Footprint Evaluation

Case study

Evaluating the environmental impact of personal protective equipment (PPE) in the COVID-19 pandemic

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The case study was fortunate to draw on the paper "Environmental impact of personal protective equipment distributed for use by health and social care services in England in the first six months of the COVID-19 pandemic" by Chantelle Rizan, Malcolm Reed and Mahmood F Bhutta (2021).

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About the Footprint Evaluation Initiative

The Footprint Evaluation Initiative is an international collaboration to support evaluators and evaluation managers to consider environmental sustainability in all evaluations, even when this is not a stated goal of the intervention. Footprint evaluation approaches focus on the 'footprint' that human systems make on natural systems. This requires attention to the nexus of human and natural systems and addressing effects across both systems. It is grounded in the premise that all evaluations should include consideration of environmental sustainability, even when this is not a stated goal of the intervention. This is so that decision-making can take into account the potential and actual impacts of planned interventions (projects, programs, policies) on the environment as well as the usual focus on equity impacts for human systems.

How terms are used in this case study:

Disability-adjusted life years (DALYs): DALYS are a measure of disease burden calculated using mortality and years of life with a disability data.

Ecosystem species loss: Eco system species loss refers to the number of local species becoming extinct per year.

Nexus and nexus settings: Nexus refers to coupling between human and natural systems. Nexus settings are where human and natural systems couple causing changes in the other systems.

Personal Protective Equipment (PPE): In this case study this refers to PPE for coronavirus (COVID-19), including surgical masks, particulate filter respirators (such as P2 or N95), gloves, goggles, glasses, face shields, gowns and aprons.

Procurement: The policies, procedures, and strategic approaches to obtaining PPE.

Provisioning: Provisioning refers to actions required to supply goods and services, including preparedness, procurement, manufacture and product design, distribution, consumption (use), and disposal.

Raw or virgin plastic: Plastic that is manufactured from fossil fuels (natural gas or crude oil).

Recycled plastic: Recycled plastic, as the naming implies, is manufactured from recovered plastic waste through a process including collection, sorting, washing, shredding, granulating, disinfecting and finally,e implies, is manufactured from recovered plastic waste through collection, sorting, washing, shredding, granulating, disinfecting and extrusion (smashing and melting into pellets).

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Summary

The Footprint Evaluation Initiative proposes that environmental sustainability should be addressed in all evaluations. However, environmental harm is often viewed as a necessary trade-off to protect human systems in urgent crises with severe negative impacts on people, such as the COVID-19 pandemic. Because of this, some might question whether it is tech nically feasible, or even of value, to include environmental sustainability in evaluations of PPE provisioning.

This report demonstrates that the answer to both questions is a resounding yes. Including environmental sustainability in the evaluation of PPE provisioning during the COVID-19 pandemic is technically feasible. Furthermore, not only is it feasible to do this, the inclusion of environmental considerations *adds significant value* to these evaluations.

Ignoring environmental sustainability in the evaluation of COVID-19 responses would result in invalid conclusