand will simply move demand and its impact somewhere else. In other words, impacts are no longer just a question of **quality** (how we interact with nature) but of **quantity** (how much we demand i.e. the size of economies' material metabolism).

Reducing the total quantity of consumption demand will therefore be essential in order to achieve Scotland's goal of having a sustainable international footprint. This will require careful management, since quantity reduction efforts can be challenging to achieve. Internationally, most efforts that have been successful to date involve shifts from using higher impact resources to lower impact resources, like the phase out of CFCs in the Montreal protocol in favour of less damaging compounds, or the move from coal-based electricity to solar and wind. There have been fewer examples to date of deliberate reductions in *amounts* consumed (examples include reductions through water and energy use efficiencies in times of scarcity).

Therefore, Section 2 emphasizes ways to reduce consumption demand while also strengthening Scotland's long-term prosperity. Approaches that position the environmental goal in ways that support wider societal goals have the highest chance of being embraced. Also, the report explains the benefit of taking the broader view of building Scotland's 'wealth' (i.e. its capacity to operate and thrive) rather than merely driving income (e.g. as measured by Gross Domestic Product), when evaluating policies. Drawing on international examples and existing policy levers, the report recommends how to think about the challenge, outlines possible policy interventions and explores how these could be positioned among current government activities.

2.5 What we can learn from others' examples

This portion of the report builds on a review by the James Hutton Institute (Rivington et al., 2023) in which they discussed policy examples from around the world that aim at reducing environmental impacts abroad. This review makes clear that even 'best practices' are too weak to respond to the size of the challenge, and that many practices have not been in place long enough to even determine their effectiveness.

Most of the existing policies addressing impacts abroad focus on quality aspects, thereby underplaying overshoot. The consequence is impact displacement rather

than their reduction. For example, policies preventing deforestation somewhere, or purchasing the deforestation-free portions of market offers while not reducing excess forest demand, inevitably shift the pressure on forests to somewhere else.

2.6 Intervention opportunities

Consequently, this report identifies specific Footprint reduction opportunities from a systemic perspective. Because the report was tasked with evaluating Scotland's impact on the **natural environment** overseas, we chose to focus on those consumption categories with large portions of their Footprints representing biological inputs, such as **food** and **clothes** (i.e. Scotland's non-carbon Footprint). Therefore, the report barely addresses the largest Footprint component, the carbon Footprint. As noted above, Scotland's consumption emissions are already being considered by other domains of Scottish Government policy. But carbon Footprint reductions would follow a similar logic as outlined here to be successful. It is also important to note that, since climate change is a key driver of biodiversity loss, Scotland's carbon Footprint contributes to its impact on nature overseas.

Finally, the Footprint reduction opportunities identified are also analysed from the perspective of how well they serve other core priority goals of the government, to avoid policy conflicts. Intervention mechanisms are categorized consistently with the Joint Nature Conservation Committee's review of sustainable consumption policy levers (Harris, 2023).

In summary, the **recommendations** presented in Section 2 address opportunities for reducing food waste, strengthening local food production, supporting agricultural innovation, promoting sustainable, healthy diets and establishing more circular supply chains for the textile industry. Scotland already has policies in place across many of these areas, but there are opportunities to go further and to address gaps. For example:

- **Reducing food waste:**
  - Increase action to tackle waste in the **broader food value chain** e.g. at the packaging, distribution, and supermarket levels.
  - Strengthen use of **regulatory and economic levers** for tackling food waste.
  - Increase the ambition of **food waste targets** (which lag behind some other European countries).
- **Strengthening local food production:**
  - Go beyond the current focus on public procurement to encourage consumption of local, sustainably-produced food by **households**.
  - Explore additional opportunities for using **ecolabelling**, and for investing in short supply chain, circular **infrastructure**, like vending machines for local produce.
- **Supporting agricultural innovation:**
  - Increase **R&D** support for agricultural innovations like vertical farming that can help to reduce land footprint, environmental impact and emissions.

- **Promoting sustainable, healthy diets:**
  - Explore additional opportunities for using **ecolabelling** e.g. on the carbon footprint of food products, to influence consumer choices.
  - Ensure school **education** empowers young people to understand the implications of different food choices, and how to cook with more seasonal, plant-based ingredients.
- **Establishing more circular supply chains for the textile industry:**
  - Make greater use of:
    - **taxation** of virgin materials, versus decreased taxes on secondary raw materials
    - **eco-design** and **sustainable production requirements**.
  - Increase action to encourage changes in consumer attitudes and consumption habits e.g. via:
    - **information** and **educational** campaigns
    - investing in **infrastructure** for rentals, repair and recycling
    - incentivising sustainable purchasing through **discounts**.

The section concludes by identifying initiatives already pursued by the Scottish Government that could be used as vehicles for implementing the recommendations. **Opportunities** identified include:

- Keep Scotland's focus on a comprehensive **Environment Strategy**, which recognises the interconnectedness of the climate and nature emergencies and the fundamental relationship with Scotland's economy.
- Accelerate Scotland's transition to a **circular economy** by exploring opportunities for products and services produced in Scotland that currently use *imported natural resources* (e.g. feed inputs for agriculture and aquaculture) to make increased use of *waste produced domestically*. This could potentially be facilitated via post-CAP agriculture funding; Scottish Enterprise and Zero Waste Scotland grants programmes; support for vertical farming to generate alternative feedstocks; redesigning waste management to maximise repurposing of wasted materials; and encouraging long-term planning by the forest industry to serve Scottish industrial needs, including for construction materials.
- **Educate** and empower young people to be sustainable consumers of the future through increased focus in the national curriculum e.g. on food products' carbon footprints; meal planning to combat food waste and use environmentally lighter ingredients; and impacts of, and alternatives to, fast fashion.
- Explore opportunities for **transferring Scotland's green skills (e.g. on remanufacturing) to overseas suppliers** to help them produce products that have lower Ecological Footprints. Also invest in expanding Scotland's green skills in areas like vertical farming.
- Explore opportunities for extending Scotland's existing successful **partnership models** (e.g. business engagement by Zero Waste Scotland and the Scottish

Environment Protection Agency, and the Dornoch Environmental Enhancement Project) to help reduce overseas ecological impact by replacing imports with domestically sourced products.

- Explore opportunities for **grants programmes** run by Scottish Enterprise and Zero Waste Scotland to provide extra incentives to grant recipients to reduce their overseas ecological impact (e.g. through awarding additional funding of points).
- Similarly, explore opportunities for adapting **public procurement** policy to award extra points to providers that demonstrate reduction in overseas impact.
- Build on Scotland's strong **metrics** approach by including indicators on Scotland's resource security e.g. by producing accounts that track demand on and availability of regeneration.
- Support **new industries that reduce Ecological Footprint** to get an early foothold in Scotland. This could potentially be facilitated through a project to identify the next ten new 'low ecological impact industries of tomorrow' and whether there is any existing or future potential to develop any of these industries partly or fully in Scotland.

Achieving the Environment Strategy's goal of ensuring Scotland has a sustainable overseas Footprint requires a **lower material metabolism of the Scottish economy**, involving a **shift to sustainable forms and levels of consumption**. The example recommendations outlined above and in Section 2 are not, in themselves, sufficient to achieve this goal. However, this report recommends how to approach the challenge, and how to position interventions to make them more likely to succeed, in the context of wider goals for a thriving Scotland.

3. Introduction

3.1 Purpose of the report

With clear evidence of the linked global climate and nature emergencies, and growing resource constraints, the Scottish Government is inquiring how Scotland can most effectively face this emerging reality. Scotland's Environment Strategy aims to support a whole-of-government approach to playing Scotland's part in tackling these crises, recognising that this will rely on transformations in Scotland's economy and society.

As part of this effort, Scotland wants to understand its overseas environmental impacts and how it can manage (and, ultimately, minimise) them. This is enshrined in one of the Environment Strategy's six outcomes: '*We are responsible global citizens with a sustainable international footprint*'. The Scottish Government is developing a 'pathway' for achieving this outcome, identifying actions and priorities across government for improving the sustainability of Scotland's overseas impact.

This report helps to provide the evidence base for informing the development of this pathway. It addresses two research questions:

1. What does evidence tell us about the impact of Scotland's consumption and production on the natural environment in other countries around the world, and the extent to which this is sustainable?
2. What policy levers could be used most effectively to improve the sustainability of Scotland's international environmental impact?

Section 1 of the report addresses the first research question, which calls for a "rapid/systematic evidence review describing Scotland's overall global environmental footprint and the extent to which this exceeds the planet's sustainable limits; and the impact of Scotland's consumption and production in relation to specific types of environmental degradation in other countries, such as deforestation, water stress and species overexploitation. The review should identify key impacts, which make a significant contribution to Scotland's overall overseas impact, to help guide and prioritise the selection of policy levers."

3.2 Key definitions used

A number of key terms that are used throughout the report are defined as follows:

- **Biocapacity:** the amount of regenerative capacity of an ecosystem. It is measured in global hectares.
- **Biocapacity Deficit (ecological deficit):** a country's biocapacity deficit is the gap between the country's Ecological Footprint and biocapacity. It is measured in global hectares. An ecological deficit at the country level does not imply the existence of negative environmental impacts domestically because biocapacity can be imported. However, in the era of overshoot, it inevitably leads to ecological depletion somewhere on the planet.
- **Consumption Land-Use Matrix (CLUM):** a table that presents Ecological Footprint results by consumption category and by area use type.
- **Ecological Footprint:** the biocapacity consumed or demanded through an activity. In the context of this report, it refers to the biocapacity demanded by activities of a population, whether Scotland, the UK or the world. The Ecological Footprint adds up all competing demands on ecosystem regeneration. It includes food, fibres, carbon sequestration, space for shelter and roads etc. The carbon Footprint is one domain of the Ecological Footprint. Other of the planet's productive surface areas covered by National Footprint and Biocapacity Accounts are fishing grounds, crop land, pasture, forests and built-up areas. Ecological Footprint is measured in global hectares.
- **Ecological Overshoot:** overshoot generally refers to the condition where demand exceeds regeneration. Global ecological overshoot is, by definition, unsustainable and results in the manifestation of negative environmental impacts. The absence of overshoot does not imply sustainability or absence of environmental impacts. But it is a necessary condition for enabling sustainability.

- **Global hectare:** the standard unit for Footprint and biocapacity accounting. It is defined as a biologically productive hectare with world average productivity. Using it allows the comparison of Footprint and biocapacity over time, across geographies and across area types (biologically productive land and sea areas).
- **Regeneration:** Regeneration is used here in the biological sense, referring to the ability of a natural system, powered by photosynthesis, to renew biomass and support life. From an ecological perspective, this is often measured and referred to as the net primary production of an ecosystem. It can be seen as the currency of life because it is the energetic basis of almost all life on earth. Even mining for ores and minerals links to regeneration. For most elements, the amounts left underground are far less limiting than the damage their extraction and processing causes to the biosphere. Therefore, products from mining are also meaningfully evaluated from a regeneration perspective: how much regeneration is needed for reaping one unit of mining product?

4. SECTION 1: Measuring Scotland's international environmental impact

4.1 Scotland – What makes it special?

Over the past three decades, Global Footprint Network has worked on sustainability projects with nations, regions, cities, businesses, NGOs, universities, communities and others around the world. One thing that has always struck us is that successful sustainability work is often based on whether those carrying it out recognise and harness their own strengths and characteristics.

So, our starting point builds on recognising what makes Scotland special, at least from our vantage point. As outsiders and observers, we sense the following about Scotland:

Nature shapes Scotland's identity as well as endows it with incredible natural wealth. Its natural abundance and nature being seen as a cultural asset make Scotland particularly suited to play a positive role in humanity's efforts to tackle these global challenges.

Scotland is a small nation that has often punched above its weight over the centuries. At different times, it has been a centre of The Enlightenment, a key hub of the Industrial Revolution, a pre-eminent medical research centre and, in more recent times, a powerhouse in the practical deployment of wind energy.

This demonstrates that Scots can pride themselves for being forward-thinking, generous and open people. Scotland wants to make its contribution to the world and share it with the world. It wants to be a global citizen in deeds, not just in fine words. Its track-record proves it. Hence the genuine question about how to reduce Scotland's overseas impact.

Creating a sustainable world requires these characteristics in abundance. As a species, we will not solve the climate or nature emergencies or other challenges

such as inequality of wealth and opportunity without considerable co-operation and openness being brought to the fore.

We, therefore, recommend that these compelling general and natural characteristics of Scotland are kept front of mind when designing and evaluating policy options in this project.

4.2 The context of overshoot

Humanity has entered a new age, living on a planet dominated by human presence. Some have called it the "Anthropocene"[1]. It is characterized by human activities having started to exceed what the biosphere can replenish. Simply said, humanity is operating in overshoot. Human demand exceeding ecosystem regeneration means that a portion of demand results in either ecosystem depletion or waste accumulation. Hence, overshoot is a situation that can only be maintained temporarily.

The persistence of global overshoot, now for over half a century, has led to an accumulated ecological debt, leading to huge decline in biodiversity, excess greenhouse gases in the atmosphere and heightened competition for food and energy. These symptoms are becoming more prominent with unusual heat waves, forest fires, droughts and floods.

The planetary context of ecological overshoot makes obvious that human activities have entered an ever-stiffer competition for regeneration. Conservative estimates, based on UN data sets, suggest that human demand now exceeds what the planet's ecosystems can regenerate by at least 75%. In addition, some of the regenerative capacity of ecosystems is also needed by wild species for their survival. Ecologists have pointed out that leaving half of the planet's capacity aside for wild species may enable us to maintain at least 85% of the planet's biodiversity (Wilson 2016). International agreements are inching in this direction, with the latest biodiversity convention, COP15, calling for conserving 30% of the planet's terrestrial and marine habitat by 2030.

This gap between how much humanity demands and the level of demand that the planet can tolerate indicates that currently, humanity's demand on our planet's biological regeneration is over three-fold[2] too large. This makes it obvious as to why regeneration, i.e. the biological services that the planet provides, is becoming the material bottleneck for the human economy.

4.2.1 Approaching "impact" in the context of overshoot

Recognising this context helps us more clearly define key terms of the research question, because the terms it uses, such as "impact" and "sustainable" are ambiguous. "Impact" is a broad and common term but lacks a specific definition. It

[1] Some have associated the beginning of this new era with the "great acceleration" of resource throughput post World War II.

[2] With human demand corresponding 1.7-fold what Earth can renew, while also recognising that demand should be within half the Earth's capacity gives us an indication of how far the human metabolism exceeds a desired state: 1.7 / 0.5 = 3.4, i.e. more than a factor three.

is an umbrella expression referring to consequences of an action. In some arenas, such as in "impact investment", impact refers to ancillary benefits. In the environmental domain, impacts typically refer to detrimental effects. Given the Anthropocene, we propose prioritizing a more specific "impact" for this report, one that is particularly relevant in the current context of persistent global overshoot. Overshoot makes clear that "competition for regeneration" has grown into a key dynamic. Hence, mapping humanity's competing demands for biocapacity becomes a helpful navigational aid for managing our economies' resources.

A deeper explanation of the approach, its underlying assumptions, practical application principles and methods used, is provided in Appendix B. That piece explains in more detail why most "environmental challenges" boil down to a competing use of regeneration. Whether it is access to minerals, the use of fossil fuels or production of food – all these activities are limited by regeneration.

Therefore, in the context of this report, we consider impact primarily in terms of "demand on regeneration". In the case where other, specific detrimental impacts on the environment are discussed, we will more clearly define them, as in the case of biodiversity loss or pollution.

4.2.2 A hierarchy of impacts

Viewing the human-nature relationship through the lens of regeneration addresses fundamental aspects of sustainability but is not inclusive of all environmental sustainability issues. It does not reflect the full complexity of biodiversity, the nuisance of noise, overuse of rare minerals, health outcomes related to air and water pollution, or human diseases. But it covers most other aspects. Overuse of regeneration may even be an enabler of these more specific environmental damages.

Still, the regeneration lens illustrates that there is a hierarchy among impacts (see Figure 1). Operating in the era of persistent global overshoot, with human demand largely exceeding what ecosystems can regenerate, the impact hierarchy becomes the following:

Given the "competition for regeneration" in the context of global overuse, the primary question is one of quantity: "How large are human demands compared to ecosystem regeneration?" This lens makes quantity the **primary** focus of an impact analysis because exceeding regeneration rates inevitably leads to overuse and depletion somewhere. Furthermore, protecting one area from overuse without reducing human demand inevitably displaces the impact to somewhere else with no net improvement.

Ultimately, human needs depend on material inputs that our planet's natural systems can regenerate. Hence it is essential to protect and maintain the health and productivity of ecosystems. However, protection and maintenance of high-quality ecosystems cannot be replicated across all ecosystems if the overarching material imbalance, i.e. human demand exceeding ecological regeneration, is not rectified. Focusing on the quantity of resource flows demanded versus regenerated provides an absolute measure of this imbalance.

Conversely, with the quantitative imbalance being addressed, it is possible to improve quality at scale. Hence, quality is **secondary** in this hierarchy.

For instance, regenerative agriculture that maintains soil health and larger agricultural variety would be a quality improvement over intensive monocropping. Another example is the need to provide for carbon sequestration. If this is achieved by restoring ecosystems, then this addresses both quantity (e.g. amount of greenhouse gases) as well as quality (e.g. healthier ecosystems, with biodiversity benefits) simultaneously. Clearly, sustainability ultimately depends on quality being scaled if we want to be able to maintain ecological health. But for that goal, addressing the quantitative imbalance is a precondition.

Since regeneration does not, as discussed, cover all aspects related to environmental sustainability, additional specific issues fall into the **tertiary** category of this hierarchy. For instance, noise, overuse of rare minerals, or diseases are not directly addressed by the regeneration lens but are nevertheless impacts that would need to be mitigated. Because symptoms of ecological overuse are often visually striking and morally compelling, sustainability solutions often focus on secondary and tertiary issues through a damage minimization or symptom reduction approach rather than the underlying drivers of ecological overuse.

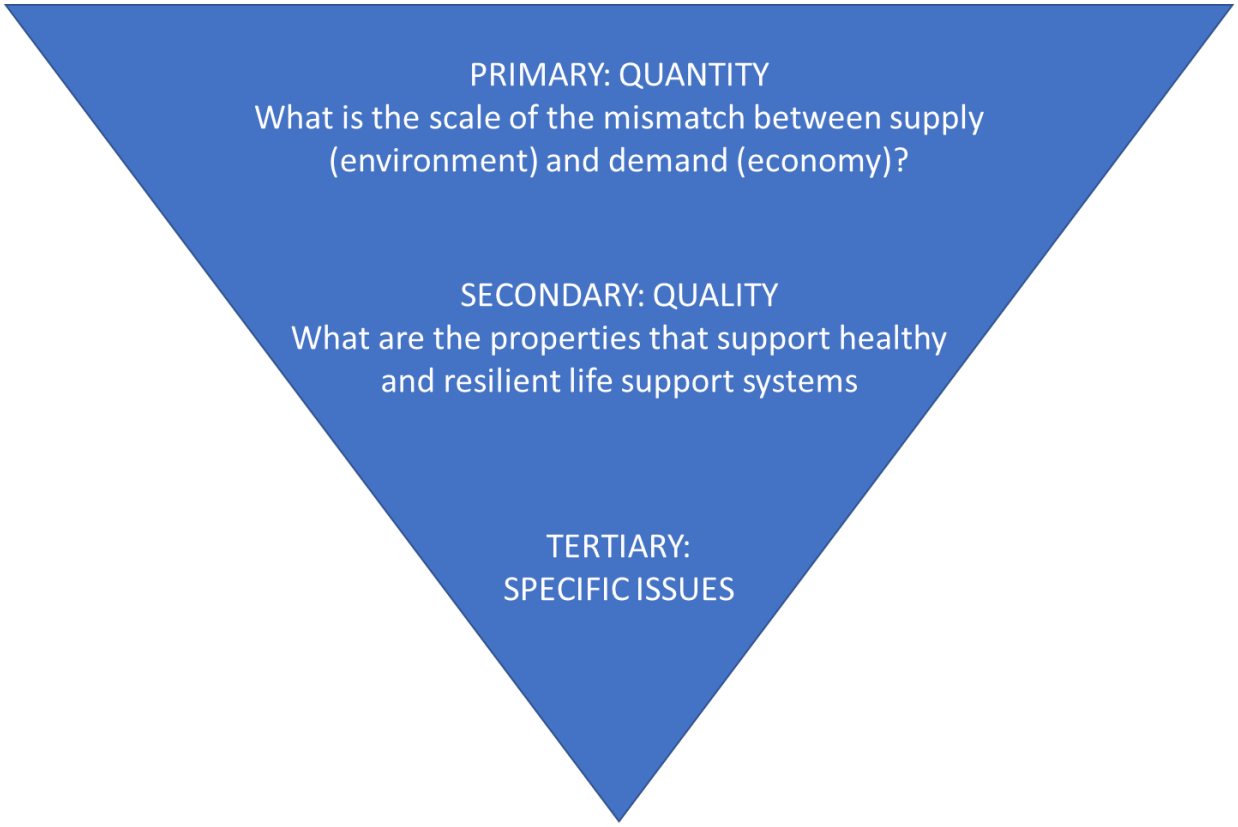

Figure 1: There is a hierarchy of impacts: in times of overshoot, the primary driver is the quantitative material imbalance. If the quantity of human demand on the regenerative capacity of the planet is not addressed, qualitative goals, such as biodiversity maintenance, clean water or protection of soils, cannot be achieved at scale. Gains in quality in one place, achieved by reducing pressures there, will be cancelled by loss in quality in other places to which excess demand is getting displaced. More specific qualitative goals may therefore also come at the cost of displacing pressures to somewhere else.

As a result, we approach **Research Question 1** through the lens of this hierarchy. This is why we first map the quantity of demands on regeneration, as well as the quantity of regeneration available. This mapping could also provide a starting point for considering quality issues, as the basic land types are distinguished. For instance, urban land used to accommodate cities compromises regeneration and biodiversity. Again, not every unit of urban land is equal. Some is more ecologically friendly, with more green space, lower pollution levels, more trees, more permeability for water, etc. Or cropland can be used for intensive mono-cropping, or it can be farmed in ways that offer greater protection for the health of the soil and of biodiversity.

In other words, establishing overarching quantitative accounts (primary impact) provides a baseline for the evaluation of the quality of use of these areas (secondary impact), and then to test whether there are any other issues on those areas (tertiary impact) that have not been addressed by the quantity or quality analysis of demand on regeneration.

This report addresses the primary tier, providing a first estimate quantitative analysis of Scotland's biocapacity and its Ecological Footprint of consumption. A more complete analysis, including additional Scotland-specific data, would also examine Scotland's production Footprint[3].

4.3 The meaning of sustainability and how we approach it here

A first task in addressing the research question is to track impacts on the environment. In addition, for interpreting impacts, we need to know how much impact the environment can absorb. After all, all human activities require material inputs, and nature does provide us with such input. The challenge is to ensure that the demand stays within an amount that the biosphere can regenerate.

It is more straightforward to define what is "not sustainable". Anything that continually degrades ecosystem regeneration capacity, through overuse or damage, cannot be maintained forever, and is therefore unsustainable. The quantitative condition of staying within the "ecological budget" or demanding less than ecosystems regenerate is therefore not a proof of sustainability, but a necessary (yet not sufficient) condition for sustainability.

Sustainable consumption would require safeguarding some amount of the planet's biocapacity budget for the maintenance of biodiversity, so this must also be taken into account. Ecologists (such as E.O. Wilson) and conservationists (such as the natureneedshalf coalition) have made the case that people using more than half of the planet's "budget" is destructive for biodiversity. The newest biodiversity agreement, CBD-COP15 "Kunming-Montreal Global Biodiversity Framework", aims to set aside 30% of the land for biodiversity protection before 2030.

[3] For lack of data, and due to limited scope of this project, this study only covers the consumption Footprint of Scotland, extrapolated, as explained in Appendix B, from the UK situation. The production Footprint would inform about resources required to power Scotland's economy. The economy in return earns the financial income that then is (largely) used to pay for Scotland's consumption.

Further, the areas being used need to be used in ways that maintains their biological integrity. UN data sets applied to national Footprint assessments are more complete on harvests and waste production, and do not provide direct information on damage to ecosystems. This means the numbers presented in this report most likely overestimate biocapacity and underestimate Footprint demands.

Also, the biocapacity estimates in this report represent current levels of regeneration. In the context of rapid and accelerating climate change, the likelihood of extreme weather events increases. This includes more potential for floods and droughts, disruption of growing seasons, migration of pests and invasive species etc. Such disruptions could make highly intensive production systems even more vulnerable. All this increases the potential for agricultural outputs not only fluctuating, but also being compromised. Therefore, to increase economic resilience, larger ecological margins may need to be considered to safeguard Scotland's resource security.

Finally, some apply the term "sustainable" even more broadly, including social dimensions, such as social equity, policy acceptability, and inclusion. They would make the valid case that situations that societies are not happy with will not last either.

Given this wide and sometimes ambiguous use of the term "sustainable", we focus here on a core, measurable aspect, which is: To what extent do human demands fit within the regenerative capacity of ecosystems?

4.4 We are entering a new era

4.4.1 The future we anticipate

While we cannot accurately predict the future, there are many aspects of the future that we can anticipate with high confidence. Since the early 1970s, humanity's metabolism has exceeded the regeneration of our planet, putting us in a state of persistent global overshoot. At present, humanity's material metabolism is exceeding Earth's regeneration by 71%, as stated above and shown in Figure 2. The cumulative impact has left an ecological debt that is shifting the context in which humanity operates.

These persistent trends make the future more predictable. We know not only that people will want to eat, be housed, have fun, feel safe. We also know that we will live in a world with far more climate change and other impacts caused by ecosystem depletion. With near certainty, any imaginable scenario will include increased climate-related disruption and resource scarcity. Mitigating the impacts of climate change will come at the cost of more rapidly phasing out fossil fuel, which will reduce reliable agricultural and forestry outputs; conversely, delaying decarbonization will lead to more rapid acceleration of climate change, which will tighten the strain on the planet's biological resources through climate disruptions. This future is approaching more rapidly than companies, cities and countries may be able to adapt, given the physical inertia of infrastructure.

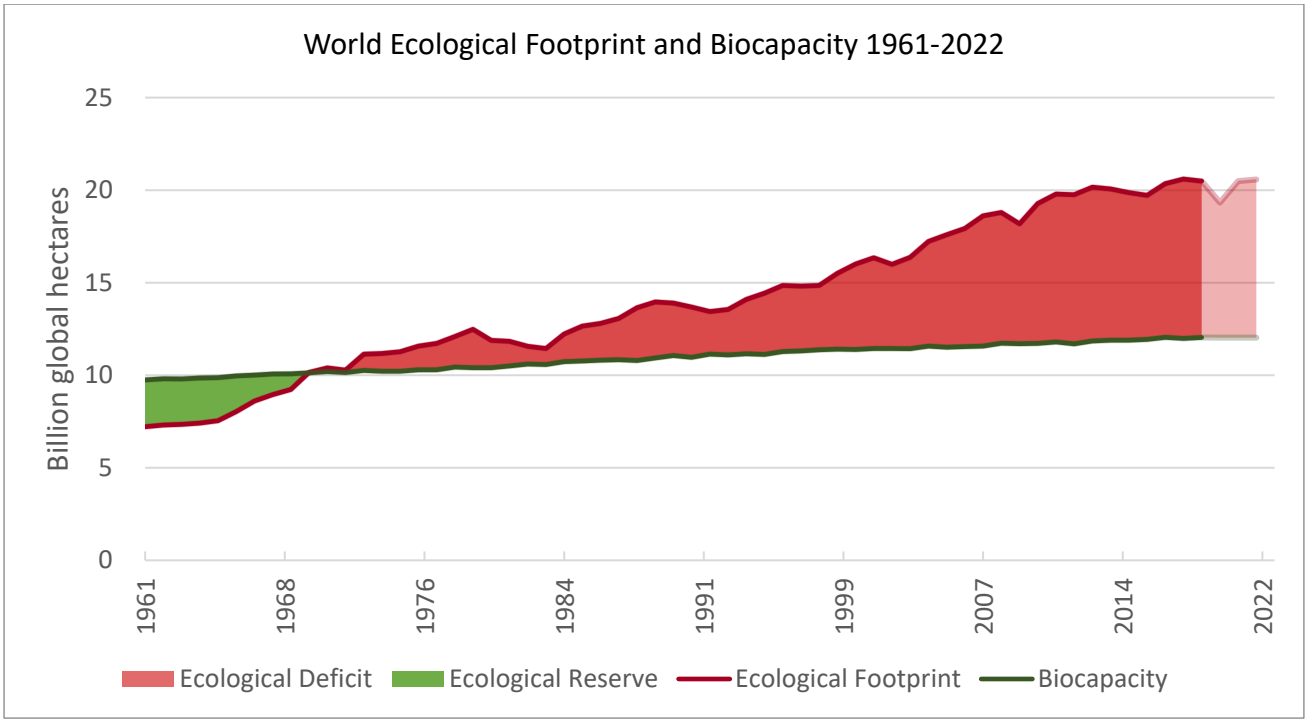

Figure 2: World Ecological Footprint and biocapacity 1961-2022 in billion global hectares. Ecological Footprint is the amount of bioproductive land area needed each year to sustain our production and consumption and absorb our waste. Biocapacity is the amount of bioproductive land area that can be renewed each year. Both are expressed in global hectares, a productivity-adjusted measure of land area.

4.4.2 What biocapacity offers as a lens

From an ecological perspective, Earth has a finite amount of biological production or regeneration that supports all life. This is called biocapacity. Given that biocapacity is humanity's physically most limiting factor, Ecological Footprint and biocapacity accounting reveals key risks and opportunities related to a future with more climate change and resource constraints. It addresses the essence of the sustainability challenge by comparing the amount of bio-productive surface area demanded by people (Ecological Footprint), with the planet's ability to regenerate (biocapacity). A foundational measure for the sustainability domain, Ecological Footprint (hereafter Footprint) accounts provides an integrated, multiscale approach to tracking the use and overuse of natural resources. Once basic resource demands are understood, the analysis can be extended to address more specific concerns, including deforestation, water stress and biodiversity loss, which themselves are also related to overusing biocapacity.

Footprint assessments encompass pressures associated with economies' resource metabolism – food, energy, carbon emissions etc. To assess these pressures, we start with the National Footprint and Biocapacity Accounts, computed annually for many countries globally (York University 2023). Combined with Multi-Regional Input Output Assessments, the composition of national resource flows, including breakdowns by consumption categories, can be deduced. To understand the Ecological Footprint of a region within a country, in this case Scotland within the UK, we use a top-down approach, with local data to distinguish the country

performance (UK) from the regional performance (Scotland) to provide insights into more specific resource demands of the region. See Appendix B for further details.

Like any accounts, Ecological Footprint accounting is a systematic way to document historic performance. It is not a normative indicator of progress. However, it provides context for users to set their targets. Its descriptive nature allows the metric to be applied across broad contexts, which is a key element of sustainability-assessment frameworks. This makes the Ecological Footprint relevant across a wide range of sectors and socio-political entities, each with their own unique cultures, natural systems and methodological approaches to sustainability responses.

4.4.3 How to thrive in this future?

Whether Scotland can thrive in the predictable future of climate change and resource constraints will depend on the ability of its infrastructure, production systems and supply chains to operate in this new context.

The question is: which assets will be able to operate, and therefore be valuable to both the investor and society, in this predictable future? Our hypothesis is that those assets which reduce global overshoot when they expand will be more valuable, because they will be less vulnerable to physical constraints. Such assets, whether infrastructure, production systems or supply chains, will be more resilient to shocks and shortages. If a country's assets can meet the future needs of its inhabitants, they will have true value.

If we accept this hypothesis, then understanding a country's resource performance is central, and this is the focus of answering Research Question 1: "What does evidence tell us about the impact of Scotland's consumption and production on the natural environment in other countries around the world, and the extent to which this is sustainable?"

4.5 Evidence base: key findings from the analysis

4.5.1 UK and Scottish resource context

Contrasting a country's biocapacity with its Ecological Footprint broadly summarizes its resource situation. The need to contain humanity's Footprint within the planet's biocapacity is a fundamental sustainability condition because the planet has no option to compensate for this imbalance with input from somewhere else. This echoes the key message from the 2021 Dasgupta Review that our economies and societies are embedded in nature, and must operate within its sustainable limits. A global natural resource deficit implies ecological overshoot with the inevitable consequence of degradation and depletion of natural capital and waste accumulation. Economically speaking, it is like living off asset liquidation rather than off the interest generated by capital. Individual countries, however, can maintain a biocapacity deficit because they can make up the difference with trade, as long as they have enough purchasing power.

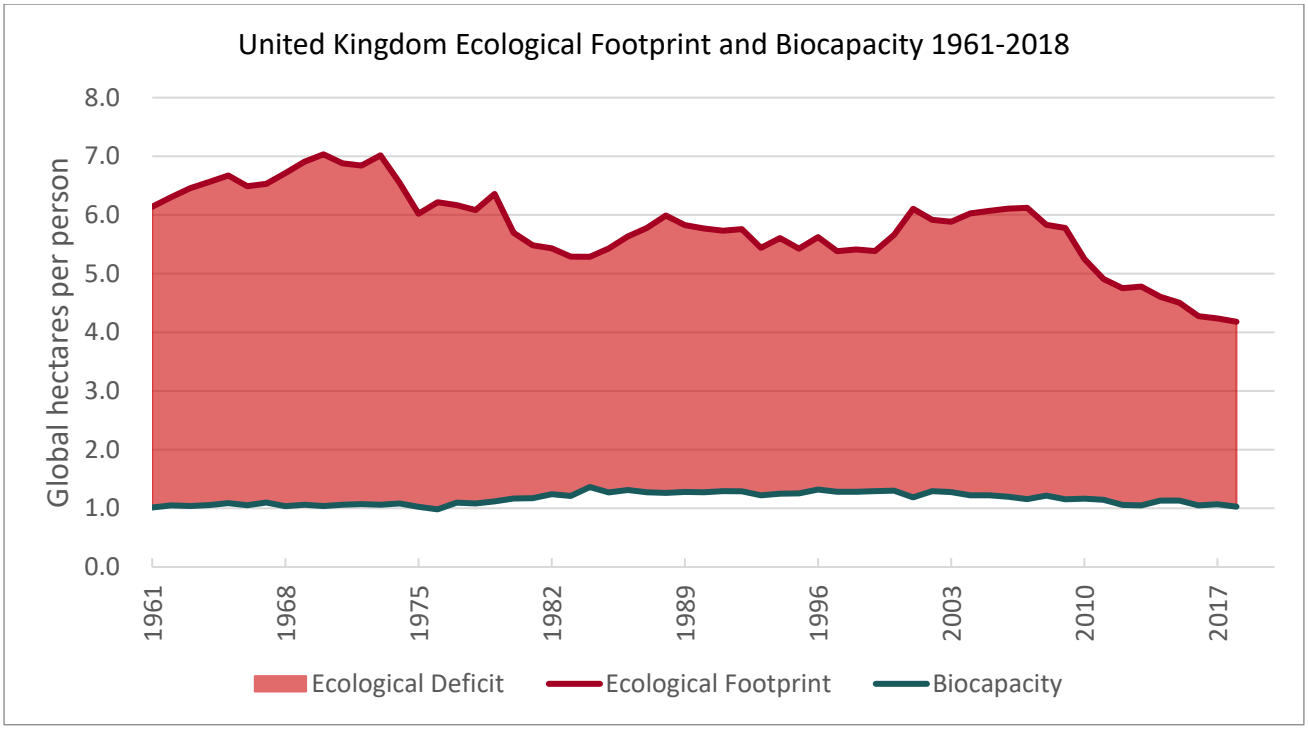

Figure 3: Ecological Footprint and biocapacity per person of the United Kingdom 1961-2018. Expressed in global hectares, a productivity-adjusted measure of land area.

According to the National Footprint and Biocapacity Accounts (NFBA; York University, 2022), the UK's Ecological Footprint per person amounts now to 4.2 global hectares per person, but has declined steadily by an average of 3.6% per year since its most recent peak in 2007. Most of the decrease is associated with decreases in the carbon Footprint, both in domestic production, as a result of cleaner electricity generation and reduced fuel consumption, electricity use and transport emissions; and also in the Footprint of imports. Still, **the UK is operating with a large biocapacity deficit: it demands over 4 times the biocapacity of its natural resource base** (Figure 3). At present, Scotland does not feature separately from the UK in the National Footprint and Biocapacity Accounts, and thus a similar understanding of Scotland's resource intensity over time does not yet exist.

However, a study by The University of Stirling and Global Footprint Network (Horsburgh et al., 2022) estimated Scotland's biocapacity for 2018, allowing the comparison with Scotland's 2018 Ecological Footprint (produced in this research) to give an indication of Scotland's resource context, relative to the UK and rest of the world for 2018.

Using the approach outlined in Appendix B, the present analysis estimates **Scotland's Ecological Footprint of consumption in 2018 at 4.33 global hectares (gha) per person** or 23.6 million gha (Table 1) when scaled by Scotland's 2018 population estimate of 5,438,100.

Scotland's biocapacity for 2018 is estimated to be 3.5 gha per person, or 19.02 million gha. On a per person basis, this is over three times the UK 2018 biocapacity

of 1.1 gha per person and more than double the average global biocapacity of 1.6 gha per person (Table 1).

Footprint Category	Ecological Footprint (EF)	Biocapacity (BC)	BC-EF
Crop land	4,460,720	2,933,952	-1,526,768
Grazing land	1,403,854	1,068,368	-335,485
Fishing grounds	448,666	6,610,102	6,161,435
Built-up land	729,819	1,298,864	569,045
Forest (Wood Products)	2,426,742		
Forest (Carbon Footprint)	14,091,344	7,112,800	-9,405,287
TOTAL	23,561,145	19,024,085	-4,537,059

Table 1: Biocapacity and Ecological Footprint for Scotland in global hectares (gha), 2018 data. Data source: Ecological Footprint this study, biocapacity from Horsburgh et al., 2022.

In contrast with the UK and rest of the world, Scotland thus has a greater wealth of biocapacity per person. While this is partly due to Scotland's low population density, Figure 4 shows that Scotland also has a **resource advantage due to a relative wealth of marine and forest biocapacity.** This stems from Scotland's large shelf sea area, and its coniferous plantations, which account for over 60% of the UK's forestry production. In a world of persistent overshoot, having domestic biocapacity can both mitigate risks and provide opportunities related to climate change and resource constraints and warrants careful consideration in long-term management.

To gain an understanding of Scotland's resource intensity, biocapacity needs to be compared with the Ecological Footprint. Comparisons of the biocapacity and Footprint of Scotland, the UK and world (Figure 5) show that **Scotland has a relatively large Ecological Footprint per person** (larger than that of the UK or world; reasons for this are discussed below). Figure 5 also shows that Scotland's substantial Footprint is offset to a large extent by its wealth of biocapacity, leading to a smaller relative ecological deficit than that of the UK or world. However, care must be taken not to place too large an emphasis on Scotland's biocapacity advantage.

As shown in Table 1, **despite Scotland's large forest and marine biocapacity, it is nonetheless operating with a biocapacity deficit of over 4.5 million gha** (or 0.83 gha per person). Scotland's excess consumption can manifest domestically as the overuse of domestic ecosystems, which leads to deforestation, biodiversity loss and other symptoms, however some of Scotland's biocapacity deficit is met by importing the difference from overseas. Given global overshoot, this deficit therefore leads inevitably to depletion elsewhere.

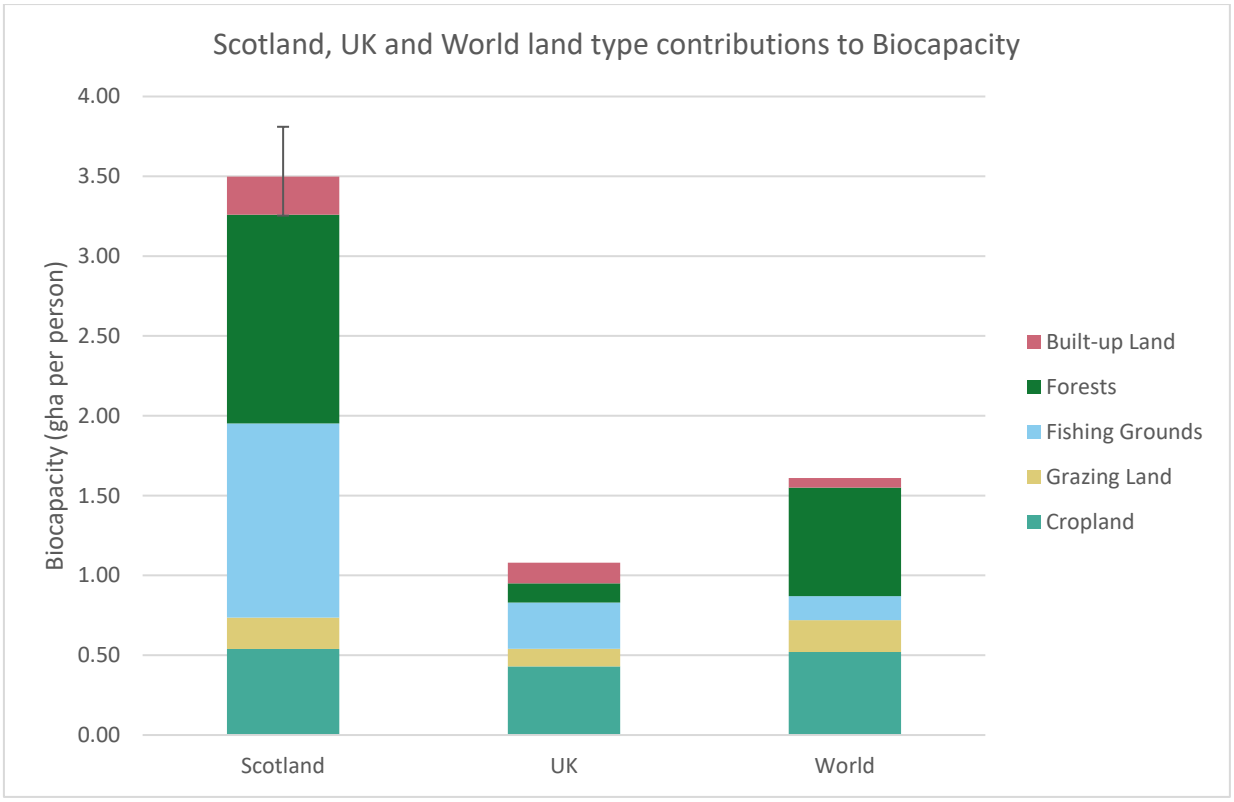

Figure 4: Land type contributions to biocapacity. Error bar = Scotland's estimated biocapacity range: 3.3 to 3.8 gha per person. UK and World biocapacity for 2017 (York University Ecological Footprint Initiative, 2022).

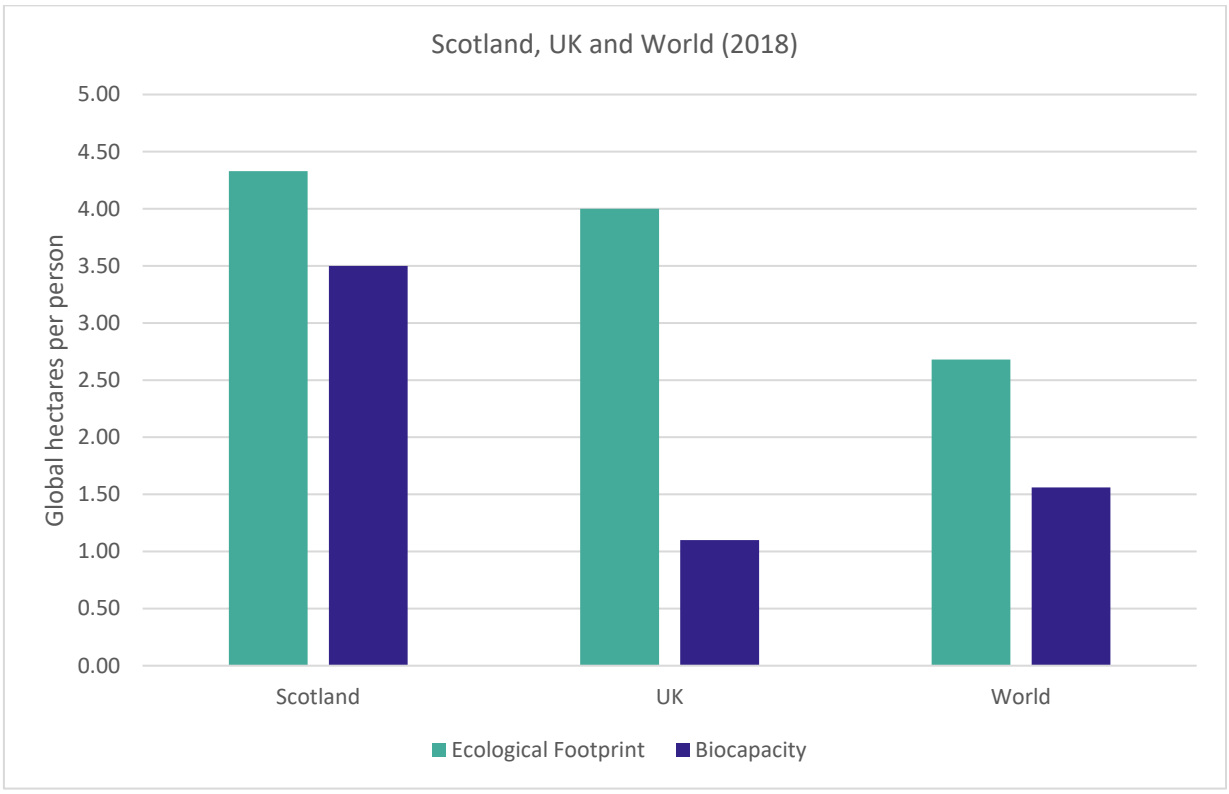

Figure 5: Ecological Footprint and biocapacity per person of Scotland, United Kingdom, World, 2018 in global hectares.

Further, Footprint categories in Table 1 reveal large biocapacity deficits in cropland (linked with food and textile consumption) and the carbon Footprint (linked with emissions in all consumption domains). The consumption categories linked with cropland and carbon Footprint thus provide potential opportunities to improve Scotland's overseas Footprint. As Scotland is also tied into the UK economy, which runs an even larger biocapacity deficit, paying attention to resource flows and dependencies is particularly relevant, and could guide economic development strategies that enhance Scotland's chances to operate effectively in the predictable future of climate change and resource constraints.

To manage the consumption Footprint more effectively, Footprint results can be broken down by consumption categories. This breakdown is produced through input output assessments (see Box 1) and results in a Consumption Land Use Matrix (CLUM). Table 2 shows a summarized version by consumption domains. Appendix A contains the full table.

Box 1. Consumption Land-Use Matrix results are derived from an Ecological Footprint Extended MRIO (Multi-Region Input Output) model and therefore include all inputs within the global supply chain associated with final demand spending or consumption. The MRIO framework considers three types of final demand: household consumption, which includes goods and services directly purchased by households; government consumption, which includes goods and services purchased by governments; and gross fixed capital formation consumption, which includes purchases of fixed investments or durables good such as infrastructure or shelter. Ultimately all goods and services consumed can be framed as a provision for human needs (Food, Housing, Transportation, Goods, and Services) either directly purchased by households, paid for by government, or provided by fixed capital formation which was paid for in the past. A detailed list of subcategories can be found in Appendix A.

This CLUM is the core offering of the research presented here and it provides a mapping of Scotland's resource dependence. Not only does it provide an estimate of Scotland's Footprint by various consumption categories, for instance Food, and sub-categories, for instance fish and seafood consumption. Also, it makes estimates of Scotland's Footprint available by country of origin. Note, because of data limitations, "overseas" in this analysis refers to originating from outside of the UK, and "domestic" refers to originating within the UK.

High level results show that **47% of Scotland's Footprint originates from overseas. Food comprises the largest overseas Footprint** among all consumption categories, with food harvested overseas making up over 10% of Scotland's total Footprint (Table 2).

The CLUM results also provide insights into Scotland's large per-person Footprint. **Compared to the UK, the portion of the Scottish Ecological Footprint that is paid for directly by households is lower**. However, the Ecological Footprints portion paid for directly by the **government** (such as policing, teaching or providing healthcare) and **fixed capital investments** (such as constructing roads and buildings), on a per person basis are **much larger in Scotland**, resulting in an overall larger per-person Footprint.

Within the Ecological Footprint directly paid for by **households** (Figure 6), **food** is the largest contributor, followed by **personal transportation**, then **services**. Because CLUM results include all supply chain inputs, all consumption categories contain inputs from all land-use types. The food Footprint, for example, contains all food producing land-types (cropland, grazing land, fishing grounds) but also built area, forest product, and carbon Footprint representing the infrastructure and wood and fibre products, and carbon emissions from energy use, packaging, and transportation that are associated with providing food for households.

Ultimately, consumption paid for by **governments** and **fixed capital investments** for long-term assets also serve the five basic need categories (food, housing personal transportation, goods, services). Therefore, these two domains can also be re-integrated into the five final household categories as indicated in Figure 7. When including those two aspects in the five basic categories, **services** and **housing** become the two largest segments of Scotland's Ecological Footprint. Housing becomes dominant because building and maintaining houses is resource intensive, not just operating them.

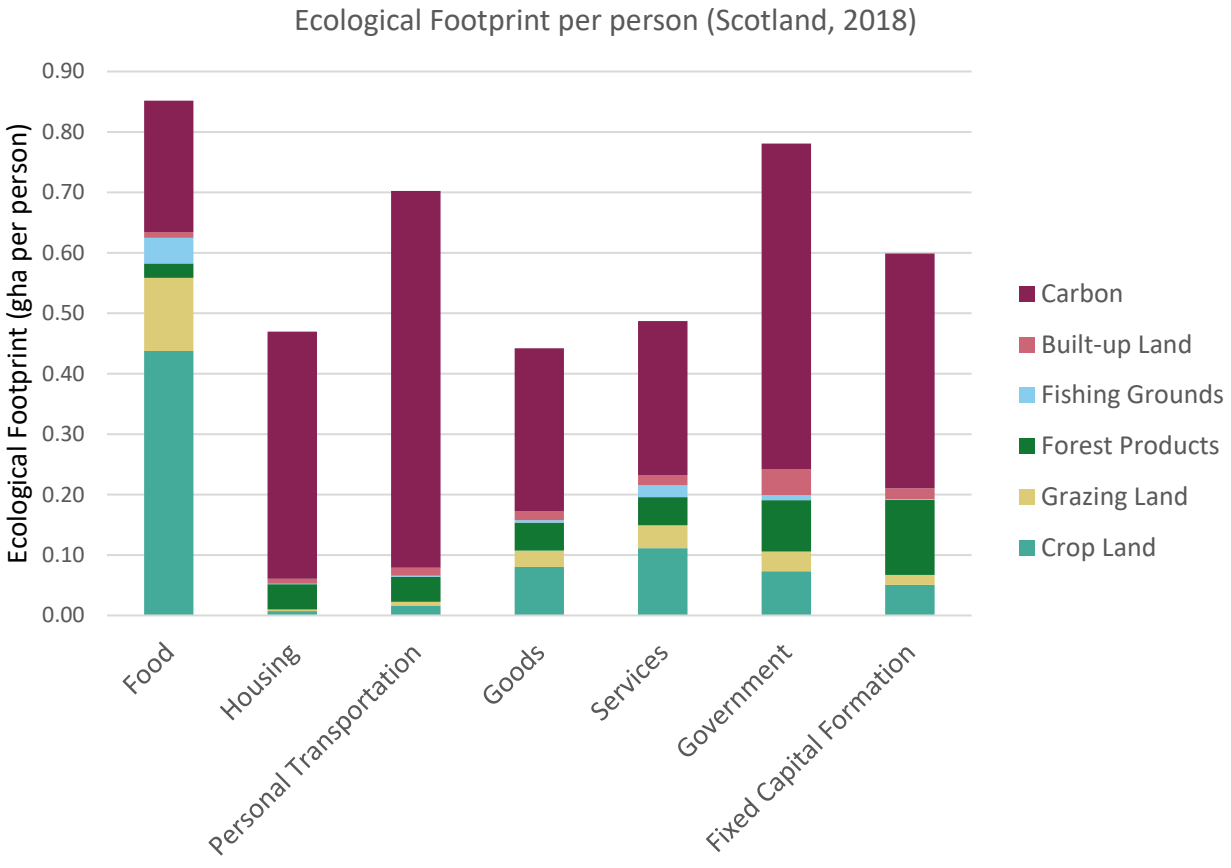

Figure 6: Ecological Footprint per person by consumption category, with 'Government' and 'Fixed Capital Investment' disaggregated. For Scotland 2018.

This reallocation of consumption paid by government and expenditure for fixed capital investment turns the CLUM into a three-dimensional representation of Scotland's resource demand: each cell of the CLUM is also broken down by who

pays for it, and whether it is short-term consumption or an investment into lasting capital stocks.

For example, in the case of Scotland, it shows that for every unit of resource households require to operate housing, there are another 2.2 units of resources needed to build and maintain that infrastructure. The analysis also shows that **38% of the Footprint for construction is sourced from overseas.**

The current CLUM also becomes a starting point for constructing an ideal CLUM, one that is compatible with the planetary resource budget. Different portions of the CLUM can be optimized more easily than others. For example, there are alternatives to high-Footprint electricity. But there may be less opportunity to reduce the Footprint of a carrot. Also, it is possible to live with very little operational energy through a Scottish winter, if the house is set up well. All these insights help develop practical resource use goals, which then can be summarized in the ideal CLUM. This CLUM then becomes the testing ground against which all policy proposals can be evaluated.

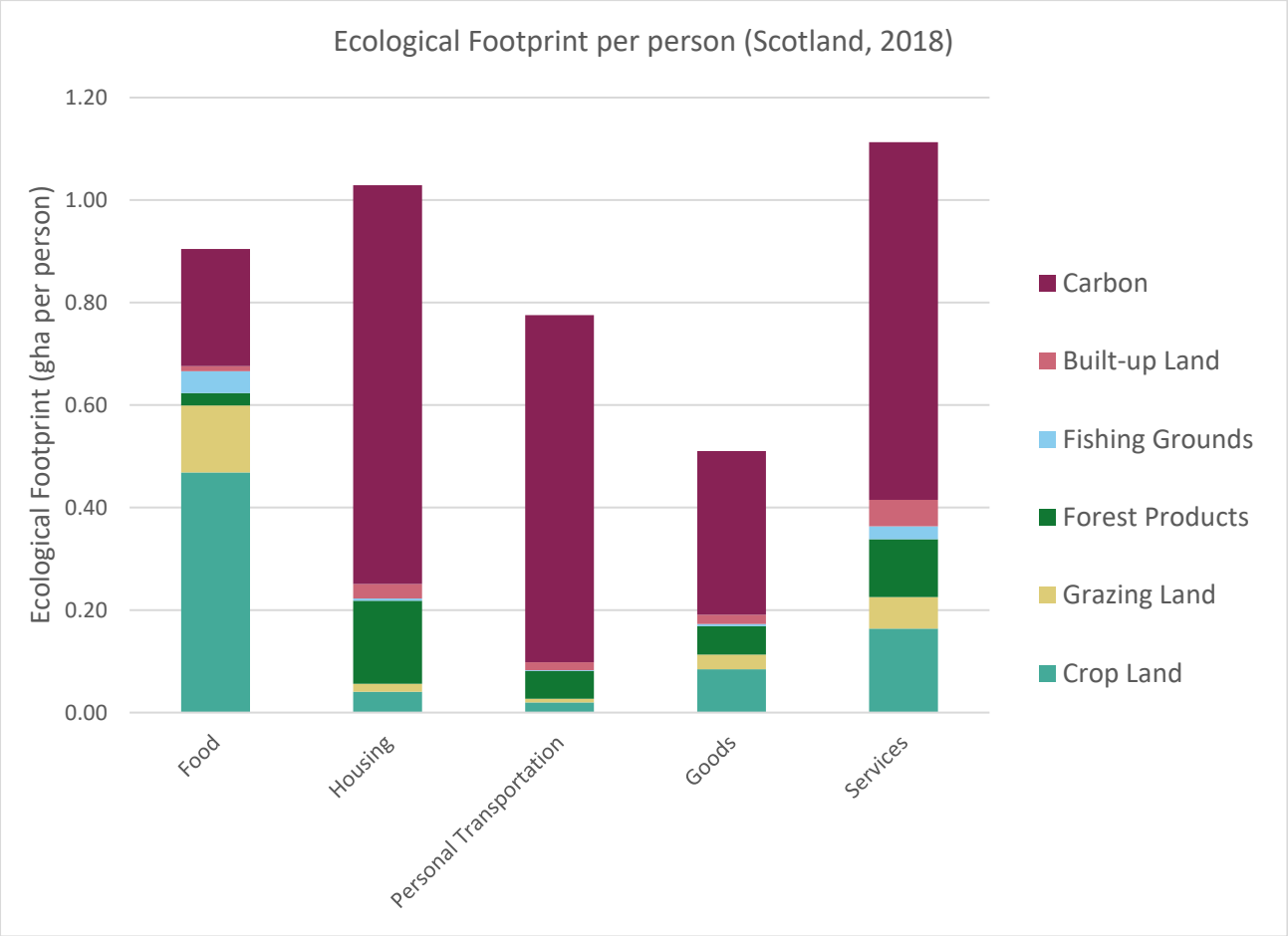

Figure 7: Ecological Footprint per person by consumption category, with 'Government' and 'Fixed Capital Investments' redistributed across the five basic need categories (food, housing personal transportation, goods, services). For Scotland 2018.

4.5.2 Scotland's overseas Footprint

Table 2 below is the essence of part one of this study. It provides the overarching answer to the posed research question on the demand Scottish consumption puts on environments outside of the UK. Appendix A provides a more detailed version. The percentage figures in the table indicate how much of the 4.33 global hectares (gha) per person Footprint is associated with each matrix cell. Carbon Footprints are allocated to where the emissions occurred.

	Total			Cropland		Grazing Land		Forest Products		Fishing Grounds		Built-Up Land		Carbon	
Ecological Footprint	Total	UK Origin	Foreign Origin	UK Origin	Foreign Origin	UK Origin	Foreign Origin	UK Origin	Foreign Origin	UK Origin	Foreign Origin	UK Origin	Foreign Origin	UK Origin	Foreign Origin
Total Ecological Footprint	**100.0%**	**53.2%**	**46.8%**	**9.3%**	**9.6%**	**2.9%**	**3.0%**	**5.4%**	**4.9%**	**0.9%**	**1.0%**	**1.6%**	**1.5%**	**33.1%**	**26.7%**
Household Total	**68.2%**	**35.3%**	**32.9%**	**7.5%**	**8.3%**	**2.2%**	**2.5%**	**2.3%**	**2.8%**	**0.7%**	**0.9%**	**0.8%**	**0.8%**	**21.8%**	**17.5%**
Food	19.7%	10.0%	9.7%	5.3%	5.2%	1.5%	1.4%	0.3%	0.3%	0.3%	0.7%	0.1%	0.1%	2.5%	2.0%
Housing	10.9%	7.9%	3.0%	0.1%	0.1%	0.0%	0.0%	0.6%	0.4%	0.0%	0.0%	0.1%	0.1%	7.0%	2.3%
Personal Transportation	16.2%	8.1%	8.1%	0.1%	0.3%	0.1%	0.1%	0.3%	0.7%	0.0%	0.0%	0.1%	0.2%	7.4%	6.8%
Goods	10.2%	2.9%	7.4%	0.4%	1.6%	0.1%	0.6%	0.4%	0.8%	0.0%	0.1%	0.1%	0.3%	1.8%	4.0%
Services	11.2%	6.4%	4.8%	1.6%	1.1%	0.5%	0.4%	0.7%	0.5%	0.3%	0.2%	0.3%	0.2%	3.1%	2.4%
Government	**18.0%**	**10.6%**	**7.5%**	**1.1%**	**0.8%**	**0.5%**	**0.3%**	**1.3%**	**0.9%**	**0.1%**	**0.1%**	**0.6%**	**0.4%**	**7.0%**	**5.0%**
Gross Fixed Capital Formation	**13.8%**	**7.3%**	**6.5%**	**0.7%**	**0.6%**	**0.2%**	**0.2%**	**1.8%**	**1.3%**	**0.0%**	**0.0%**	**0.2%**	**0.2%**	**4.3%**	**4.2%**

Table 2: Estimated Ecological Footprint by consumption category[4] for Scotland 2018 (percent of total Ecological Footprint)

The most relevant overarching finding of our analysis indicates that **47% of Scotland's Ecological Footprint is sourced from areas outside of the United Kingdom** (Table 2). The largest imports originate from **China**, which is the **main supplier of Scotland's consumption for almost all categories** (Tables 3a to 3c). Of all consumer categories, **food consumption has the largest overseas Footprint**. Most of that Footprint originates from **European countries** (Table 3a). Food is the only category where the largest supplier is not China. The Footprint associated with **housing** represents the **largest proportion of consumption originating domestically** in the UK (73%) (Table 3b). Conversely, the Footprint of the **goods** category has the **smallest proportion of consumption originating in the UK** (28%) (Table 3a).

[4] Consumption categories are based on the UN Classification of Individual Consumption by Purpose (COICOP). See Appendix A for detailed subcategories.

4.5.3 Non-carbon Ecological Footprint components

From a total demand perspective, identifying the largest categories of consumption is critical to developing solution pathways. Both carbon and non-carbon Footprints are quantified in terms of their demand on regeneration, however the symptoms of overuse in these categories may differ. For example, over longer time scales, climate change may be the largest driver of biodiversity loss, while in the short term, land use change is the most acute driver. While the carbon Footprint remains the largest demand, this is considered separately through the Scottish Government's climate change policies and here we focus on **non-carbon components of Scotland's overseas Footprint**.

Tables 3a through 3c break down the CLUM categories according to the **regional origin** of those demands. The top ten countries of origin outside of Europe are separated out in each of the consumption categories.

Food, Goods, and Services represent a major source of Scotland's non-carbon international Footprint estimated for 2018 and are represented together because they are highly comprised of demand for agricultural products (Table 3a). The majority of cropland and grazing land demand is related to the production of food items such as staple foods, fruits, vegetables and meat, but also the production of fibres and leather for clothing and textiles. Due to the categorization of consumption (COICOP[5]), the largest category in "Services" is also related to food: "catering services" includes all food consumption provided as a service, as in the case of restaurants and related establishments.

[5] The UN Classification of Individual Consumption by Purpose (COICOP) is used widely as a categorization scheme for household consumption expenditure. While spending on food may logically be considered food, this consumption falls under the "services" of restaurants and hotels, and therefore is not disaggregated from services in the CLUM.

Within these categories, **food is largely sourced regionally** with nearly **80 percent** coming from within **Europe.** Outside of Europe, the largest sources of food do include **countries at high risk of biodiversity loss and deforestation in South America and Africa.**

Conversely, **goods are largely sourced internationally,** with **56 percent** originating **outside Europe,** and a large majority, 33 percent, coming from **China.** The non-carbon Ecological Footprint of goods sourced from China largely comes in the form of **clothing, footwear and associated textiles**.

Overall, **23% of Scotland's imported cropland Footprint and 22% of Scotland's grazing land and forest product Footprint come from regions experiencing the highest potential biodiversity loss** (Asia, Africa, and Latin America).

Food			Goods			Services		
Source	**EF gha**	**(%)**	**Source**	**EF gha**	**(%)**	**Source**	**EF gha**	**(%)**
Total	3,564,266	(100%)	Total	1,070,112	(100%)	Total	1,298,775	(100%)
Domestic (UK)	1,760,320	(49.4%)	Domestic (UK)	243,822	(22.8%)	Domestic (UK)	784,897	(22.8%)
International (Europe)	1,066,595	(29.9%)	International (Europe)	226,050	(21.1%)	International (Europe)	263,068	(21.1%)
International (Remaining)	737,351	(20.7%)	International (Remaining)	600,241	(56.1%)	International (Remaining)	250,810	(56.1%)
Largest Intl. (Remaining) Sources			Largest Intl. (Remaining) Sources			Largest Intl. (Remaining) Sources		
China	105,254	(3.0%)	China	351,210	(32.8%)	China	77,322	(32.8%)
United States of America	57,050	(1.6%)	India	35,822	(3.3%)	United States of America	25,172	(3.3%)
India	51,980	(1.5%)	Pakistan	25,696	(2.4%)	India	20,904	(2.4%)
Australia	43,673	(1.2%)	Bangladesh	21,915	(2.0%)	Thailand	10,046	(2.0%)
New Zealand	40,128	(1.1%)	Viet Nam	18,890	(1.8%)	Australia	7,102	(1.8%)
Brazil	36,063	(1.0%)	Indonesia	17,668	(1.7%)	Canada	6,248	(1.7%)
Canada	29,461	(0.8%)	United States of America	17,221	(1.6%)	Brazil	5,883	(1.6%)
Argentina	26,697	(0.7%)	Turkey	15,659	(1.5%)	New Zealand	5,684	(1.5%)
South Africa	22,664	(0.6%)	Cambodia	13,314	(1.2%)	Turkey	5,584	(1.2%)
Viet Nam	22,335	(0.6%)	Brazil	7,589	(0.7%)	Viet Nam	5,416	(0.7%)

Table 3a: Origin of Scotland's Non-Carbon Ecological Footprint 2018 – Food, Goods, Services. Data bars illustrate relative value, with orange bars representing relative regional sourcing, while green bars represent relative international sources. Percentages represent the proportion of the individual category by source.

The non-carbon Ecological Footprints associated with **housing** and **personal transportation** (Table 3b) are relatively small and represent demand in the form of current use and maintenance of infrastructure. However, housing and personal transportation represent major Ecological Footprint categories both because they have **large carbon Footprints**, but also because from a solution perspective, they represent the efficiency of our physical infrastructures. Improvement of physical infrastructures operate on longer timescales, but also present impactful long-term Footprint reductions when addressed early. These critical categories are addressed elsewhere by Scotland's Environment Strategy and climate change policies.

Housing			Personal Transportation		
Source	**EF gha**	**(%)**	**Source**	**EF gha**	**(%)**
Total	370,258	(100%)	Total	483,113	(100%)
Domestic (UK)	222,612	(60.1%)	Domestic (UK)	165,851	(34.3%)
International (Europe)	67,774	(18.3%)	International (Europe)	147,675	(30.6%)
International (Remaining)	79,873	(21.6%)	International (Remaining)	169,586	(35.1%)
Largest Intl. (Remaining) Sources			Largest Intl. (Remaining) Sources		
China	24,800	(6.7%)	China	79,901	(16.5%)
United States of America	12,482	(3.4%)	India	11,804	(2.4%)
India	3,775	(1.0%)	United States of America	11,708	(2.4%)
Egypt	3,053	(0.8%)	Thailand	5,065	(1.0%)
Canada	3,027	(0.8%)	Rest of East Asia	4,578	(0.9%)
Rest of Eastern Africa	2,364	(0.6%)	Turkey	4,307	(0.9%)
Tanzania, United Republic of	1,988	(0.5%)	Japan	4,184	(0.9%)
Uganda	1,796	(0.5%)	Korea, Republic of	3,293	(0.7%)
Brazil	1,551	(0.4%)	Canada	2,934	(0.6%)
Qatar	1,192	(0.3%)	South Africa	2,870	(0.6%)

Table 3b: Origin of Scotland's Non-Carbon Ecological Footprint 2018 – Housing and Personal Transportation. Data bars illustrate relative value, with orange bars representing relative regional sourcing, while green bars represent relative international sources. Percentages represent the proportion of the individual category by source.

Government and **gross fixed capital formation** (Table 3c) represent indirect support for multiple categories of human need and are more difficult to interpret with detail. To a large degree, these categories support the direct consumption categories of **housing** and **services**. Relevant to this project, gross fixed capital formation represents the largest **forest products** Footprint, likely because it represents the Footprint associated with the purchase of physical infrastructure such as houses and other buildings. From a solution perspective, these categories represent indirect consumption and are therefore not focused on here.

Government			Gross Fixed Capital Formation		
Source	**EF gha**	**(%)**	**Source**	**EF gha**	**(%)**
Total	1,437,879	(100%)	Total	1,245,142	(100%)
Domestic (UK)	849,569	(60.4%)	Domestic (UK)	702,534	(58.7%)
International (Europe)	228,846	(20.3%)	International (Europe)	238,359	(15.3%)
International (Remaining)	359,464	(19.3%)	International (Remaining)	304,249	(26.1%)
Largest Intl. (Remaining) Sources			Largest Intl. (Remaining) Sources		
China	176,387	(6.0%)	China	153,837	(13.1%)
United States of America	43,172	(1.9%)	United States of America	25,992	(3.3%)
India	20,467	(1.6%)	India	15,919	(1.4%)
Viet Nam	8,886	(0.8%)	Canada	12,283	(0.7%)
Thailand	6,999	(0.5%)	Brazil	7,749	(0.5%)
Korea, Republic of	6,884	(0.5%)	Turkey	6,246	(0.5%)
Japan	6,471	(0.5%)	Japan	6,018	(0.5%)
Malaysia	5,578	(0.4%)	Korea, Republic of	5,719	(0.4%)
Canada	5,310	(0.4%)	Malaysia	5,487	(0.4%)
Turkey	5,132	(0.4%)	Viet Nam	5,260	(0.4%)

Table 3c: Origin of Scotland's Non-Carbon Ecological Footprint 2018 – Government and Gross Fixed Capital Formation. Data bars illustrate relative value, with orange bars representing relative regional sourcing, while green bars represent relative international sources. Percentages represent the proportion of the individual category by source.

4.6 Linking consumption with other environmental impacts

The previous sections of the report provide a quantitative assessment of Scotland's demand for regeneration. The results quantify the Ecological Footprint according to consumption activity, and by location and type of biocapacity demand. The analysis describes the degree to which the total scale of consumption relative to regeneration is "sustainable" or unsustainable. As outlined above, a secondary level would analyse how gently (or intrusively) these areas of biocapacity are used. Here we provide a review of the linkages between consumption and impacts on qualitative aspects of natural systems. These impact categories do not look at the scale of consumption vs regeneration. Rather, biodiversity loss and deforestation are symptoms of overuse of natural systems. These, in addition to water availability, are also factors relevant to the continued "healthy" or "optimal" function of ecosystems. They can be seen as the ability for natural systems to continue to support life through regeneration.

In this section of the report, we aim to summarize the existing evidence linking Scotland's consumption to **biodiversity loss**, **deforestation** and **water use** based on a review of scientific and grey literature as well as existing datasets. Our approach aimed to identify linkages through research into two lines of evidence: location-specific and category-specific.

Location-specific evidence included direct evidence of Scotland's overseas impacts and more broad evidence of the impacts of the United Kingdom's overseas impacts.

Category-specific evidence included general consumption-specific linkages, such as final demand categories (food, housing, transportation, goods, services) and land-demand categories (cropland, grazing, fishing grounds, forest products, built-up land, carbon Footprint), to specific impacts.

The evidence related to consumption specific linkages was often associated with specific countries or regions of impact.

With further analysis, some of these secondary quality aspects could be built into a more comprehensive first-tier quantity assessment (Figure 1). For instance, if agricultural practice leads to soil erosion, then the full Footprint should include the regenerative capacity needed to restore that soil loss. However, this extends beyond the scope of this report, and would require detailed assessments for different quality aspects.

In this section, we explain what additional metrics exist for specific impacts such as biodiversity loss, deforestation and impact on distant fresh water through trade. These impacts represent the more prominent and urgent symptomatic impacts of overshoot. For more detailed results and analysis, tracking these more specific environmental effects adds more depth to an overarching, quantitative biocapacity assessment. For each of these impacts, the section below describes why they are relevant to Scotland's overseas impact, the key drivers of change and how these relate to consumption. Further information on relevant datasets, additional considerations and unknowns is set out in Appendix C.

4.6.1 Biodiversity loss

- *Relevance*

Biodiversity is a key property of healthy ecosystems, both natural and human managed, and is essential for ecosystems to adapt and thrive. Not only do biodiverse natural systems function well, they are also more resilient.

A wide range of studies have highlighted the scale of biodiversity loss, including the 2019 IPBES Global Assessment, leading many countries to declare nature emergencies.

- *What are the drivers?*

IPBES (2019) identifies 5 major direct drivers of biodiversity loss:[6] changes in land and sea use (including habitat fragmentation), direct exploitation, climate change, pollution and invasive species. Land/sea use change, primarily through the conversion of natural forests and grasslands to intensive agriculture and livestock, is currently the dominant direct driver of biodiversity loss, closely followed by direct exploitation of resources (Jaureguiberry et al., 2022).

The dominant drivers of biodiversity loss differ between terrestrial, freshwater and marine systems. Direct exploitation and climate change are the top two drivers in marine ecosystems while land/sea use change is the top driver in terrestrial and freshwater ecosystems. All five drivers are correlated, or strongly correlated, with the size of the human resource metabolism. This is true even for invasive species who spread into new regions aided by the transportation network, with more resources being transported offering more opportunities for species to migrate. The relative importance of the five drivers is shifting over time. For instance, climate change has been a minor influence on biodiversity in the past decades but may become the dominant driver of biodiversity loss over the next century and beyond.

IPBES (2019) also highlighted that these direct drivers result from a range of indirect drivers. A recent report[7] by the James Hutton Institute evaluated how these indirect drivers apply in Scotland, categorising these drivers as: i) socio-cultural, ii) demographic, iii) economic, iv) technological and v) relating to politics, institutions and governance.

- *How do these relate to consumption?*

Globally, the majority of biodiversity loss is not associated with international trade. Studies show that **75% to 83% of biodiversity loss is due to agriculture land use for domestic consumption** while the remainder can be attributed to international trade (Pendrill et al., 2022; Chaudhary and Kastner, 2016). This underlines the reality that biodiversity loss is associated with the volume of the human resource metabolism.

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[6] Isbell et al. identify as indirect drivers of biodiversity loss, in order of importance, production and consumption, human population dynamics, governance, trade, and technology (2022).

[7] Pakeman, R.J., Eastwood, A., Duckett, D., Waylen, K.A. Hopkins, J. and Bailey, D.M. 2023. Understanding the Indirect Drivers of Biodiversity Loss in Scotland. NatureScot Research Report 1309.

Hence, trade related policies (such as banning certain goods), while important, are fundamentally more limited in their potential to reduce biodiversity loss compared to curbing aggregate human resource demand, including in impacted countries.

Nevertheless, **most of the current biodiversity loss that can be linked to consumption in Western Europe is embodied in international trade,** primarily coming from Asia and Pacific (33%), Africa (26%), and Central and South America (20%); **with food products contributing 74% to that biodiversity loss.** Among food, consumption of **animal products** is the largest driver by far of potential biodiversity loss (Sun et al., 2022; Wilting et al., 2017). **Forest products** are also a major driver of both biodiversity loss and carbon emissions (Pendrill et al., 2019).

Estimates from this analysis show that **23% of Scotland's imported cropland Footprint and 22% of Scotland's grazing land and forest product Footprint come from regions experiencing highest potential biodiversity loss** (Asia, Africa and Latin America).

Some agricultural products have greater impact per area of cropland occupied. For example: sugarcane, palm oil, coconut, cassava, rubber, and coffee (Chaudhary and Kastner, 2016). An examination of seven agricultural commodities (beef & leather, cocoa, palm oil, pulp & paper, rubber, soy and timber) found that 28% of the UK's imported land Footprint comes from countries with high or very high risk of deforestation, land conversion or human rights abuses (WWF and RSBP, 2020).

4.6.2 Deforestation

- *Relevance*

Forests provide habitat for biodiversity, regenerate forest products and represent one of the largest terrestrial carbon stores. Deforestation focuses on marginal impact, but is nevertheless important to consider, as external consumption (i.e. from international sources) can be linked with deforestation effects, as in the case of expanding production of palm oil or soya. Between 2015 and 2020, the rate of deforestation was estimated at 10 million hectares per year (FAO and UNEP 2020). Deforestation has both climate as well as biodiversity impact.

- *What are the drivers?*

Major drivers of deforestation include land use change for extending agriculture, harvest of forest products and wildfire. In the tropics, 90-99% of deforestation is linked to agricultural expansion (Pendrill et al., 2022).

- *How do these relate to consumption?*

Agriculture and forest commodity production sectors are identified as the predominant cause of land use change and the **largest drivers of deforestation**. Southeast Asia, Madagascar, Liberia, Central America and the Amazonian rainforest were identified as hotspots for international trade, deforestation and biodiversity loss (Pendrill et al., 2019). As noted in the biodiversity section above, **28% of the UK's imported land Footprint comes from countries with high or very high risk of deforestation, land conversion or human rights abuses** (WWF and RSBP, 2020).

4.6.3 Water use

- *Relevance*

All life requires water. In some areas it is plentiful, but increasingly it is becoming a limiting factor. In those cases, water use turns into another case of humanity's competition for regeneration. For example, if in a dry area more water is used for domestic applications, less will be available for agricultural use, reducing yields. Or, polluting water puts demands on infrastructure and energy to manage and clean that water, reducing opportunities to use that energy elsewhere.

Water being such a central input warrants more specific metrics. A basic one is a water balance, tracking how much is being used, compared to how much is available given rainfall and recharge rates. The UN considers regions where more than 25% of its renewable freshwater is being withdrawn as water stressed. It estimates that 2.3 billion people live in water-stressed countries. Complementary measures are needed since water resources can be harmed in so many ways, including diversion, pollution and salination, over-exploitation and physical modification of water bodies.

The water footprint is one metric to estimate overall water demand, including both direct use as well as indirect, such as water embodied in the products being consumed (the virtual water in trade).

- *What are the drivers?*

72% of all water withdrawals are used by agriculture, 16% by municipalities for households and services, and 12% by industries (UN-Water, 2021). Because water availability is a local factor, water scarcity, the balance between withdrawal and availability, is an important issue in water use. Globally, the drivers of water scarcity are not as well known (Huang et al., 2021).

- *How do these relate to consumption?*

This study did not produce a separate water footprint assessment. However, a study of the UK from 2008, commissioned by WWF, shows that **62% of the UK's overall water demand occurred overseas**, based on water footprint assessments. The authors of the study also found that **73% of the external water was used for agriculture** (mainly linked to production of **food** and **cotton**), the remainder for **industrial processes**. These numbers reflect the situation for the early 2000s. More details are available in Chapagain and Orr's study on the UK Water Footprint (2008).

4.7 Conclusions

In the first section of this report, we have outlined a comprehensive approach to mapping the impact on an economy during a period of persistent overshoot. Our initial focus is on tracking the overall demand placed on ecosystems' regenerative capacity, as this is the fundamental resource that all activities compete for. To facilitate this analysis, we have provided an overview of Scotland's consumption demand, categorized by different consumption sectors. Additionally, this analysis enables us to determine the proportion of demand satisfied through overseas regeneration.

Furthermore, we have conducted an initial assessment of Scotland's biocapacity. Notably, the **per person biocapacity in Scotland is much greater than both the rest of the UK and the global average**. Through this resource accounting approach, we have discovered the following insights:

- Scotland's demand on regeneration, i.e. its **Ecological Footprint of consumption**, stretches to **4.3 global hectares per person**, slightly higher than the UK average of 4.2 global hectares per person.
- Compared to UK's biocapacity, which is only 1.1 global hectares per person, Scotland's biocapacity per person (3.5 global hectares) is over three times larger. Still, **Scotland runs a biocapacity deficit, with its Footprint per person exceeding its per person biocapacity by an estimated 25%.**
- An estimated **47% of Scotland's consumption originates from countries outside the United Kingdom**. **Food** comprises the largest overseas Footprint among all consumption categories. **Goods** has the largest portion of its Footprint originating overseas (over 70%), driven, in particular by **clothing**. Housing is on the other end of the extreme with only one quarter sourced overseas.

A key issue we were not able to assess within the scope of this project is the Ecological Footprint of **production** – how much regeneration is needed to maintain Scotland's economy, or its "income machine". Results are available for the UK as a whole, but we do not know how different that would be in Scotland as the average structure of Scotland might be quite different from the UK average, given the fossil fuel industry of the North Sea as well as the significance of resource-intensive industries such as salmon farming.

As per the 'hierarchy of impacts', described above, this assessment provides a **quantitative** mapping of the biocapacity flows. This assessment could be extended by asking how these flows affect the **qualities** of the environment from which they originate. **Specific issues** such as pollution, ecological mismanagement, or localized biodiversity loss, to take a few examples, could then also be monitored and addressed. We highlighted three areas of particular concern in the sections above.

Still, we acknowledge and emphasize that addressing quality issues alone, through direct management of impacts, will not be sufficient to tackle overshoot. Management of impacts needs to be seen in the context of managing our overarching resource budgets.

5. SECTION 2: Improving Scotland's international environmental impact

5.1 From evidence to policy options

Section 1 identified how Scotland's international Footprint can be monitored. Section 2 explores options for containing this Footprint, addressing **Research Question 2**: "What policy levers could potentially be used most effectively to improve the sustainability of Scotland's international environmental impact?"

5.1.1 Operating in the context of wider societal goals

Meaningful actions need to show a commensurate impact on Scotland's overseas Footprint. Further, since Scotland, like any other nation, pursues multiple goals, efforts that also support wider societal outcomes are more likely to have a chance to succeed. Therefore, particularly effective and lasting ways to achieve reduced Footprints overseas would be those which also contribute to central goals of Scotland's society. Some are spelled out in the National Outcomes of the National Performance Framework[8], while three core missions on equality, opportunity and community are set out in the First Minister's Policy Prospectus, published in April 2023.[9] International Footprint reduction policies that also advance these core goals may be more likely to be implemented.

If we accept the premise of a future with increased climate change and resource constraints, and we recognise that these trends will have a major impact on the Scottish economy, then it becomes more obvious how to link this Footprint reduction goal with overall ambitions for Scotland. Because in this case, reducing Scotland's resource dependence, particularly from overseas resources, turns into a meaningful economic resilience strategy. We submit therefore, that there are three critical conditions for an effort to succeed:

a. It meaningfully and measurably reduces Scotland's overseas impact.

b. It strengthens Scotland's ability to thrive. Given the evidence of Scotland's resource context, identifying assets that will become more valuable in the future is a critical step towards sustainability. Such assets make the Scottish economy more robust for the predictable future. Therefore, we look for recommendations that build such assets.

c. It speaks these benefits so clearly that enough stakeholders are in favour of it. This is simple because if not, those opposing stakeholders may hamper any such effort. This may be complicated since in some cases short-term costs can be a deterrent even though the long-term benefits are demonstrably higher than the costs. Delayed gratification can make it challenging and requires more planning and careful communication to overcome.[10]

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[8] https://nationalperformance.gov.scot/national-outcomes

[9] See Policy Prospectus, published in April 2023 which sets out the First Minister's overarching goals: Equality, opportunity, community

[10] One way to overcome this may be how they dealt with such challenges in Curitiba, Brazil. They implemented such solutions, as in the case of urban high-speed bus lines, in smaller batches thereby demonstrating the benefits more clearly to the ones to be convinced next.

These criteria imply what we might call an "ecosystemic approach" to policy development. It considers which solutions are more likely able to thrive in the policy ecosystem. Such an approach recognises the reality of multiple and potentially conflicting societal goals. These are all contexts a single focus approach may ignore. Single focus approaches only consider what policy options could be deployed to achieve a particular goal. Hence their ability to manoeuvre around potentially competing goals and survive in such an ecosystem are slim.

5.1.2 Shifting the focus from growth to wealth

This report also suggests a fresh way to navigate a polarized debate between those who believe that:

- **without persistent economic growth** (as measured by GDP) the economy would become unstable (because of asset value decay, unemployment and financial instability); while others believe that
- **with persistent economic growth** (as measured by GDP) the economy would become unstable (because of ecological decline).

To overcome this fundamental contradiction in views, we take a different approach here. Rather than focusing on income (which is the lens of GDP), we take a **wealth** approach. We suggest that the focus needs to be on determining what activities and investments build, rather than erode, society's wealth.

Wealth is a **stock**. In contrast, GDP tracks income which is a **flow** or an amount per year. Building wealth is therefore a distinct consideration from GDP growth. GDP growth on its own generally leads to increased Ecological Footprints (Cumming and von Cramon-Taubadel, 2018; Haberl et al., 2020). **A wealth focus pays attention to what assets are being built which enable generating income over time.**

A more useful interpretation, or even name, for wealth or capital would be **'capacity'**: the capacity to feed people, move them about, house them, produce goods etc. Hence the practical question with every investment becomes whether it enhances, in this case Scotland's, capacity to provide the critical goods and services for a thriving population. In other words, the premise of this report is about **how to increase Scotland's capacity to operate and thrive**, rather than debating whether it will be economic growth or degrowth that will lead to this desired outcome.

5.1.3 The significance of trade policy

Policy recommendations for reducing overseas environmental impacts are often linked to trade. Recent examples can be found in:

- Stockholm Environment Institute's *Stockholm+50: Unlocking a Better Future* report[11], which includes recommendations focusing on the sustainability of global supply chains and environmental due diligence;

[11] Stockholm+50: Unlocking a Better Future

- OECD 's *Biodiversity, natural capital and the economy* report[12], which includes a section discussing 'Biodiversity and Trade'; and
- WWF UK & RSPB's *Riskier Business: The UK's overseas land footprint* report [13], which explores the impact of global supply chains and, through that, the environmental impact of trade.

These studies correctly recognise that in order to understand the overall impact of a product, one needs to consider the life-cycle of products, which includes where and how something was produced, how it was transported etc. So, this makes clear that what and how things are being traded makes an environmental difference.[14]

But, as these studies also acknowledge, trade policy alone is not sufficient to address international environmental impacts. Because, in the epoch of the Anthropocene, impact is no longer merely a qualitative problem stemming from poor practices. Rather some of the impact is inevitable as long as we operate in global overshoot. Scotland is facing an "overusing the resource budget" problem, not merely a "specific impact" problem. Given global overshoot, some parts of human demand must come from depletion, since overall demand exceeds what the planet's ecosystems can renew. This means that green import policies may just lead to burden shifting. For instance, higher income countries may import greener portions of the available goods, leaving the products that were manufactured using more destructive practices to lower bidders. This is why reducing the **quantity** of demand is central if countries want to contribute to tackling climate change, nature loss and resource constraints. A recent study by James Hutton Institute (Rivington et al., 2023) illustrates this point by differentiating between reducing consumption and reducing the impacts of consumption, emphasizing that fundamental changes to reduce overall consumption are required to be "responsible global citizens".

Still, trade policies have power. They can reduce environmental harm, even though in the era of overshoot, they address symptoms rather than drivers. For example, trade policy has the potential to help address some of the quality issues related to certain environments, such as deforestation or biodiversity loss in specific geographies.

A 2020 study by the Joint Nature Conservation Committee (JNCC), *The Linking Environment to Trade (LET) Guide*, reviewed existing policies designed to reduce the embodied environmental impact associated with global trade and consumption (Hawker et al., 2020). Key tools and approaches identified in that study are summarized in Table 4. Many of these were further discussed in JNCC's recent review of policy levers for promoting sustainable consumption. Rivington et al.

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[12] Biodiversity, natural capital and the economy: A policy guide for finance, economic and environment ministers

[13] Riskier Business: The UK's overseas land footprint

[14] The James Hutton Institute explains in its section 1.2 on 'Transboundary spillovers' (Ishii et al., 2022: pg. 2) that the prosperity of high-income countries is often associated with the burden of erosive practices in low-income countries. "For example, while trade is an important source of income, the production of goods destined for [higher income] nations can often lead to pollution of communities around manufacturing plants, drive deforestation, reduce soil fertility and be done under poor labour conditions. Therefore, the consumption of goods in Scotland can have consequences elsewhere."

(2023) explored international best practice in using these levers, including a range of trade-related policy options such as mandatory due diligence requirements, measures to improve supply chain traceability, public procurement directives, sustainable commodity import guarantees and capacity building. Overall, these trade-related policy options can play a significant role in addressing some localized impacts.

For example, Rivington et al. (2023) noted that the establishment of **due diligence obligations** (which falls within the reserved powers of the UK Government) on businesses is widely recommended as a critical policy intervention to address environmental impacts in supply chains and investments. Organisations such as the UK Government's Global Resource Initiative Taskforce, conservation charities like WWF and RSPB, academics, and stakeholders advocate for the establishment of mandatory due diligence obligations on businesses and financial institutions to address environmental impacts in their supply chains and investments. The emphasis is on transparency and integrating environmental considerations throughout supply chains, as supported by the Dasgupta review on biodiversity economics. While the UK and EU have both responded to these recommendations, the UK's response has been criticised due to its narrower scope. Additionally, some uncertainty remains regarding the effectiveness of such policies since they are relatively new.[15]

Mandatory public procurement directives are a further example. Green public procurement has the potential to help reduce environmental footprints through two primary mechanisms. Firstly, it directly impacts overall consumption due to the substantial volumes of goods and services purchased by public sector organisations. Secondly, it sets an example, provides price stability, and fosters market expansion and financing for more sustainable products. However, the complexity and unpredictability of its environmental impacts have been noted as potential challenges.

Green public procurement is prominently featured in EU Green Deal policies, to help achieve environmental objectives related to supply chains and the circular economy transition. EU Directives establish legal frameworks for socially responsible

[15] Responding to such environmental pressures, the UK Government introduced provisions for due diligence obligations related to forest-risk commodities in the Environment Act 2021. These provisions aim to prevent large businesses from importing illegally produced forest-risk commodities through legal restrictions, mandatory due diligence exercises and annual reporting. A consultation on their implementation was completed in March 2022. However, criticism exists regarding the UK's approach, which covers only deforestation and land conversion deemed illegal according to producer countries' local laws. In contrast, the EU proposes a broader 'deforestation-free' approach, requiring companies to confirm that products have been produced on land that has not been subject to deforestation or forest degradation after 31 December 2020. Robust certification schemes could assist businesses in fulfilling due diligence, but overreliance on them presents risks due to the limitations of current certification schemes and traceability barriers. Concerns also arise regarding compliance with World Trade Organization rules, potential trade obstacles, and the burden on producers arising from varying regional and domestic deforestation legislation. There is a call for more meaningful involvement of stakeholders from lower-income countries when shaping these regulations. Not only would they be more appropriate, but also increase in their legitimacy. While the UK Government holds authority over due diligence regulations, the Scottish Government can seek to influence their alignment with EU standards and broaden their scope to cover businesses placing forest-risk commodities on Scottish and UK markets beyond a legally-based approach.

public procurement. The effectiveness of such measures relies on robust and transparent systems for mandatory reporting and compliance monitoring. Despite some complexity and uncertainty, green public procurement holds promise as a policy instrument that can influence supply chains beyond international trade, making it valuable for promoting local produce and dietary changes. The Scottish Government has significant opportunities to engage in this domain, aligning with UN Sustainable Development Goal 12, which encourages governments to use public procurement practices to advance sustainable consumption and production patterns. An example highlighted by the European Committee of the Regions[16] is Munich's inclusion of social and environmental criteria in awarding a contract for school meals, earmarking 5% for aspects like Fairtrade-certified raw materials.

Bilateral, plurilateral or multilateral international trade agreements[17] are also significant as such agreements can enable more consistency among trade partners, for example by setting common environmental standards, which can have the effect of levelling the playing field. They can also facilitate trade in environmental goods and services and incentivise greener production mechanisms and materials.[18] Consideration of trade in other forums, such as Multilateral Environmental Agreements also has the potential to support coherence between trade and environmental ambitions. [19]

This report does not review trade-related policy options in detail – instead, we signpost to further information and recommendations on relevant tools and approaches in the studies mentioned above. In summary, trade policy offers some opportunities for reducing overseas environment impacts. However, these

[16] European Committee of the Regions, Soldi, R., Sustainable public procurement of food, European Committee of the Regions, 2018, https://data.europa.eu/doi/10.2863/1187

[17] The strengthening of multi-lateral commitments and partnerships to address sustainability in international trade and supply chains features in the recommendations of bodies such as the WWF and RSPB (2020), the World Economic Forum (2020), the UK Global Resource Initiative (2020), and other stakeholders (Bager *et al*., 2021). The Dasgupta review on the Economics of Biodiversity (Dasgupta, 2021) highlights agreements in relation to deforestation, such as the New York Declaration on Forests (halving deforestation by 2020 and ending it by 2030) and the Amsterdam Declaration (aiming for deforestation-free supply chains by 2020).
More recently, in the Glasgow Leader's Declaration on Forest and Land Use (at COP26 in Glasgow, November 2021), 140 leaders committed to halting and reversing forest loss and land degradation by 2030. However, thus far, international agreements and international environmental law have been ineffective in halting global deforestation (Dasgupta, 2021; Henn, 2021). Dasgupta (2021) provides an example of deforestation in Brazil, noting that most of the countries bearing the greatest responsibility for driving deforestation there, and the resultant loss of biodiversity, are signatories to one or both of the New York or Amsterdam Declarations. Henn (2021) points to the failure of previous multilateral efforts as leading to an increased drive for the adoption of unilateral approaches by national and supranational organizations such as the EU.
Deforestation is an example of an issue about which it is important that the Scottish Government and UK Government continue to support and drive action through multi-lateral partnerships and commitments, but where there is a growing need to address the problem through complementary unilateral action and domestic policy.

[18] E.g. Agreement on Climate Change, Trade and Sustainability (ACCTS)

[19] Montreal Protocol as successful example of Multilateral Environmental Agreement with trade considerations: https://www.unep.org/ozonaction/who-we-are/about-montreal-protocol
Potential role of Non Determined Contributions from the Paris Agreement to consider trade, see Trade Elements in Countries' Climate Contributions under the Paris Agreement, Clara Brandi
https://euagenda.eu/upload/publications/untitled-81229-ea.pdf

should be considered as supplementary to wider efforts to address the underlying **quantity** issue that gives rise to overshoot.

It is also important to note that trade policy is a highly complex area, and solutions for improving environmental impact must take account of a wide range of factors, such as resource production efficiency, goals for self-sufficiency and consumer choice, while also considering impacts on upstream supply chain economies. For example, for some commodities, importing may be a more environmentally sound option than domestic production. These complexities mean that trade-related policy approaches must be carefully designed in the context of the products and countries in question. Moreover, since trade policy is primarily reserved to the UK Government, this constrains the policy options available to Scotland. Finally, although this report focuses on the Footprint of Scotland's consumption, Scotland's position in global supply chains means that exporters in Scotland are also dependent on imports. Consideration should also therefore be given to export-related trade policy levers when exploring opportunities for improving Scotland's overseas environmental impact.

Challenges of consumption and environmental impact	Fundamental tools and approaches for understanding and reducing impact
1. Environmental impacts associated with trade and consumption	• **Trade flow models** – by modelling trade routes to connect consumption to production • **Earth Observation technology and remote sensing** – for detecting large scale environmental impacts • **Global commitments and multi-lateral environmental agreements** – for global collaboration on common goals • **Scenario models** – for modelling impacts of potential future environmental and/or supply chain changes
2. Supply chain transparency	• **Trade flow models** – by modelling trade routes to connect consumption to production • **Due diligence approaches** – which address risks • **Certification schemes** – an example of due diligence but also holds the entire supply chain to a standard set by the scheme • **Life cycle analysis** – understanding the whole life cycle of a product • **Supply chain risk assessments** – to monitor risks in supply • **Hot-spotting tools** – to highlight areas at risk or of value to conservation

3. The complexities of the production landscape and achieving sustainable production	• **The landscape approach** – to understand the interdependencies (social, economic and environmental) of the production landscape • **Community engagement and collaborative governance** – to design appropriate responses • **Ecosystem services approach** – to understand impacts and dependencies of production • **Development of condition indicators** – to monitor change
4. Agreeing a common understanding of sustainability	• **Sustainability frameworks** – for cross-sectoral understanding of sustainability • **Certification schemes** – for defined sustainability standards with conformance criteria

Table 4: Summary of existing tools and approaches for understanding and reducing the embodied environmental impacts associated with global trade and consumption – as set out The Linking Environment to Trade (LET) Guide by JNCC (2020). See full report for further detail. The Linking Environment to Trade (LET) Guide

5.2 Choice of policy domains for this analysis

Research Question 1 shows Scotland's consumption demand broken down by five domains: food, housing, personal transportation, goods and services. It highlights the relative contributions from each domain to Scotland's overall Ecological Footprint. It also shows how much of each domain depends on biocapacity abroad or required emissions released abroad. Of these, **food** consumption paid for by households makes the largest contribution to Scotland's overall Footprint and has the largest overseas Footprint. **Goods** has the largest overseas proportion of its Footprint at 72%, driven largely by **clothing**. The Consumption Land Use Matrix (CLUM, Table 2 and Table A1) also showed that all household consumption categories have a significant carbon Footprint, both of UK and overseas origin, and that the Footprints of **housing** and **personal transportation** are dominated by their **carbon Footprints**.

Carbon emissions from fossil fuel use put pressure on ecosystems around the world and play a central role in Scotland's overseas Footprint. However, as noted above, since Scotland's carbon Footprint is already being considered through the Scottish Government's climate change policies, this report focuses on complementary areas that have larger **non-carbon** components. These are particularly prominent in the consumption domains of **food** and **goods** as shown in the CLUM (Table 2 and Table A1).

Based on CLUM results from Section 1 and feedback solicited from the working group on specific issues pertinent to Scotland, we identified the following list of policy domains, organised by consumption categories. Because of the targeted scope of this analysis, and overlap with climate policies, we clarify below which domains are included within this report and which ones are not covered here.

The most relevant domains and subdomains were identified as:

- **Food** has the highest portion of non-carbon inputs.
  - **Food waste.** Food waste is a significant contributor to the food Footprint and has an impact on Footprints both on the emissions side, including methane, as well as on the production side. We cover food waste in **5.3.1** (page 48).
  - **Localizing food** allows Scotland to be less dependent on food production from overseas. We cover the issue of local food production in **5.3.2** (page 53).
  - **New technologies** and approaches are emerging which can reduce the land Footprint of food production. These are covered in **5.3.3** (page 57).
  - Our **diets** make a big difference to the Footprint. Healthy choices often also go hand in hand with lower demands on nature. We cover this in **5.3.4** (page 59).
  - **Food exports** are integral to the Scottish economy. Salmon farming and whisky production are particularly prominent examples of sizable industries in the food sector. Because an analysis of the production Footprint and the environmental challenges associated with specific food industries falls outwith the remit of this report, those industries have **not been evaluated in detail.** Still, it is important to note that a significant input for salmon farming stems from fish harvested outside of Scottish waters and even land abroad, for instance for soy production. It may be helpful to study these particular flows in more detail.
  - **Biocapacity for food** could have an impact on overseas Footprint. Higher domestic production would relieve pressure overseas. For instance, if there was capacity for more sustainable fish farming, or regenerative agriculture, more local products could be made available. Vice versa, agricultural activities that erode local capacities and natural capital would have the inverse effect over time, leading to more Footprint abroad. Since biocapacity was not analysed in as much detail in this study, nor the sustainability of particular agricultural practices, **this assessment is not included here.** However, we cover the topic of **vertical farming**, which has the potential to increase local biocapacity for food, in **5.3.3** (page 57).
- **Shelter/housing** is **not covered here** as it is largely a climate change topic. Significant aspects of this domain include:
  - **Efficiency of housing**, including how to "future-proof" the building stock.
  - **Land-use and resource efficiency**, reflecting how sustainability-oriented urban design and management can not only make the building stock more efficient, but also encourage ways of living that are far more resource efficient.
  - **Energy provision**, particularly the electric grid, which shapes energy use and the sector's environmental impact.
  - Biocapacity provides many **materials for building shelters**. Structural materials are largely made of wood, while interior design often uses more refined materials, including special wood from afar, leather, textiles, etc. Therefore, buildings and their interiors are likely to contribute to Scotland's

overseas Footprint. Some of these aspects are covered in **5.4.1** (page 63) on clothes and textiles.

- **Mobility** is largely a climate topic as well as one of local land use. The latter also has biodiversity impacts. Its dependence on overseas Footprints is relatively small and if so, largely carbon and climate related - hence the topic is **not covered in this report**. However, key issues to consider would include:
  - **Transport systems**, mode preferences and transportation capacities.
  - **Energy** demand, including opportunities to reduce carbon emissions through electrification.
- **Goods** cover a large variety of products. The majority of goods consumed by Scottish households are manufactured overseas, as reflected by the Footprint of goods which has 72% foreign origin. For many, the carbon Footprint is their dominant demand on nature, but other impacts are also important. The areas we cover in the report are:
  - **Non-food agricultural items** are often land and water intensive, and since the products are not eaten, often associated with more aggressive chemicals, including pesticides. When carbon Footprints are excluded, clothing makes up 51% of the Footprint of goods - the largest component within the goods category - 90% of which originates from overseas. Policy options therefore focus on **clothing and textiles**, covered in **5.4.1** (page 63). Other non-food agricultural crops, including for tobacco (representing 18% of the non-carbon Footprint of goods) and flower production, are also important, but not covered in detail here.
  - **Electric devices and electronics** are ever more prevalent in our lives, and often produced in distant global supply chains. They require energy in their production, but sometimes also use highly polluting materials in their manufacturing. This may be a domain where other environmental impacts than demand on regeneration are of highest concern: persistent pollution from mining all the way to production. But the even bigger impact may stem from the systematic electrification of all our energy systems, with large implications for the demand of transition minerals such as cobalt, lithium, manganese, nickel and rare earth metals. Their environmental impact is briefly discussed in **5.4.2** (page 68), drawing on a recent Friends of the Earth Scotland report.
- **Services** sound dematerialised. However, many services require significant amounts of resources to operate, including the hospitality industry, health care, education and security (including policing and military forces). Also, services such as the financial industry are a key component of a highly material reality – without the industry there would be little to finance. Consumption linked with services is therefore cross-cutting, and in the scope of this report only certain aspects are considered, largely those linked with sustainable procurement policies related to food waste (**5.3.1**) and local food production (**5.3.2**).

- **Population numbers** obviously amplify demand. Our assessment in Research Question 1 showed per person consumption through the CLUMs; and per person biocapacity, to compare it to. Population numbers are the complementary factor to per person consumption. Multiplied they make up the total demand. Therefore, it would be mathematically incomplete not to mention population numbers. In Scotland, over the last six decades, population numbers have moved slowly, with the population today just 6% larger than 60 years ago. Hence, we are not covering population dynamics in this report.

5.2.1 How policy levers are assessed

Based on our "ecosystems" perspective on policy interventions, described above, we highlight how possible responses fit within the larger policy environment.

Therefore, we assess options in each domain area based on five central questions:

- **What?** What aspects of a particular domain are being addressed? For example, in the food domain: food waste, local food production, land Footprint of food production, and the environmental impact of diets.
- **Impact?** How much can this effort reduce Scotland's Footprint, and how much of that is overseas?
- **How?** What types of policy levers can governments use to reduce overseas Footprints? The general categories of policy levers governments can use go beyond the proverbial carrots (economic incentives) and sticks (regulations). For example, governments can also, through their procurement power, shape markets and curate information to convince market players. A recent JNCC report (Harris, 2023) provides examples and identifies the following broad categories of policy levers:
    - infrastructure-based
    - information-based
    - economic
    - regulatory.

  In our analysis, we identify how the Scottish Government currently uses policy levers within these categories. We then contrast this with case studies of international best practice and recommendations from the literature . This evaluation is used to inform recommendations.
- **Impact per effort?** To compare the effectiveness of interventions, it is helpful to put impacts in proportion to efforts it takes to intervene. Are there synergies or conflicts with other Scottish Government policies? This also may help to identify easy or symbolic wins.
- **Strengthening Scotland?** Ultimately, those interventions which also support Scotland's wider overarching goals are more likely to be welcomed and produce lasting effects. Therefore, it is key to explore how efforts are making

Scotland better positioned to thrive now and in the future. Practically speaking: how are they making Scotland stronger? What are the wider co-benefits, for example for supporting jobs and making society more equitable, in line with the missions set out in Scotland's new Policy Prospectus and the outcomes of the National Performance Framework?

When exploring potential recommendations, we also considered three practical factors to increase likelihood of policy success:

- **Link to existing Scottish Government policies and programmes**. Here, the question is whether they already contribute or could be adjusted to contribute to reducing Scotland's overseas Ecological Footprint. This will have the benefit of lowering policy cost to the Scottish Government and should also make for quicker implementation.
- **Identify policy actions** which lead to clear and measurable practical results.
- **Prioritize policy actions** that harness Scotland's natural strengths as a nation.

5.3 Focus area: food

Food consumption directly paid for by households (hereafter food Footprint) makes up **19.7% of the total Ecological Footprint of Scotland**. Of this, **52% originates from abroad**. This implies that **over half of the bioproductive land needed to produce, process and transport the food consumed in Scotland is outside the UK**[20]. Thus **reducing Scotland's food Footprint can make an important contribution to reducing the total overseas Footprint of Scotland's consumption**. The three largest contributors to Scotland's food Footprint are cropland, carbon and grazing land, contributing 51% (25.9% domestic and 25.5% overseas), 26% (14.2% domestic and 11.3% overseas) and 14% (7.3% domestic and 6.9% overseas) respectively to Scotland's food Footprint.

5.3.1 Food waste

➢ *What?*

Food waste reduction can directly reduce the Ecological Footprint of food through increased efficiency. This is one of the few current strategies that can address the quantity of consumption by "doing more with less".

➢ *Impact?*

An estimated one third of food produced globally for human consumption is wasted. The greenhouse gas emissions linked with global food waste is estimated to be 6% of global emissions[21]. Were food waste its own country, it would be the third-largest global emitter after China and the USA (FAO 2011). In addition to emissions, food waste also causes inefficient use of resources linked to the production,

[20] Because of data limitations, this assessment could only distinguish inside versus outside UK.
[21] Food waste is responsible for 6% of global greenhouse gas emissions - Our World in Data

transportation, distribution and preparation of food, including demands on ecosystems.

In Scotland, an estimated 987,890 tonnes of food and drink was wasted in 2013. This is split between household food and drink waste of 598,946 tonnes (60.6%), commercial and industrial food and drink waste of 248,230 tonnes (25.1%), and other sectors who contributed 140,714 tonnes (14.2%)[22]. Given similar levels of per capita consumption, food waste reduction will directly drive down Scotland's Ecological Footprint of food (52% of which is overseas) through greater resource efficiency. If the 2025 target of 33% per capita food waste reduction set out in the Scottish Government's Food Waste Reduction Action Plan is achieved, Scotland would produce around 330,000 tonnes less food and drink waste in 2025 against the 2013 baseline, assuming food and drink waste grew in line with expected population growth. This would directly help to reduce the overseas Footprint of Scotland's food consumption.

Over-consumption can also be viewed as a form of food waste, with clear links to obesity and other health problems. Curbing over-consumption can thus simultaneously deliver public health and environmental benefits. We address diets and environmentally sustainable healthy food choices in **5.3.4** (page 59).

➢ *How?*

Current policies on food waste reduction, as included in the Food Waste Reduction Action Plan[23], set out how the Scottish Government, public sector organisations, businesses, industries and consumers can work together to reduce per capita food waste by 33% in 2025, compared to 2013 levels. The plan has a strong focus on food waste prevention, with the top priority being waste reduction of raw materials and products, followed by food redistribution to people and animals. Policy levers currently used by the Food Waste Reduction Action Plan include:

Information-based levers

- Public sector procurement guidance and training.
- Food waste reduction plans for the NHS and education sector, supported by awareness raising campaigns.
- Food waste as a topic in the national educational curriculum.
- Engagement with the hospitality sector and demonstration of return on investment.
- Engagement with the food and drink business sector to address food waste hotspots.
- Consumer awareness raising and education: 'Food Gone Bad' and 'Save Food. Save Money. Save The Earth.' campaigns were delivered in 2019 and

[22] How much food is wasted in Scotland? | Zero Waste Scotland
[23] Zero Waste Scotland; waste reduction plan

2022, encouraging Scottish households to reduce and recycle their food waste.
- Improved food labelling advising consumers on how to minimise waste.
- Initiative to share good practice with retailers on the way products are packaged, labelled and priced: Food date labelling.

Infrastructure-based levers

- Funding of community food redistribution via community fridges, food sharing hubs and apps to connect consumers with surplus food offered by the hospitality sector.
- Improvement of waste monitoring infrastructure and data by the Scottish Waste Data Strategy Board.
- Promotion of waste monitoring and reporting in public, business and hospitality sectors.
- Development of environmental accreditation schemes for the business sector.

Regulatory levers

- A ban on landfilling of biodegradable municipal waste (2021) to address emissions from food in landfill.
- Consultation on the mandatory annual reporting of food waste by food businesses, along with mandatory food waste reduction targets.
- Consultation on the mandatory requirement for large supermarkets to redistribute food that is still fit for human consumption.

Economic levers

- Scottish Government's support for food surplus redistribution.
- Research and development of innovative methods and technologies to reduce food waste, funded by national research councils.

A review of progress since 2019 in implementing the measures in the Food Waste Reduction Action Plan will soon be published by the Scottish Government.

- *International case studies*

Regulatory levers: No country has yet fully overcome the issue of food waste. However, internationally, government legislation has been found to be effective in driving reductions. An example is France's Loi Garot, enacted in February 2016, which made it illegal for large supermarkets to dispose of food safe for human consumption and added a legal requirement for food distributors with over 400 square metres retail space to offer food donation agreements to food aid associations. As a result of Loi Garot, 93% of eligible supermarkets were engaged in food redistribution in 2018, compared to 33% before the law came into effect. The volume of food donated has also increased by between 15% and 50% since the law was enacted, depending on region (EY, 2019). France followed Loi Garot with the EGAlim law in 2018, which required commercial catering operators to offer a "doggy bag" to customers, and which extended the food donation requirement to collective catering operators and the agri-food industry. The ban on rendering foodstuffs that are still edible unfit for consumption was also extended to these players. In comparison with Scotland's target of 33% per person waste reduction by 2025, France has taken a more aggressive position, setting a 50% food waste reduction target (compared to 2015 levels) for the sectors of food distribution and collective catering by 2025, and a 50% target by 2030 for households, food producers, processors and commercial catering sectors[24].

At EU level (from Rivington et al., 2023), the Farm to Fork Strategy (European Commission, 2020a), which is included in the European Green Deal (European Commission, 2019a), aims to make food systems fair, healthy and environmentally friendly. One of the four main elements in the Strategy is *Food Loss and Waste Prevention*, with proposed legally binding targets for food waste reduction, and the promotion of a bio-based economy that uses food waste as fertilizers, animal feed and bioenergy. The EU Food Loss and Waste Prevention Hub reports the actions EU Member States are taking to prevent and reduce food losses and food waste. The hub shows that France is not the only EU country with ambitious food waste reduction targets – the Netherlands, Spain and Portugal all aim to halve food waste in various parts of the sector by 2030.

- *Opportunities*

While Scotland's Food Waste Reduction Action Plan has set out near-term food waste reduction targets, using a range of policy levers, it mainly targets waste reduction at the consumer and food business level via information-based levers. In 2022, the Scottish Government set out a number of proposals to tackle food waste as part of its plan to deliver a zero waste, circular economy. Actions targeting waste in the **broader food value chain** are still largely lacking, for example at the **packaging, distribution and supermarket levels**. There is also opportunity in reducing **overconsumption** of food. **Regulatory and economic levers**, at present a minor component of Scottish food waste policy, can be effective whether or not actors such as businesses or individuals are actively seeking to reduce their

[24] French Legal Scheme on Food Waste ('Lutte contre le gaspillage alimentaire: les lois francaises')

environmental impact (Harris, 2023). Food waste reduction **targets** are also not as ambitious as those set in other European countries, and thus it is recommended that Scotland increases the breadth and depth of actions to tackle food waste[25]. Referring to France again as an example of progressive food waste policy in Europe, some of the implemented measures by the French government include:

- Facilitate donation agreements between distributors and associations by requiring food retailers with a store area of more than 400 square metres to donate surplus food to community organisations.
- Ensure a tax reduction of 60% of the value of donation is applied to the agricultural producer in cases where the donation has passed through a processing and/or packaging intermediary.
- Make information on food waste prevention available to all stakeholders of the food chain by creating a website with the most innovative actions.
- Promote awareness-raising activities on food waste in schools, secondary education institutions and leisure centres. For example, in 2020, a national 'zero waste' challenge in high schools was created.
- Strengthen efforts to raise consumer awareness of the fight against food waste through public communication campaigns, documents and tips. For example, the communication campaign 'Jeter moins c'est manger mieux!' (Throwing away less means eating better!) raises awareness through tales from childhood in a world without food waste.
- Work with representatives of the catering industry to encourage the implementation of actions to combat food waste within companies.

➢ *Impact per effort?*

Food waste reduction has strong synergies with other active policy areas like circular economy and waste, sustainable public procurement[26] and, in the case of over-consumption, public health benefits. In the food value chain, which ranges from production to processing, distribution and final use, a reduction of food waste has few trade-offs, as it improves efficiency and reduces disposal costs, with potential benefits accruing to the entire value chain.[27] For the production and supply sectors, process changes, training and new procurement strategies carry a cost, but this can be outweighed by long-term gains in efficiency. For households, consumers benefit directly through money saved. However, achieving food waste reduction at household level requires consumer behaviour change, which is not trivial and will require further investment in information-based and financial levers.

[25] A revised approach to tackle food waste in Scotland is expected to be outlined in the forthcoming Scottish Government Circular Economy and Waste Route Map which has identified priority and long-term actions to reduce food waste.

[26] Public procurement - taking account of climate and circular economy considerations: SPPN 3/2022

[27] One potential trade-off with waste reduction at the consumer end is a reduction in supply requirements. This may have implications for the supply chain's profitability as less gets sold.

➢ *Strengthening Scotland*

Scottish householders waste more than £1 billion of food each year (Scottish Government, 2019). Household food waste reduction thus brings a direct financial benefit to consumers. Further, if done well, food waste reduction along the value chain could help to increase resource efficiency in food production and consumption, allowing Scotland to meet its food needs with fewer resources. In a world of finite resources and a growing global population, this shows responsible global citizenship and will also increase Scotland's potential to thrive in a future of increased resource constraints. Finally, given the large greenhouse gas emissions linked with food waste, food waste reduction will also strengthen Scotland's international contribution to emissions reductions at a low cost.

5.3.2 Local food production

➢ *What?*

Increased consumption of locally produced food can potentially reduce the carbon Footprint of food distribution. However, this assumption doesn't apply to every product, and highlights the need for robust metrics to allow for a distinction to be made. Nonetheless, local production can better internalise natural resource use, environmental impacts and social impacts of food production, as the feedback loops are more direct.

➢ *Impact?*

A recent global study suggests that global food-miles account for nearly 20% of total food-systems emissions when accounting for transport, production and land use change. The study also finds that global freight transport associated with vegetable and fruit consumption contributes almost twice the amount of greenhouse gases released during their production (Li et al., 2022). Similar results are reported by UNEP, who found that the carbon Footprint of food distribution is significant and comparable to that of food production (UNEP 2021). These transport-related emissions can be addressed through greater local consumption, particularly of fruit and vegetables. Obviously, this would also require linking food consumption more tightly to seasonality. Further, the carbon Footprint of food can also be heavily influenced by production methods. For instance, soy production associated with natural vegetation loss in Brazil carries a larger carbon Footprint, with associated imports entailing up to six times greater emissions per unit of product than the Brazilian average (Escobar et al., 2020).

Considering wider impacts, globally the majority of natural resource use, social and environmental impacts that take place along food value chains are occurring at the primary production stage through farming crops, raising livestock and fishing (UNEP, 2021). Where efficient from a trade perspective, the consumption of locally produced food can thus internalise the wider impacts of food production. If domestic policy to address these impacts is stronger, which arguably is the case for Scotland, it is likely to result in impact reduction. It is also likely to create a better

understanding of the environmental and social impacts of food production, increasing public demand and political will to address these impacts (Harris, 2023).

➢ *How?*

In August 2021, the Scottish Government published the consultation "Local Food for Everyone: A Discussion" to ensure that the public and relevant organisations had a chance to further shape government action to encourage local food. The consultation focussed on the three pillars of the Scottish Government's draft local food strategy: connecting people with food; connecting Scottish producers with buyers; and harnessing public sector procurement. These pillars outlined the wide range of activities being undertaken by the Scottish Government and agencies relating to local food.

The Scottish Government has committed to publishing a final version later this year, which will support locally-based production and circular supply chains, cutting food miles and enabling more people to enjoy food grown locally. Relevant interventions in the strategy include:

Information-based levers

- Certification of school caterers with the Food for Life catering mark, ensuing menus are fresh, seasonal, high welfare, with progress towards more healthy, locally sourced and ethical choices.
- As part of the Scottish Government's Out of Home Action Plan, there is a commitment to develop an Eating Out, Eating Well Framework to support the out of home sector to provide a range of healthier options to consumers. This will include principles around sustainability.
- Regional showcasing events, connecting buyers and Scottish suppliers.
- The Scottish-Government joint-funded Supplier Development Programme, which provides information, guidance and training to prospective suppliers across multiple sectors, including food and drink, on how to bid for and win contracts for public procurement.
- Public education and awareness-raising campaigns about local, seasonal food.

Infrastructure-based levers

- Utilising land or vacant lots for local production.
- Providing local market infrastructure and temporary space in popular locations to support interaction between local producers and consumers (e.g. farm shops, farmers markets).

Regulatory levers

- Good Food Nation (Scotland) Act 2022, placing duties on Scottish Ministers and certain public authorities to produce plans of their policies in relation to food, setting out outcomes, policies and measures to assess progress[28].
- Public sector food procurement reform via The Procurement Reform (Scotland) Act.

Economic levers

- Funding for allotments, community gardens and community orchards to promote Grow Your Own activities.

Currently, SG promotes local consumption mainly through a large variety of information and infrastructure-based levers. Regulatory levers are mostly used for public sector procurement, while economic levers are limited to small-scale local initiatives. While there has been a general lack of policy levers encouraging local consumption by households, in particular financial incentives that are known to have a strong influence on consumer choices (Harris, 2023), SG continues to support Scotland's Towns Partnership to deliver the Scotland's Loves Local programme, including the Scotland Loves Local Gift Card, which remains a major opportunity to support local economies[29]. Effectively creating a local currency, it provides a means for companies and individuals to reward and incentivise in a way that ensures that the value of that spending stays local and recirculates round the local economy. Current actions still only target a small segment of the population and food products, with the majority of food being consumed without consideration of whether it is local or not. The challenge is therefore to promote localisation at a higher 'systems' level.

SG's Curriculum for Excellence[30] encourages learning about food through making food education an integral part of the national educational curriculum. Strengthening education through a concerted educational campaign, including teaching school children how to prepare and cook local, seasonal food is a key

[28] The Good Food Nation (Scotland) Act 2022 makes an explicit link between food and sustainability issues. The Act requires Scottish Ministers to prepare a national Good Food Nation plan and for local authorities and health boards to have regard to this when preparing their own plans. The Good Food Nation plan will set out the direction for future food policies, helping to achieve food-related outcomes in coordination with other policy areas and linking more widely to strategic programmes such as the National Performance Framework and Sustainable Development Goals. The Scottish Government intends to publish the draft Good Food Nation Plan for consultation in 2023.

[29] Scotland Love's local gift card

[30] Scotland's Curriculum for Excellence outcomes

aspect as education and food confidence is at the heart of long-term consumer behaviour change.

- *International case studies*

A rapid literature review found that there are numerous studies that aim to quantify the emissions related to food production and distribution, and that local consumption is often recommended to address this (e.g. Weber et al., 2023; Tidaker et al., 2021). Still, the literature seems to lack proven recommendations on how to upscale local consumption among end consumers.

Ecolabelling seeks to empower consumers to make environmentally conscious decisions. Using ecolabels in food to convey metrics like related emissions in production and transport could be one way to encourage local consumption by households. Rivington et al. (2023) found that research in Spain and Scotland (Akaichi et al., 2020) show the effects of labels such as organic, local and low greenhouse gas emissions on consumer preferences. Results showed a willingness to pay premiums for certain combinations of food attributes and labels, and UK demand for beef mince increased if also labelled as organic or low in emissions. Ecolabelling is thus a potential way in which to encourage household consumption of more local produce with lower associated transport emissions. However, while ecolabelling can inform the end consumer, it is vulnerable to data quality issues, and has to date been limited in providing information about the labour and social conditions which make up the wider impacts of food production (Rivington et al., 2023).

Other initiatives found in the literature include the use of **vending machines** for local products, a circular business model based on a short supply chain. For example, a study by Pereira et al. (2018) found that vending machines selling locally produced milk led to savings in packaging and transport energy compared to supermarkets. However, the success of the initiative relied on investment in vending machine infrastructure, public awareness and engagement with local farmers.

While initiatives like short circular supply chains have potential, in reality, the majority of food is purchased in supermarkets, where price and quality are major drivers of consumer choices. Broader structural changes at **supermarket level** (e.g. the retailer offering a larger proportion of local products at an affordable price) are thus likely to deliver more impact in the near term.

- *Opportunities*

There was a commitment in the 2022/23 Programme for Government to update Catering for Change, which will set out principles in relation to **sustainable procurement** of food and catering services in the public sector, to align public procurement behind sustainable, low carbon farming and food. This refreshed guidance will incorporate and sign post all those involved in public procurement to the Sustainable Procurement Tools.

While not without its challenges, there is evidence that **information-based levers** like **ecolabelling** can empower consumers to make more environmentally friendly

purchasing decisions. Investment in **short supply chain, circular infrastructure**, like vending machines for local produce, presents another opportunity to reduce food miles, in conjunction with more local and seasonal offerings by **supermarkets**. Addressing the wider challenge of long-term behaviour change, it is imperative to have strong **educational** campaigns aimed at school-aged children, teaching them how to prepare and cook local, seasonal food.

- *Impact per effort?*

Although not the focus of this study, by reducing food miles, initiatives to promote local food consumption align with emissions reduction policies and Scotland's net zero agenda. Local consumption also has the potential to reduce Scotland's impact on ecosystems overseas. As noted above, the majority of natural resource use and environmental impacts that take place along food value chains occur at the primary production stage, so the consumption of locally produced food can help to internalise these impacts. Since domestic policy to address these impacts may often be stronger in Scotland, this is likely to result in impact reduction. Local consumption also ensures that a larger part of consumer spending remains within the Scottish economy. As Scotland's public sector is already intent to boost local consumption, extending policies to the household consumer is a logical progression. Educational campaigns for children have strong synergies with public health targets, as it could increase the proportion of fresh food consumed and lead to long-term consumer behaviour change.

- *Strengthening Scotland*

In a future of increasing climate extremes, food production will become more challenging in many parts of the world, and this is likely to have impacts on food prices and supply chains. A recent report on the potential trade-linked cross-border climate impacts to EU supply chains finds that there still exists uncertainty in the nature and severity of such impacts, and that this calls for a highly precautionary approach, where low- or no-regrets measures like localised food supply systems are adopted (West et al., 2022). Consumption of more locally produced food products can thus make Scotland less vulnerable to future trade-related food supply chain shocks, while providing present-day benefits for Scottish producers.

5.3.3 Agricultural innovation

- *What?*

Vertical farming (VF), a form of controlled environment agriculture (CEA) with multiple growing levels, reduces the amount of bioproductive land area needed for food production, and thus has the potential to reduce Scotland's cropland Footprint. However, such practices are also material and resource intensive. Therefore, they need to be carefully designed to produce net benefits. Depending on the share of renewables in the national electricity mix, VF could also lead to a reduction in the carbon Footprint of food production (Sandison et al., 2022). Looking beyond the Footprint accounting framework, technological innovation in

VF can reduce other environmental impacts of food production like pesticide and fertiliser inputs and water use (Avgoustaki and Xydis, 2020).

- *Impact?*

Food makes up 19.7% of Scotland's total Ecological Footprint. 52% of the food Footprint comes from overseas, with cropland and carbon the largest components of Scotland's food Footprint at 51% (25.9% domestic and 25.5% overseas) and 26% (14.2% domestic and 11.3% overseas) respectively. Further, considering the detailed household category breakdown of food presented in Research Question 1, the overseas Footprints of fruit and vegetables are approximately three times larger than their domestic Footprints, indicating the heavy reliance in Scotland on imported fruit and vegetables.

A recent study by the James Hutton Institute found that VF has the potential to reduce both the cropland area and carbon Footprints of food (Sandison et al., 2022). By comparing land use area, carbon Footprints and water Footprints of vertical lettuce farming in Scotland with that of open farms in the UK and Spain, the study found that VF required 74% to 84% less land area than open farms, directly reducing the cropland Footprint.

The analysis also found that the carbon Footprint of open farms is dominated by transport, fertiliser and soil management, while in VF the carbon Footprint is dominated by electricity use. It follows that, under a 100% renewable electricity scenario in Scotland, the carbon Footprint of VF would be lower than that of open farms. Finally, VF was also found to have the smallest water Footprint of all production methods. While this study focused on lettuce production, it highlights the potential of VF to reduce the land, carbon and water Footprints of food production, much of which is overseas for Scotland. However, while VF has the potential to revolutionise food production, it cannot yet be applied to all foodstuffs, and therefore needs to be considered alongside other policies like food waste and diets.

- *How?*

No existing policies of the Scottish Government were identified which directly promoted VF. However, the "Local Food for Everyone: a discussion" consultation included an overview and questions relating to VF.

Food production innovation is also a priority at UK level, reflected in government funding for agricultural research and innovation via UKRI's "Transforming food production challenge". The challenge has a budget of £90 million, running from 2019 to 2024, with the aim to help businesses, researchers and industry to transform food production, meet the growing demand, reduce environmental impacts and move towards net zero emissions. In the development of cutting-edge technology, continued government support of research and development is essential.

- *Impact per effort?*

Government support of **VF and CEA research and innovation** aligns with SG targets to reduce emissions and environmental impacts of food production. It can also

enable urban food production, which can aid urban regeneration and reduce food miles. Investment in VF research and development thus has many synergies with other policy areas in government and those identified in this report to reduce the impact of Scotland's consumption.

- *Strengthening Scotland*

In the predictable future of climate change and resource scarcity, VF can contribute to Scotland's food security by providing a controlled environment less vulnerable to climate extremes, requiring less resource inputs. VF also allows production of a wider range of produce not otherwise suited to the Scottish climate, thus reducing Scotland's reliance on imports of fruit and vegetables and the associated vulnerability to international supply chain challenges, as highlighted during the Covid-19 pandemic. While the high electricity requirements of VF makes it vulnerable to high energy prices, it will benefit from increased Scottish green energy production. VF can also bring about more efficient land use (e.g. vertical farms in unused urban buildings) and increased food production in urban areas, which can further contribute to Scotland's food security.

Coupled with the reduced land, water and carbon Footprints outlined above, VF can thus strengthen Scotland by providing, if designed well, a potentially sustainable and climate-resilient method of food production. Such initiatives would also bring jobs to Scotland and give it an edge on an emerging technology that will be increasingly needed around the world.

5.3.4 Diets

- *What?*

Switching to more sustainable diets, particularly a shift away from emission-intensive meat options towards more diverse plant-based diets, can reduce the Footprint of Scotland's food domain.

- *Impact?*

Research Question 1 noted that "most of the current biodiversity loss that can be linked to consumption in Western Europe is embodied in international trade...with food products contributing 74% to that biodiversity loss. Among food, **consumption of animal products** is the largest driver by far of potential biodiversity loss (Sun et al., 2022; Wilting et al., 2017)".

Further, globally, emissions from food systems (from production to consumption) make up over a third of total GHG emissions (Crippa et al., 2021). In Scotland, the CO_2 emissions of household food consumption makes up a significant 8% of Scotland's total carbon Footprint. Reducing the carbon Footprint of food is thus both a global and national priority to progress towards emission reduction targets.

The literature recommends various ways to reduce the carbon Footprint of food. Beyond technical innovations to increase food production efficiency (e.g. VF) and a reduction in food waste, diet change, and specifically a shift away from meat

products with a large carbon Footprint, has been identified as a means by which to reduce the carbon Footprint of food and keep food systems within safe operating limits, given the expected growth in the global population (Springmann et al., 2018; Willett et al., 2019).

Potential benefits of more sustainable diets also apply to Scotland, with household meat consumption shown to be the largest contributor to the carbon Footprint of food. Meat consumption is also the largest and second-largest contributor to grazing land and cropland Footprints of food respectively, both of which have large overseas components. A reduction in consumption of meat and other animal products can thus benefit Scotland's carbon Footprint, as well as Scotland's demand for grazing land and cropland.

In Scotland, venison, as a niche product, has specific relevance to lowering the Footprint of meat consumption, or at least a small portion of it. NatureScot has the statutory responsibility for sustainable management of wild deer species in Scotland, based on the *Code of Practice on Deer Management* which itself is based on the 2008 policy *Scotland's Wild Deer: A National Approach*.[31] Under the guidance of NatureScot, deer management groups, landowners, local residents and partners like Forestry and Land Scotland manage deer numbers through culling, resulting in a limited amount of Scottish venison available as a high-quality food product. Venison lacks the Ecological Footprint associated with farmed meat production, and its production supports rural jobs while reducing the pressures associated with Scotland's excessive deer populations. It should be noted that the recommendation is not to drive a large-scale switch from beef to venison, but rather to point out that there are potential synergies between existing landscape-scale ecosystem restoration projects (e.g. Cairngorms Connect, which is aiming to control excessive deer numbers that are preventing woodland regeneration) and offering venison as a local, low-carbon meat option. However, availability and price are currently barriers to Scottish venison being recognised and consumed more widely as a 'niche-product with a positive *contribution*', as part of a drive towards more flexitarian, sustainable diets.

As reported by Rivington et al. (2023), the EAT-Lancet report (Willett et al., 2019) highlights the imbalance in human diet and the need for reduced consumption of some food goods but increases in others: "*Transformation to healthy diets by 2050 will require substantial dietary shifts. Global consumption of fruits, vegetables, nuts and legumes will have to double, and consumption of foods such as red meat and sugar will have to be reduced by more than 50%. A diet rich in plant-based foods and with fewer animal source foods confers both improved health and environmental benefits*". The dichotomy of needing to reduce consumption of meat whilst increasing consumption of (seasonal and preferably local) fruit and vegetables has substantial consequences for land use and management. In the UK, approximately 85% of farmland is used to feed livestock, but provides only 32% of

[31] https://www.nature.scot/code-practice-deer-management#:~:text=The%20Deer%20Code%20sets%20out,do%20to%20manage%20deer%20sustainably.

the calories we eat; whilst the 15% of farmland that is used to grow plant crops for human consumption provides 68% of our calories. Overconsumption of meat is a direct cause of diet related health issues – which points to a clear bridge between environmental and health benefits.

- *How?*

The UK Climate Change Committee has recommended a 20% reduction in the consumption of high-carbon meat and dairy products by 2030, with further reductions in later years to cut emissions and protect natural ecosystems. As reported by Rivington et al. (2023), such substantial behavioural changes are likely to have significant impacts on land use both in the UK (and elsewhere) and on trade in food and livestock feeds. The UK Food Strategy (Dimbleby et al., 2021; Dimbleby et al., 2022) makes recommendations on dietary change for human health and environmental sustainability, alongside the need for food system and land use transformations. The report recommends cutting meat consumption by 30% within a decade.

The Dimbleby recommendations have only partially been acted on in developing a food strategy and eventual legislation in England and Wales. The recent Scottish Government Good Food Nation (Scotland) Act places a strong emphasis on the need for healthy diets and sustainable food production.

Despite evidence-based arguments for a reduction in meat consumption (e.g. flexitarians with lower meat consumption than their omnivore peers can significantly reduce environmental impacts, according to Springmann et al. (2018)), meat forms an important part of many western food cultures, and thus a shift away from meat poses a large policy challenge. In addition to cultural barriers, there are also educational barriers, where people may be willing to change, but lack the practical knowledge on how to plan and prepare meat-free meals. Linking with the topic of localising consumption, here a similar recommendation is to invest in educational campaigns that target consumers, and to adjust the national curriculum to empower children and young adults with the knowledge of how to prepare local and seasonal food, with a focus on plant-based alternatives to meat, prepared freshly.

- *International case study*

Recent research commissioned by the French Government evaluated the effectiveness of traffic light **ecolabelling** across food categories in enabling consumers to compare the environmental impact of food products at point-of-purchase (Arrazat et al., 2023). Results showed that front-of-pack traffic light ecolabelling across food categories had a statistically significant effect in driving consumers to make more environmentally-friendly food choices, e.g. a move away from red meat towards plant-based foods. The efficacy of ecolabelling in this study was argued to stem from the simple and uniform labelling applied on the front of packs across all food types, as this allowed clear and unambiguous comparisons between different food types at the point of decision making. However, this poses a difficult challenge, due to the complexity of environmental impacts, and the rigor

needed to reduce these to a simple five-scale metric. It may be possible to capture metrics like the product's carbon Footprint with existing data. While not complete, this could illustrate a contrast between different types of meat, soy products, and local and imported fruit and vegetables. This metric, if applied rigorously, could capture impacts like deforestation in soy production, and benefits like local meat produced from pasture rather than solely with animal feed. Admittedly, this poses significant data and methodological challenges. While price and quality are expected to remain the main drivers of consumer choices, an indication of carbon Footprint may however influence some consumers at the point of purchase and serve to create awareness and understanding of products' carbon Footprint.

- *Opportunities*

The shift away from red meat towards more sustainable diets is a complex and substantial policy challenge. In Scotland, there are some niche opportunities, such as increasing the consumption of venison as a meat option with co-benefits linked with land management and rural job creation. There is also some opportunity to influence consumer choices via **ecolabelling** that illustrates, for instance, the carbon Footprint of food products. However, the largest opportunity lies in **education**, where the national curriculum should empower young people to understand the implications of different food choices, and plan, prepare and cook meals with more fresh, seasonal plant-based ingredients.

- *Impact per effort?*

A switch to more sustainable diets aligns with existing SG policies that target emissions reductions, public health and food security. Due to the importance of meat in many cultures, it will take substantial investments in public information and education to encourage and foment desire for switching away from meat towards environmentally lighter plant-based foods.

- *Strengthening Scotland*

In addition to reducing Scotland's food Footprint, a switch to more sustainable diets can benefit consumers directly through reduced food bills (e.g. substituting expensive processed and/or meat-heavy meals for freshly prepared options with plant-based proteins like pulses, with the exception of highly industrial plant-based meat alternatives). Creating a more diverse food culture will also make consumers more resilient to supply chain challenges that may arise in the future. Finally, there are public health benefits associated with more freshly prepared, plant-based diets, and so to drive this in the national curriculum could contribute to addressing wider health-related challenges in Scotland, many of which are diet related.

5.4 Focus area: goods

Research Question 1 showed that the consumption category of goods makes up 10.2% of Scotland's total Ecological Footprint. Along with food, 'goods' is another consumption category for which there is a predominantly overseas Ecological Footprint, with 72% of the goods Footprint being of overseas origin (Table 2).

Reducing the Footprint of goods consumed in Scotland can therefore make an important contribution to the overall reduction of Scotland's Ecological Footprint.

5.4.1 Clothing and textiles

- *What?*

Clothing is the largest contributor to Scotland's goods Footprint, making up 45% (or 51% when carbon Footprint is excluded). The vast majority (91%) of Scotland's clothing Footprint is overseas, and thus any policies that can address the size of the clothing Footprint, or the impacts associated with the production of clothing, will make an important contribution to Scotland's mission as a responsible global citizen.

- *Impact?*

A recent UNEP report on sustainable consumption and production analyses the global textile value chain to identify where (both geographically, and at which points in the value chain, Figure 8) impacts arise (UNEP 2021).

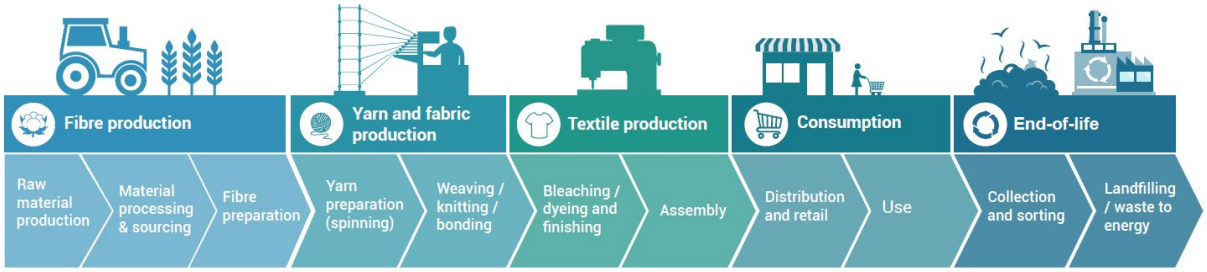

Figure 8: 8 Linear representation of activities along the textile value chain (From UNEP 2021)

The report finds that globally, clothing production has approximately doubled in the last 15 years, with less than 1% of clothing currently being recycled. The climate impacts of the textile value chain are substantial, with over 3.3 billion metric tons of greenhouse gases emitted across the value chain per year, more than all international flights and maritime shipping combined. Of this, the largest emissions (36%) exist in the bleaching/dying phase, followed by the emission of electricity used for clothing care (24%) (Figure 9). However, land use impacts of the textile value chain are also significant and largely linked to cotton production, which has driven large-scale land conversion and now occupies 2.5% of global arable land (Figure 9).

Further, the clothing industry is estimated to use 215 trillion litres of freshwater annually. Absolute water use is highest in the end use, bleaching/dying and production stages, but when viewed through a water scarcity lens, the highest water scarcity Footprint is at the raw material production stage, again mostly due to cotton cultivation (Figure 10).

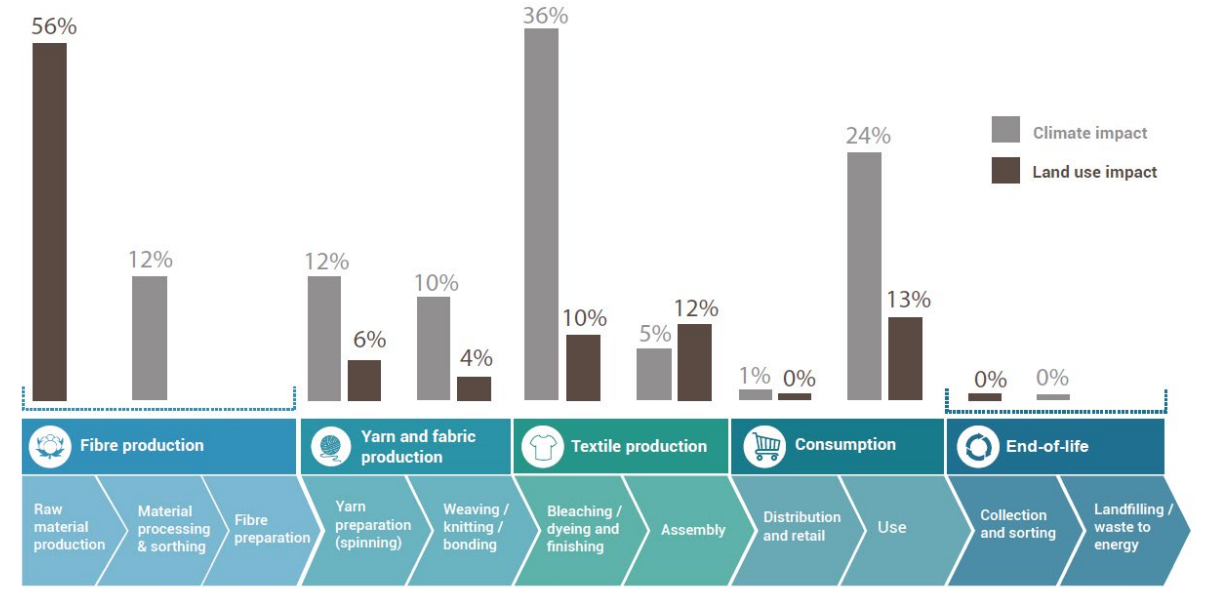

Figure 9:9 Climate impact and land use impact across the global apparel value chain (UNEP, 2021)

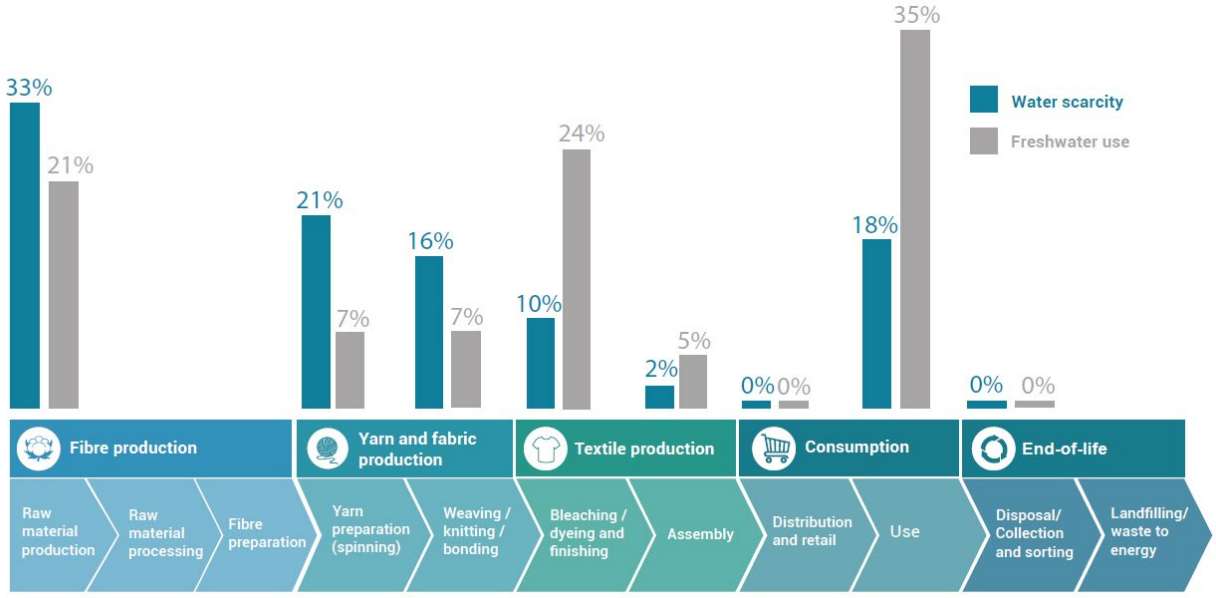

Figure 10:10 Freshwater use and water scarcity footprint across the global apparel value chain (UNEP, 2021)

Textile production also has large negative impacts on ecosystems, with 16% of global pesticide use and 4% of global fertiliser use linked to cotton production. Microfibres from synthetic textiles released into the environment during manufacture, use and end of life is an area of active research, and knowledge gaps still exist about impacts on biodiversity and human health through uptake into the food chain.

The social risks associated with the textile value chain are significant, with the highest social risks occurring during natural fibre production and excessive working time in high-risk garment assembly. The report finds that social risks are mainly due

to three common practices: demand for short lead times, demand for flexibility, and a continual search for lower prices (UNEP, 2021).

In essence, significant environmental and social impacts characterize the global clothing and textile value chain. At the farm level, fibre production has impacts linked with water scarcity, land use, agrichemicals, GHG emissions and poor working conditions. Yarn and fabric production stages have impacts related to water scarcity and GHG emissions. The textile production stage not only releases GHG emissions, but it is associated with chemical pollution, microfibre release and poor working conditions. Finally, clothing users put additional demand on water and electricity for clothing care, release lasting microfibres, and still largely fail to recycle (<1% recycling rate) (UNEP, 2021).

As Scotland is very much part of this global supply chain, these impacts can also be linked to Scotland's high level of consumption of clothing and textiles. GHG emissions of waste textiles is another impact. In total, it is estimated that the clothing and textiles value chain contributes 8% to global GHG emissions. Zero Waste Scotland's latest Carbon Metric Report shows that textiles make up four per cent of Scotland's household waste by weight, but account for nearly a third (32%) of the carbon impact of Scotland's household waste.

Any mitigation related to quantity consumed or environmental quality improvements will thus contribute to Scotland's mission of being a responsible global citizen.

- *How?*

One way to mitigate the environmental impacts of textile production and reduce the quantity challenge is via increased quality, allowing consumers to wear clothes for longer, and breaking the fast fashion cycle. Not only will this reduce the quantity of clothing and textiles that need to be produced from virgin materials, but also reduce GHG emissions in waste by slowing the flow of textiles and clothing into landfills.

Textile recycling is a secondary opportunity, as whilst reducing the demand for virgin materials and keeping textiles out of landfill, the process still carries a water, carbon and environmental Footprint. The Scottish Government is currently using a range of policy levers to speed up the transition[32] to a circular economy, as set out in Making Things Last: a circular economy strategy for Scotland. Regulatory levers include the recently published Circular Economy Bill.[33]

SG is also using economic levers like the Circular Textiles Fund (delivered through Zero Waste Scotland) to support the development of circular supply chains in Scotland and promote innovation.

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[32] See the forthcoming route map: Delivering Scotland's circular economy – now in consultation. https://www.gov.scot/publications/delivering-scotlands-circular-economy-consultation-proposals-circular-economy-bill

[33] See also the comments by Zero Waste Scotland on their website: The Circular Economy Bill (zerowastescotland.org.uk)

Financial and information-based levers within and beyond the textile industry are being deployed through the partnership between Zero Waste Scotland and South of Scotland Enterprise, where Zero Waste Scotland will provide access to expertise and advice on the opportunities and benefits of embracing a more circular way of operating; while South of Scotland Enterprise will work with people and businesses across the region to grow its economy by providing investment, expertise and mentoring in more sustainable ways of living and operating.

Public procurement is also included in SG's drive towards greater circularity, as guided by the National Climate and Procurement Forum, policy guidance and SG's Sustainable Procurement Toolkit.

- *International initiatives*

At present, international initiatives that aim to address the environmental and social impacts of the clothing and textile industry are largely voluntary. Existing multi-government initiatives include the UNFCCC Fashion Industry Charter for Climate Action, created in 2018 and renewed at COP26, where signatories and supporting organisations collaborate to drive the fashion industry to net-zero GHG emissions no later than 2050.

Initiatives addressing social impacts of the textiles industry include the Transparency Pledge where clothing and footwear signatories transparently report their manufacturing supply chains with the aim of identifying and preventing human rights violations; and the Better Work Programme. The Better Cotton Initiative aims to embed sustainable farming practices, enhance producer welfare, and drive global demand for sustainable cotton. This initiative has received large uptake, and to date nearly a quarter of the world's cotton is produced under the Better Cotton Standard. The Fashion Pact is another example and aims to halt climate change, restore biodiversity and protect the oceans.

Recently, the drive for increased circularity has brought recognition that true circularity requires systemic change throughout the whole value chain, with actors following a common agenda (UNEP, 2021). One example of an initiative that aims to drive systemic change in textile use is the Ellen McArthur Foundation Make Fashion Circular initiative which aims to build an industry that designs products to be used more, made to be made again, and made from safe and recycled or renewable inputs.

- *Opportunities*

To reduce the environmental and social impacts related to textiles and clothing, UNEP (2021) identifies the need for a comprehensive approach with strategic interventions across the entire textile value chain, with governments applying new legal frameworks and incentives; industry and innovation creating textiles for reuse and recycling; and civil society encouraging behaviour change. Specific recommendations include (UNEP, 2021):

Governance (economic and regulatory levers)

- **Incentives** for new circular business models. This is being done in Scotland via the Circular Textiles Fund.
- **Disincentives**, e.g. taxation of virgin materials versus decreased taxes on secondary raw materials. Such disincentives do currently not exist in Scotland.
- **Eco-design and sustainable production requirements**. Such requirements are currently largely lacking in Scotland.

Collaboration and finance (economic and information levers)

- Provide support for scaling circular business models through **public-private partnerships**. This is being done through the partnership between Zero Waste Scotland and South of Scotland Enterprise.
- **Leverage funding.** This is being done in Scotland via the Circular Textiles Fund.

Change consumption habits (information, infrastructure and financial levers)

- Change consumer attitudes through **information** and **educational campaigns**. Currently largely lacking in Scotland.
- Provide **infrastructure** for rentals, repair and recycling. Currently there is still much room to improve in Scotland.
- Incentivise **sustainable purchasing** through discounts. Such schemes do not exist in Scotland.

Comparing the levers currently used in Scotland to boost circularity and sustainability in the clothing and textile domain with the recommendations by UNEP (2021), shows that Scotland's current policy attention is largely focused on providing the support (economic and capacity building) to develop and upscale circular business models. **Disincentives** like **taxation of virgin materials** and **regulation of production practices** are still largely absent, and limited use has been made of **financial levers** like incentivising **sustainable purchasing**, and **information levers** like improved **ecolabelling** to influence consumer choices at point of purchase. There is also a lack of **educational campaigns** on the impacts of clothing and textile production and waste to build consumer appetites for more circular approaches.

- *Impact per effort?*

As outlined above, increased circularity in clothing and textiles is an active policy area, which aligns with emissions reduction and waste reduction policies. There are thus large synergies with other parts of government.

- *Strengthening Scotland?*

Investment in circular economy approaches in Scotland not only contributes to Scotland's mission as a responsible global citizen, but can also lead to job creation and a transition to growing Scotland's green economy.

5.4.2 Electronics and transition minerals

With the electrification of all societal domains, as part of the transition from fossil fuels, the demand on minerals and metals for such an electrification is skyrocketing, even though electrification is essential for a sustainable future. This cuts across several of the consumption domains explored in this report, including personal transportation, housing and goods. The implications and contradictions are significant and well summarized in the "Unearthing Injustice" report commissioned by Friends of the Earth Scotland, launched in May 2023.

Apart from the social implications of mining (also covered in that report), mining is an extremely energy intensive process, with most of that energy coming from fossil fuel. This leads to significant carbon Footprints.

In addition to GHG emissions, mining impacts ecosystems, polluting the air and the water, to different degrees for different mines. Some mining can also be water intensive. Often mines operate in remote sites and pose a threat to the biodiversity there. Tailings, i.e. the mining left-overs including toxic waste, are often deposited on surfaces around the mine, behind dams that have high failure rates.

While this study was too limited to meaningfully analyse the relative importance of mining among all Footprints overseas, it cannot be ignored, and the "Unearthing Justice" report provides a powerful introduction to the challenges of growing demands for mining products.

5.5 Recommendations: linking opportunities to current government efforts

The examples outlined here in this report would be far from enough. Marginal changes here and there will not have the necessary effect to either reduce Scotland's overseas Footprint or to make Scotland ready for the predictable future. Rather, this report recommends how to think about these possible interventions, and how to structure them to make them more likely to succeed. The reality is that Scotland, like most other places, faces competing policy ambitions, with goals like "adjusting the material metabolism to a level that fits within planetary constraints" often finding themselves low on the priority list.

For this reason, this report emphasizes how central it is to recognise the policy context. This means that positioning interventions in a way that aligns with wider goals, that may otherwise be perceived as competing, is essential.

Additionally, it is helpful to consider where to host the transformational policy opportunities. Therefore, after identifying key domains that shape Scotland's overseas Footprint, and discussing the ones which have the greatest direct (non-carbon) impact on the natural environment overseas (food and clothes), a central question also becomes how such initiatives can be taken forward in the real-world policy context.

Let's recognise that meaningfully and substantially addressing those overseas Footprints in an era of overshoot requires a **lower material metabolism of the Scottish economy**, involving a **shift to sustainable forms and levels of consumption**. There is no way around reducing the metabolism, otherwise impacts may just be displaced, rather than eliminated. But, equally importantly, such a reduction is much more likely achieved if it also strengthens the Scottish economy,[34] and people feel enhanced, not diminished by those shifts. The focus and emphasis need to be on how to restructure the economy to be fit for the future and making it more secure, rather than only advocating to avoid certain materials or certain sources.

What are the practical ways forward? **5.3** and **5.4** included options for reducing the metabolism in the consumption domains of food and clothing. All other domains, more dominated by carbon Footprints, would have similar recommendations. The task is to find effective vehicles for such recommendations. Since Scotland's government is already actively involved in shaping its future, the best opportunities for recommendations to find outlets is to be woven into existing initiatives pursued by the government.

Here are some options for how the above recommendations for reducing Scotland's overseas Footprint could be linked to existing initiatives.

5.5.1 Keep Scotland's focus on a comprehensive environment strategy

Scotland's Environment Strategy says it beautifully: "*The Environment Strategy for Scotland creates an overarching framework for Scotland's strategies and plans for the environment and climate change. Its 2045 vision and supporting outcomes describe our guiding ambitions for restoring Scotland's natural environment and playing our full role in tackling the global climate and nature crises. In turn, this will help to build a stronger, more resilient economy and improve the health and wellbeing of Scotland's people. It will help to ensure we live within the planet's sustainable limits as responsible global citizens.*"

Recognising the interconnectedness of the environmental challenge, and the fundamental relationship with Scotland's economy, gives Scotland a strong foundation.

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[34] This means that Scotland favors assets and economic activities that can operate effectively in the predictable future of climate change and resource constraints. It is not about present GDP maximization, but rather a wealth proposition: making sure that the wealth (or Scotland's assets) stays valuable. Just monitoring GDP can distract from the structural situation of an economy – with the wrong assets, longer-term income generation would be compromised.

Others have separated out climate change. This is, in our view, a strategic mistake, because isolating the problem makes the challenge next to unwinnable, since it overemphasises "free rider" dynamics. Free-riding means that the actors and society's incentives are not aligned. The emitter profits from the energy benefits while society carries the emission costs. Or vice versa, those who cut their own emissions give up easy access to energy, while the benefit of emission reductions accrues to humanity as a whole. Such dynamics are tough to overcome.

However, by upframing the climate challenge to the bigger dynamic – overshoot – the free-riding trap can be overcome. Because, from an overshoot perspective to one of resource security, it becomes clear that individuals, companies, cities and countries have a direct self-interest to act and prepare themselves for a future of climate change and resource constraints. In other words: fighting climate change in isolation is largely an unwinnable proposition, putting it into the larger context of overshoot makes it potentially winnable.

Recommendation: **Implement the approach outlined in the Environment Strategy Vision and Outcomes**, and the forthcoming 'outcome pathways'.

5.5.2 Accelerate circular economy strategies

Scotland has many initiatives already focusing on the transition to a circular economy. A simple way to identify opportunities is to ask the question: are there products and services produced in Scotland that currently use imported natural resources that could be partly replaced with waste produced domestically?

For example, are there feed inputs that are imported for use in agriculture, aquaculture and general food production that could be replaced by turning wastes into feedstock?

This could potentially be facilitated by:

- The new Scottish **farming funding programme** that will replace the EU CAP support mechanism.
- Scottish Enterprise and Zero Waste Scotland **grants programmes** could be targeted at supporting such innovation.
- Existing or additional support to the emerging **vertical farming** sector could be partly focused on generating alternative feedstocks.
- **Waste management** could be redesigned to benefit from maximum, and most energy efficient, repurposing of wasted materials. Circularity could be optimised by creating maximum overshoot reduction per effort. This would require improving current metrics for circularity to go beyond kilograms of material, in order to capture both the biocapacity effects of circular practices and the Ecological Footprint savings.
- The **forest industry** could be invited to develop a longer-term perspective on how it could serve Scottish industrial needs, including for construction materials.

5.5.3 Education

Education has a critical role to play in shaping Scotland's future as a responsible global citizen, with the youth of today becoming the consumers of tomorrow. The two major focus areas of this report - food and textiles - form part of a global value chain with significant environmental and social impacts displaced from the area of consumption. It is critical to not only address the "quality" of consumption, but also the overall "quantity" of Scotland's metabolism. This will require substantial consumer behaviour change, much of which is currently hindered by a lack of awareness of the impacts, scale of the problem and practical solutions. While the current national curriculum has made progress, more needs to be done to empower young people with the knowledge and skills to be sustainable consumers of the future.

Focus areas could include **education** and **awareness-raising** about:

- **Meal planning** to combat food waste
- Food products' **carbon Footprints** (e.g. seasonal and local versus imported; whole food versus processed; meats versus pulses)
- Practical meal preparation with **environmentally lighter ingredients**
- **Fast fashion** – impacts, alternatives, career opportunities.

Strong synergies exist between these areas of education and aims in other parts of government (e.g. public health, carbon reductions, job creation) and so this recommendation is considered a no-regrets option.

5.5.4 Transferring skills, job training

Internationally, Scotland has been recognised for its efforts to deploy offshore oilrig workers to develop and install offshore wind turbines. Further, Scotland has had extensive success in decarbonising its energy system. Another new arena may be resource-efficient, well-designed vertical farming as discussed above. Also, ecological restoration work, for instance in the context of restoring peatlands, would produce local jobs, and could also bring economic development through carbon credits.

Some of the equipment (e.g. wind turbines) is partly or fully manufactured overseas. Can Scotland's manufacturing and, in particular, remanufacturing skills base be used with overseas suppliers to help them produce products that have lower Ecological Footprints? Could such skills also become an asset to Scottish companies selling their expertise overseas or even to Scottish workers seeking opportunities abroad? What other skills exist in Scotland that could help in reducing Scotland's overseas Footprint?

This could potentially be facilitated by:

- A project to examine, say, the top ten imported inputs to Scotland as measured by value or volume to see if **joint work** can take place with the **overseas sellers** to reduce the Footprint of these inputs.

- For the long-term it is also essential that **school curriculum** adequately incorporates the sustainability transformation in its topics.

5.5.5 Partnership models

There are some great examples of partnership models in Scotland that work out how to use resources more efficiently or generally protect the environment. Examples include the programs of Zero Waste Scotland, the more recent Hydro Nation Chair initiative, or the build out of SEPA's sustainable growth agreements etc.

Could these partnership models be extended to help reduce overseas ecological impact by either import replacement or export enhancement?

This could potentially be facilitated by:

- Taking **models** such as the Dornoch Environmental Enhancement Project (DEEP) which we understand is a partnership involving industry, NGOs and government agencies and **extending** them in other areas. For example, could projects such as these lead to the replacement of oyster importing, thereby reducing overseas ecological impact? Could this partnership model be applied to other impact reduction challenges?

5.5.6 Grants programmes

Could existing grants programmes run by Scottish Enterprise and Zero Waste Scotland be adjusted, in general, to provide extra incentives to grant recipients to reduce overseas ecological impact?

This could potentially be facilitated by:

- A project gets **extra funding** (e.g. a 10% top-up) or **points** awarded in project evaluation for any grant application that can demonstrate any significant type of reduction in overseas ecological impact?

5.5.7 Procurement

Over 13 billion pounds are spent annually by the Scottish Government on procurement. There may be opportunities for the Scottish Government's **purchasing policy** be adapted to give **extra points** to any product or service provider that includes demonstrable ways of reducing overseas Footprint.

5.5.8 Metrics

Scotland has a strong metrics approach already in place. Given that platform, and the significance of current resource trends, it might be helpful to expand the platform with indicators that can reveal more about the state and progress of Scotland's resource security. This would also help build the bridge between seemingly separate policies.

This could potentially be facilitated by:

- Verifying whether **regeneration** is the materially limiting factor for economies, and if so, developing robust accounts that track demand on and availability of regeneration to understand Scotland's situation in detail.
- Produce such **accounts** within Scotland or join international efforts to produce them collectively (which may be more robust and cost-effective).

5.5.9 New industries and economic development

Scotland's economic development strategies have a proactive history of including energy and resources within their overarching framing. Could Scotland be one place where new industries that reduce Ecological Footprint get an early foothold? This would also be a value proposition for the economy, as such industries are more likely to gain in value and be needed more as we enter a future shaped by increasing climate change and resource constraints.

Such an initiative could potentially be facilitated by:

- A project to identify, say, the next ten new **'low ecological impact industries of tomorrow'** and whether there is any existing or future potential to develop any of these industries partly or fully in Scotland?

In **conclusion**, while there are many possibilities for reducing Scotland's impact abroad, deploying those that build on Scotland's unique strengths while also advancing the most central goals held by the Scottish Government and Scotland's residents is likely to create advantages in efficiency and effectiveness. The most expedient approach for deployment is to **link such efforts to existing initiatives**, as exemplified here in the last section of the report, and to **use those to include fresh dimensions that address Scotland's overseas impact**. This could support progress towards the Environment Strategy's goal of being a responsible global citizen with a sustainable international footprint, while at the same time helping to strengthen Scotland.

6. References

Akaichi, F., Revoredo Giha, C., Glenk, K. & Gil, J.M. (2020). How Consumers in the UK and Spain Value the Coexistence of the Claims Low Fat, Local, Organic and Low Greenhouse Gas Emissions. Nutrients 2020, 12, 120. https://doi.org/10.3390/nu12010120

Allan, G., Lochhead, R., & McGrane, S. (2023). A water stress perspective on the UK's water footprint. *Applied Economics Letters*, *30*(5), 649–656. https://doi.org/10.1080/13504851.2021.2009111

Arrazat, L., Chambaron, S., Arvisenet, G., Goisbault, I., Charrier, J.C., Nicklaus, S. and Marty, L., (2023). Traffic-light front-of-pack environmental labelling across food categories triggers more environmentally friendly food choices: a randomised controlled trial in virtual reality supermarket. International Journal of Behavioral Nutrition and Physical Activity, 20(1), pp.1-13.

Avgoustaki, D. D., & Xydis, G. (2020). Chapter one - how energy innovation in indoor vertical farming can improve food security, sustainability, and food safety? In M. J. Cohen (Ed.), Advances in food security and sustainability (Vol. 5, pp. 1–51). Elsevier.

Chapagain, Ashok and Stuart Orr, (2008), UK Water Footprint: the impact of the UK's food and fibre consumption on global water resources, Volume One, WWF UK, Godalming. Https://wwfeu.awsassets.panda.org/downloads/wwf_uk_footprint.pdf

Chaudhary, A., & Brooks, T. M. (2019). National Consumption and Global Trade Impacts on Biodiversity. *World Development*, *121*, 178–187. https://doi.org/10.1016/j.worlddev.2017.10.012

Chaudhary, A., & Kastner, T. (2016). Land use biodiversity impacts embodied in international food trade. *Global Environmental Change*, *38*, 195–204. https://doi.org/10.1016/j.gloenvcha.2016.03.013

Crippa, M., Solazzo, E., Guizzardi, D., Monforti-Ferrario, F., Tubiello, F.N. and Leip, A.J.N.F., (2021). Food systems are responsible for a third of global anthropogenic GHG emissions. Nature Food, 2(3), pp.198-209.

Cumming, G. S., & von Cramon-Taubadel, S. (2018). Linking economic growth pathways and environmental sustainability by understanding development as alternate social–ecological regimes. Proceedings of the National Academy of Sciences, 115(38), 9533-9538.

Curtis, P. G., Slay, C. M., Harris, N. L., Tyukavina, A., & Hansen, M. C. (2018). Classifying drivers of global forest loss. *Science*, *361*(6407), 1108–1111. https://doi.org/10.1126/science.aau3445

Cuypers, D., Geerken, T., Gorissen, L., Lust, A., Peters, G., Karstensen, J., ... & Van Velthuizen, H. (2013). The impact of EU consumption on deforestation: Comprehensive analysis of the impact of EU consumption on deforestation.

Díaz, S. M., Settele, J., Brondízio, E., Ngo, H., Guèze, M., Agard, J., Arneth, A., Balvanera, P., Brauman, K., Butchart, S., Chan, K. M. A., Garibaldi, L. A., Ichii, K., Liu, J., Subramanian, S., Midgley, G., Miloslavich, P., Molnár, Z., Obura, D., … Zayas, C. (2019). *The global assessment report on biodiversity and ecosystem services: Summary for policy makers*. Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. https://ri.conicet.gov.ar/handle/11336/116171

Dimbleby, H., (2021). National food strategy: part one.

Dimbleby, H., (2022). National Food Strategy: The Plan (Part Two: Final Report).

Escobar, Neus, E. Jorge Tizado, Erasmus K.H.J. zu Ermgassen, Pernilla Löfgren, Jan Börner, Javier Godar, (2020). Spatially-explicit footprints of agricultural commodities: Mapping carbon emissions embodied in Brazil's soy exports, Global Environmental Change, Volume 62, 2020, 102067, ISSN 0959-3780, https://doi.org/10.1016/j.gloenvcha.2020.102067

European Commission, (2019a). The European Green Deal, COM(2019) 640 final, Brussels.

European Commission, (2019b). Good practices. European Circular Economy Stakeholder Platform. Available online: https://circulareconomy.europa.eu/platform/en/good-practices [Accessed 22/03/23]

European Commission, (2020a). Farm to Fork Strategy for a fair, healthy and environmentally-friendly food system. https://ec.europa.eu/food/horizontal-topics/farm-fork-strategy_en

European Commission, (2020b). EU Biodiversity Strategy for 2030. European Commission. pp28.

European Commission, (2020c). A new Circular Economy Action Plan For a cleaner and more competitive Europe, European Commission. Communication from the commission to the European Parliament, the council, the European Economic and Social Committee and the Committee of the Regions: A new Circular Economy Action Plan For a cleaner and more competitive Europe. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?Qid=1583933814386&uri=COM:2020:98:FIN

EY, (2019). Evaluation of the application of the provisions of the law of 11 February 2016 on the fight against food waste, and the implementing decree of 28 December 2016. https://agriculture.gouv.fr/telecharger/116052

Fabrique [merken, design & interactie. (n.d.). *WaterStat*. Retrieved March 17, 2023, from https://www.waterfootprint.org/

FAO (2011). Global food losses and food waste – Extent, causes and prevention. Rome

FAO and UNEP. (2020). The State of the World's Forests 2020. Forests, biodiversity and people. Rome. https://doi.org/10.4060/ca8642en

Feng, K., Hubacek, K., Minx, J., Siu, Y. L., Chapagain, A., Yu, Y., Guan, D., & Barrett, J. (2011). Spatially Explicit Analysis of Water Footprints in the UK. *Water*, *3*(1), 47–63. https://doi.org/10.3390/w3010047

Global Footprint Network, (2023) Consumption Land-Use Matrix - Year 2019. [Dataset]. Global Footprint Network, Oakland, CA. https://www.footprintnetwork.org/resources/mrio/

Haberl, H., Wiedenhofer, D., Virág, D., Kalt, G., Plank, B., Brockway, P., ... & Creutzig, F. (2020). A systematic review of the evidence on decoupling of GDP, resource use and GHG emissions, part II: synthesizing the insights. Environmental research letters, 15(6), 065003.

Harris, M. (2023). Policy interventions to encourage sustainable consumption. JNCC Guidance report, JNCC, Peterborough, ISSN 0963-8091. https://hub.jncc.gov.uk

Hawker, J., Smith, M., Way, L., Harris, M., Donovan, D., Wright, E. and Wilkinson, S. (2020). The LET (Linking Environment to Trade) Guide. JNCC, Peterborough. Download here: The LET Guide: Linking Environment to Trade – An Introductory Guide (jncc.gov.uk)

Huang, Z., Yuan, X., & Liu, X. (2021). The key drivers for the changes in global water scarcity: Water withdrawal versus water availability. Journal of Hydrology, 601, 126658.

Hoang, N. T., & Kanemoto, K. (2021). Mapping the deforestation footprint of nations reveals growing threat to tropical forests. *Nature Ecology & Evolution*, *5*(6), 845–853. https://doi.org/10.1038/s41559-021-01417-z

Hoekstra, A. Y. (2017). Water Footprint Assessment: Evolvement of a New Research Field. *Water Resources Management*, *31*(10), 3061–3081. https://doi.org/10.1007/s11269-017-1618-5

Hoekstra, A. Y., & Mekonnen, M. M. (2012). The water footprint of humanity. *Proceedings of the National Academy of Sciences*, *109*(9), 3232–3237. https://doi.org/10.1073/pnas.1109936109

Hoekstra, A. Y., & Mekonnen, M. M. (2016). Imported water risk: the case of the UK. *Environmental Research Letters*, *11*(5), 055002. https://doi.org/10.1088/1748-9326/11/5/055002

Horsburgh, N., Tyler, A., Mathieson, S., Wackernagel, M. and Lin, D., (2022). Biocapacity and cost-effectiveness benefits of increased peatland restoration in Scotland. Journal of Environmental Management, 306, p.114486. https://doi.org/10.1016/j.jenvman.2022.114486

Irwin, A., Geschke, A., Brooks, T. M., Siikamaki, J., Mair, L., & Strassburg, B. B. N. (2022). Quantifying and categorising national extinction-risk footprints. *Scientific Reports*, *12*(1), 5861. https://doi.org/10.1038/s41598-022-09827-0

Isbell, F., Balvanera, P., Mori, A. S., He, J., Bullock, J. M., Regmi, G. R., Seabloom, E. W., Ferrier, S., Sala, O. E., Guerrero-Ramírez, N. R., Tavella, J., Larkin, D. J., Schmid, B., Outhwaite, C. L., Pramual, P., Borer, E. T., Loreau, M., Omotoriogun, T. C., Obura, D. O., … Palmer, M. S. (2023). Expert perspectives on global biodiversity loss and its drivers and impacts on people. *Frontiers in Ecology and the Environment*, *21*(2), 94–103. https://doi.org/10.1002/fee.2536

Jaureguiberry, P., Titeux, N., Wiemers, M., Bowler, D. E., Coscieme, L., Golden, A. S., Guerra, C. A., Jacob, U., Takahashi, Y., Settele, J., Díaz, S., Molnár, Z., & Purvis, A. (2022). The direct drivers of

recent global anthropogenic biodiversity loss. *Science Advances*, *8*(45), eabm9982. https://doi.org/10.1126/sciadv.abm9982

Kitzes, J., Berlow, E., Conlisk, E., Erb, K., Iha, K., Martinez, N., Newman, E. A., Plutzar, C., Smith, A. B., & Harte, J. (2017). Consumption-Based Conservation Targeting: Linking Biodiversity Loss to Upstream Demand through a Global Wildlife Footprint. *Conservation Letters*, *10*(5), 531–538. https://doi.org/10.1111/con4.12321

Lenzen, M., Moran, D., Kanemoto, K., Foran, B., Lobefaro, L., & Geschke, A. (2012). International trade drives biodiversity threats in developing nations. *Nature*, *486*(7401), 109–112. https://doi.org/10.1038/nature11145

Li, M., Jia, N., Lenzen, M. et al. Global food-miles account for nearly 20% of total food-systems emissions. Nat Food 3, 445–453 (2022). https://doi.org/10.1038/s43016-022-00531-w

Marques, A. (2021). Distant drivers of deforestation. *Nature Ecology & Evolution*, *5*(6), 713–714. https://doi.org/10.1038/s41559-021-01420-4

Marques, A., Verones, F., Kok, M. T., Huijbregts, M. A., & Pereira, H. M. (2017). How to quantify biodiversity footprints of consumption? A review of multi-regional input–output analysis and life cycle assessment. *Current Opinion in Environmental Sustainability*, *29*, 75–81. https://doi.org/10.1016/j.cosust.2018.01.005

Mekonnen, M. M., & Gerbens-Leenes, W. (2020). The Water Footprint of Global Food Production. *Water*, *12*(10), 2696. https://doi.org/10.3390/w12102696

Mekonnen, M. M., & Hoekstra, A. Y. (2020). Blue water footprint linked to national consumption and international trade is unsustainable. *Nature Food*, *1*(12), 792–800. https://doi.org/10.1038/s43016-020-00198-1

ONS (2019a, January 19). *Detailed household expenditure by countries and regions: Table A35*. UK Office for National Statistics. Retrieved December 22, 2022, from https://www.ons.gov.uk/peoplepopulationandcommunity/personalandhouseholdfinances/expenditure/datasets/detailedhouseholdexpenditurebycountriesandregionsuktablea35

Pendrill, F., Persson, U. M., Godar, J., & Kastner, T. (2019). Deforestation displaced: trade in forest-risk commodities and the prospects for a global forest transition. *Environmental Research Letters*, *14*(5), 055003. https://doi.org/10.1088/1748-9326/ab0d41

Pendrill, F., Persson, U. M., Godar, J., Kastner, T., Moran, D., Schmidt, S., & Wood, R. (2019). Agricultural and forestry trade drives large share of tropical deforestation emissions. *Global Environmental Change*, *56*, 1–10. https://doi.org/10.1016/j.gloenvcha.2019.03.002

Pendrill, F., Persson, U. M., Kastner, T., & Wood, R. (2022). *Deforestation risk embodied in production and consumption of agricultural and forestry commodities 2005-2018*. Zenodo. https://doi.org/10.5281/zenodo.5886600

Pereira, Á., Villanueva-Rey, P., Vence, X., Moreira, M.T. and Feijóo, G., (2018). Fresh milk supply through vending machines: Consumption patterns and associated environmental impacts. Sustainable Production and Consumption, 15, pp.119-130.

Rivington, M., Colley, K., Ballesteros-Figueroa, A., Boucher J. and Miller, D. (2023). Reducing Scotland's international environmental impact: learning from international best practices. The James Hutton Institute, Aberdeen, Scotland. pp.54.

Sandison, F., Yeluripati, J. and Stewart, D., (2023). Does green vertical farming offer a sustainable alternative to conventional methods of production?: A case study from Scotland. Food and Energy Security, 12(2), p.e438. https://doi.org/10.1002/fes3.438

Scottish Government (2019). Food Waste Reduction Action Plan. Edinburgh. Available: https://www.zerowastescotland.org.uk/resources/scotlands-food-waste-reduction-action-plan

Scottish Government (2023). Environment Strategy - survey on current SG use of policy levers - Collated Responses", draft, personal communication through Marianna Menis.

Springmann M, Clark M, Mason-D'Croz D, Wiebe K, Bodirsky BL, Lassaletta L, et al. (2018). Options for keeping the food system within environmental limits. Nature [Internet]. Springer US; 2018;562:519–25. Available from: https://doi.org/10.1038/s41586-018-0594-0

Sun, Z., Behrens, P., Tukker, A., Bruckner, M., & Scherer, L. (2022). Global Human Consumption Threatens Key Biodiversity Areas. Environmental Science & Technology, 56(12), 9003–9014. https://doi.org/10.1021/acs.est.2c00506

Tidåker, P., Potter, H.K., Carlsson, G. and Röös, E., (2021). Towards sustainable consumption of legumes: How origin, processing and transport affect the environmental impact of pulses. Sustainable production and consumption, 27, pp.496-508. https://doi.org/10.1016/j.spc.2021.01.017

UK Government (2022, November 16). *Country and Regional Analysis*. GOV.UK. Retrieved January 23, 2023, from https://www.gov.uk/government/statistics/country-and-regional-analysis-2022

UN-Water, (2021) Summary Progress Update 2021 – SDG 6 – water and sanitation for all. Version: July 2021. Geneva, Switzerland.

United Nations Environment Programme (UNEP), (2020, May 21). *The State of the World's Forests: Forests, Biodiversity and People*. UNEP - UN Environment Programme. http://www.unep.org/resources/state-worlds-forests-forests-biodiversity-and-people

United Nations Environment Programme (UNEP), (2021). Catalysing Science-based Policy action on Sustainable Consumption and Production – The value-chain approach & its application to food, construction and textiles. Nairobi.

Weber L., Bartek L., Brancoli P., Sjölund A., Eriksson M. (2023). Climate change impact of food distribution: The case of reverse logistics for bread in Sweden. Sustainable Production and Consumption, 36, pp. 386 – 396. doi: 10.1016/j.spc.2023.01.018

West, C. (UoY), Ebrey, R. (UoY), Simpson, J. (UoY), Stokeld, E. (UoY), Lager, F (SEI), Croft, S. (UoY), Bosello, F. (CMCC), Delpiazzo, E. (CMCC), Key, R. (CMCC), King, R. (CH), Parrado, R. (CMCC), Schewe, J. (PIK), Zaatour, R. (PIK) (2022). Report on preliminary impact and policy insights from model and sectoral case study analysis of WP3. Deliverable 3.6 of the H2020 CASCADES project.

Willett W, Rockström J, Loken B, Springmann M, Lang T, Vermeulen S, et al. (2019). Food in the anthropocene: the EAT–lancet commission on healthy diets from sustainable food systems. Lancet. 2019;393:44

York University Ecological Footprint Initiative & Global Footprint Network, (2022). National Footprint and Biocapacity Accounts, 2022 Edition. Produced for the Footprint Data Foundation and distributed by Global Footprint Network. Available. https://data.footprintnetwork.org/.

York University Ecological Footprint Initiative & Global Footprint Network, (2023). National Footprint and Biocapacity Accounts, 2023 Edition. Produced for the Footprint Data Foundation and distributed by Global Footprint Network. Available. https://data.footprintnetwork.org/.

Zhongming, Z., Linong, L., Xiaona, Y., Wangqiang, Z., & Wei, L. 2020. The State of the World's Forests: Forests, Biodiversity and People.

7. Appendix A: Full Consumption Land-Use Matrix (CLUM) data tables

	Total			Cropland		Grazing Land		Forest Products		Fishing Grounds		Built-Up Land		Carbon	
Detailed Consumption Category	Total	UK Orgn	FRGN Orgn	UK Orgn	FRGN Orgn	UK Orgn	FRGN Orgn	UK Orgn	FRGN Orgn	UK Orgn	FRGN Orgn	UK Orgn	FRGN Orgn	UK Orgn	FRGN Orgn
Food	**19.7%**	**10.0%**	**9.7%**	**5.3%**	**5.2%**	**1.5%**	**1.4%**	**0.3%**	**0.3%**	**0.3%**	**0.7%**	**0.1%**	**0.1%**	**2.5%**	**2.0%**
Bread and Cereals	4.2%	2.9%	1.3%	2.5%	1.0%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.2%
Meat	4.0%	2.3%	1.6%	0.9%	0.5%	0.8%	0.8%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%	0.3%
Fish and Seafood	1.4%	0.5%	1.0%	0.1%	0.3%	0.1%	0.1%	0.0%	0.0%	0.1%	0.4%	0.0%	0.0%	0.2%	0.2%
Milk, cheese, and eggs	1.5%	1.1%	0.4%	0.5%	0.2%	0.2%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.4%	0.2%
Oils and fats	1.0%	0.6%	0.4%	0.4%	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%
Fruit	2.2%	0.6%	1.6%	0.3%	1.1%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.3%
Vegetables	2.2%	0.6%	1.6%	0.3%	1.1%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.3%
Sugar, jam, honey, chocolate, confectionery	1.2%	0.5%	0.7%	0.2%	0.4%	0.1%	0.1%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.2%	0.2%
Food products n.e.c.	1.0%	0.4%	0.6%	0.1%	0.3%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.2%
Non-alcoholic beverages	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Alcoholic beverages	0.9%	0.4%	0.4%	0.1%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.2%
Housing	**10.9%**	**7.9%**	**3.0%**	**0.1%**	**0.1%**	**0.0%**	**0.0%**	**0.6%**	**0.4%**	**0.0%**	**0.0%**	**0.1%**	**0.1%**	**7.0%**	**2.3%**
Actual rentals for housing	0.6%	0.3%	0.3%	0.0%	0.0%	0.0%	0.0%	0.2%	0.1%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%
Imputed rentals for housing	0.8%	0.8%	0.1%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%	0.0%
Maintenance and repair of the dwelling	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Water supply and miscellaneous services relating to the dwelling	0.6%	0.3%	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.2%
Electricity, gas and other fuels	4.9%	2.6%	2.3%	0.0%	0.0%	0.0%	0.0%	0.2%	0.2%	0.0%	0.0%	0.1%	0.1%	2.2%	2.0%
Services for household maintenance	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Direct household consumption (Heating)	3.9%	3.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	3.9%	0.0%
Personal Transportation	**16.2%**	**8.1%**	**8.1%**	**0.1%**	**0.3%**	**0.1%**	**0.1%**	**0.3%**	**0.7%**	**0.0%**	**0.0%**	**0.1%**	**0.2%**	**7.4%**	**6.8%**
Purchase of vehicles	1.7%	0.7%	1.0%	0.0%	0.1%	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.5%	0.8%
Operation of personal transport equipment	4.5%	1.7%	2.8%	0.1%	0.1%	0.0%	0.0%	0.1%	0.4%	0.0%	0.0%	0.0%	0.1%	1.4%	2.2%
Transport services	6.8%	2.5%	4.3%	0.1%	0.1%	0.0%	0.0%	0.1%	0.3%	0.0%	0.0%	0.1%	0.1%	2.2%	3.8%
Direct household consumption (Transportation)	3.3%	3.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	3.3%	0.0%

Table A1. Domestic (UK) and Foreign Ecological Footprint broken down by consumption category[35]. (Percent of total Ecological Footprint)

[35] These results are derived using Multi-Regional Input Output assessments to allocate the total footprint to 52 consumption categories. The trade assessments then also reveals where the resource consumption originates. The result is Table 1 which shows a simplified CLUM, with columns split by domestic versus foreign.

Table A1 continued

	Total			Cropland		Grazing Land		Forest Products		Fishing Grounds		Built-Up Land		Carbon	
Detailed Consumption Category	Total	UK Orgn	FRGN Orgn	UK Orgn	FRGN Orgn	UK Orgn	FRGN Orgn	UK Orgn	FRGN Orgn	UK Orgn	FRGN Orgn	UK Orgn	FRGN Orgn	UK Orgn	FRGN Orgn
Goods	**10.2%**	**2.9%**	**7.4%**	**0.4%**	**1.6%**	**0.1%**	**0.6%**	**0.4%**	**0.8%**	**0.0%**	**0.1%**	**0.1%**	**0.3%**	**1.8%**	**4.0%**
Clothing	4.7%	0.4%	4.2%	0.0%	1.1%	0.0%	0.4%	0.1%	0.3%	0.0%	0.0%	0.0%	0.2%	0.3%	2.2%
Footwear	0.3%	0.1%	0.2%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%
Furniture and furnishings, carpets and other floor coverings	0.4%	0.2%	0.2%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%
Household textiles	0.2%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%
Household appliances	0.1%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%
Glassware, tableware and household utensils	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Tools and equipment for house and garden	0.1%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%
Medical products, appliances and equipment	0.4%	0.2%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.2%
Telephone and telefax equipment	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Audio-visual, photographic and information processing equipment	1.1%	0.5%	0.6%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.4%	0.5%
Other major durables for recreation and culture	0.1%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Other recreational items and equipment, gardens and pets	0.5%	0.3%	0.3%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.2%	0.1%
Newspapers, books and stationery	0.4%	0.1%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%
Goods for household maintenance	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Tobacco	1.8%	0.9%	0.9%	0.2%	0.3%	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.5%	0.5%
Services	**11.2%**	**6.4%**	**4.8%**	**1.6%**	**1.1%**	**0.5%**	**0.4%**	**0.7%**	**0.5%**	**0.3%**	**0.2%**	**0.3%**	**0.2%**	**3.1%**	**2.4%**
Out-patient services	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Hospital services	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Postal services	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Telephone and telefax services	1.1%	0.7%	0.4%	0.2%	0.1%	0.1%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.2%
Recreational and cultural services	2.2%	1.3%	0.9%	0.4%	0.3%	0.1%	0.1%	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%	0.6%	0.4%
Package holidays	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Pre-primary and primary education	0.9%	0.6%	0.4%	0.2%	0.1%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.2%
Catering services	3.1%	1.9%	1.2%	0.7%	0.4%	0.2%	0.1%	0.2%	0.1%	0.1%	0.1%	0.0%	0.0%	0.7%	0.5%
Accommodation services	0.7%	0.5%	0.3%	0.2%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.1%
Personal care	0.8%	0.1%	0.6%	0.0%	0.1%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.1%	0.5%

Given the available data set, this analysis can only distinguish between UK and non-UK origin, meaning Scottish demands on the rest of the UK cannot be captured in this analysis.

Table A2 Domestic (UK) and Foreign Ecological Footprint by final demand category. (Percent of total Ecological Footprint)

	Total			Cropland		Grazing Land		Forest Products		Fishing Grounds		Built-Up Land		Carbon	
Detailed Consumption Category	Total	UK Orgn	FRGN Orgn	UK Orgn	FRGN Orgn	UK Orgn	FRGN Orgn	UK Orgn	FRGN Orgn	UK Orgn	FRGN Orgn	UK Orgn	FRGN Orgn	UK Orgn	FRGN Orgn
Household subtotal	68.2%	35.3%	32.9%	7.5%	8.3%	2.2%	2.5%	2.3%	2.8%	0.7%	0.9%	0.8%	0.8%	21.8%	17.5%
Government	18.0%	10.6%	7.5%	1.1%	0.8%	0.5%	0.3%	1.3%	0.9%	0.1%	0.1%	0.6%	0.4%	7.0%	5.0%
Gross Fixed Capital Formation	13.8%	7.3%	6.5%	0.7%	0.6%	0.2%	0.2%	1.8%	1.3%	0.0%	0.0%	0.2%	0.2%	4.3%	4.2%

8. Appendix B: Footprint and biocapacity accounting methodology

8.1.1 Scotland's biocapacity

The first estimate of Scotland's biocapacity was produced by Horsburgh et al. (2022). This assessment was produced using the methods of the National Footprint and Biocapacity Accounts (NFA), the national accounting framework now maintained by York University, Canada (York University 2022, 2023) which generates Ecological Footprint and biocapacity estimates annually for most of the world's countries, including the UK. Scotland's biocapacity was estimated for six land types (Crop Land, Grazing Land, Marine Fishing Grounds, Inland Fishing Grounds, Forests and Built-up Land). For each land type, biocapacity was calculated by scaling the bioproductive land area (in hectares) by the relative primary productivity of the land type to yield a productivity-adjusted land area in global hectares (gha) and summed to yield Scotland's total biocapacity. Peatlands, not currently included in the NFA methodology, cover approximately 1.9 million ha (25% of land area) in Scotland, and were included by Horsburgh et al. (2022) in their estimate of Scotland's biocapacity. However, to enable comparison with results from the NFA for the UK and other countries from around world, assessments which do not at present contain peatlands, peatland biocapacity from Horsburgh et al.'s study was not included in the Scottish biocapacity estimate used in this report.

8.1.2 Scotland's Ecological Footprint and its overseas Footprint component

Scotland's Ecological Footprint is based on a top-down, sub-national calculation methodology. This approach is well documented in the literature and has been most recently applied to Mediterranean cities (Baabou et al., 2017), Canadian Municipalities (Isman et al., 2017), Portuguese Cities (Galli et al., 2020) and Japanese regions (Tsuchiya et al., 2021). One of the key results of the sub-national calculation is an Ecological Footprint calculation with a breakdown by household consumption category (UN COICOP) called the Consumption Land-Use Matrix (CLUM) (Global Footprint Network, 2019).

Building on the NFA, which includes annual results up to the year 2018, the results are derived from an Ecological Footprint Extended Multi-Region Input Output (MRIO) model to calculate the Ecological Footprint of the United Kingdom and derive a CLUM for the UK for the year 2018. The MRIO model is based on GTAPv10 year 2014. A Scotland specific Ecological Footprint is then calculated based on existing financial proxy data, including household expenditure (ONS, 2022) and government expenditure (UK Government 2022) and consumption patterns following a top-down sub-national methodology.

The Scotland specific CLUM is used as the base for estimating the overseas impact of consumption in Scotland. This analysis is built on Global Footprint Network's Ecological Footprint-MRIO database, which includes the origin (country/sector) and destination (UK) of biocapacity consumed in the UK, as well as all direct input sectors to the UK. To derive a Scotland specific estimate of overseas impact, we apply the basic assumption that UK supply chains are consistent among sub-national regions for each consumption category. For example, the CLUM will tell us

the Ecological Footprint associated with the consumption of Fish and Seafood in the UK and in Scotland. If the consumption Footprint of Fish and Seafood in Scotland is double that of UK, we would assume that the origin country and sector of the Fish and Seafood consumed in Scotland are the same as the UK, while the quantity (on a country and sector basis) would be double. This basic assumption is applied to all detailed consumption sub-categories (COICOP) and Footprint categories (cropland, grazing land, fishing grounds, forest products, built-up, and carbon footprint) to obtain estimates of the supply chain origin of Scotland's consumption.

The underlying MRIO generally provides resolution for trade relationships at the UK level, therefore estimates presented here can only delineate the origin of domestic consumption as coming from within the UK, rather than coming from Scotland.

9. Appendix C: Linking consumption with other environmental impacts

This Appendix complements the section on 'Linking consumption with other environmental impacts' in **4.6** (page 33), by providing further information on relevant datasets, additional considerations and unknowns for each of the environmental impacts considered in that section: biodiversity loss, deforestation and water use.

9.1.1 Biodiversity loss

Relevant datasets:

- Since all biodiversity-loss drivers are correlated or strongly correlated with the size of the human metabolism, the CLUM is a useful starting point for identifying priority areas. This points to the food subcomponent of the Ecological Footprint, particularly the cropland, pasture and forest products Footprint associated with food consumption.
- MRIO-based data for the United Kingdom is available through the Global environmental impacts of consumption database model. This calculator quantifies associated tropical deforestation, predicted species loss and demand on species-richness weighted area for products consumed in the UK.
- Country scale, MRIO-based studies have quantified and linked consumption to biodiversity-relevant metrics (Lenzen et al., 2012; Kitzes et al., 2016; Marques et al., 2017; Wilting et al., 2017; Chaudhary and Brooks, 2019; Marquardt et al., 2019).

Additional considerations and unknowns:

- Biodiversity type bias: current knowledge on biodiversity is strongly biased towards vertebrate species, while invertebrate, plant, and other types of biodiversity are not well studied.
- Location bias: studies and data availability are biased towards more studied areas, including tropical rainforest, while African countries are less studied.
- Observation bias: direct competition for habitat leading to biodiversity loss, as in the case of plantations versus virgin forests, can be observed directly. More diffuse threats, such as invasive species, pollution or climate change, or growing demand, are harder to observe, even though their impact may lead to more biodiversity loss.

Potential synergies:

- Drivers of biodiversity loss strongly overlap with drivers of deforestation.
- Changing impacts over time: future impacts of climate change will likely be greater. Also, invasive species grow their impact over time.
- A key requirement for policy and action to effectively address global biodiversity loss is an approach that targets all the major drivers and their interactions, as opposed to single specific targets (Jaureguiberry et al., 2022)

9.1.2 Deforestation

Relevant datasets and linkages:

- This report: total demand for forest and agricultural products are linked here by type of consumption, land-use and location of supply chain origin.

- Data available for the UK on tropical deforestation for the UK can be found in the Global environmental impacts of consumption database.
- Data on deforestation risk embodied in production and consumption of agricultural and forestry commodities for the UK, for 2005-2018, is available here https://doi.org/10.5281/zenodo.5886600.
- Global Forest Watch provides overviews on forests by country. Primarily geospatial data by country, it also includes time series of tree cover gain and loss.

Additional considerations and unknowns:

- While the drivers are well known, 75% of deforestation is driven by domestic demand, suggesting that the promotion of deforestation-free supply chains are inherently limited in the degree of deforestation that can be prevented.
- Data wise, satellite, MRIO and combined analyses have numerous limitations in terms of nature and magnitude of deforestation/degradation and resolution in determining specific drivers of identified deforestation.
- The UK and other high-income countries have experienced net forest gain. At the same time, their external demand adds to the pressure on tropical forests. Biodiversity preservation in the UK is therefore accompanied by biodiversity loss in other countries.

Potential synergies:

- Drivers of deforestation strongly overlap with drivers of biodiversity loss. Deforestation is also a major source of anthropogenic GHG emissions, and there may be opportunities to couple avoiding deforestation with driving the carbon transition.

9.1.3 Water use

Relevant datasets and linkages:

- UK (but not Scotland) specific data is available in the Global environmental impacts of consumption database. This database distinguishes how UK consumption depends on green water, blue water and scarcity-weighted blue water.

Additional considerations and unknowns:

- Virtual water considerations, underlying the water Footprint concept, help identify to what extent a population depends on water from elsewhere. This aligns with the research question posed here – understanding environmental impacts overseas. The water Footprint does not show to what extent water demands operate within available budgets, or whether they are also part of damaging overuse. If the main concern is to avoid putting resource demands on ecosystems abroad, then water Footprint assessments do point to potential areas that do depend on foreign resources. If the concern is about resource uses that are depleting ecosystems, then water use would need to be analysed in the context of availabilities in those regions. By linking it to other competing demands for biocapacity, then that water use could also be compared more directly to other environmental pressures.

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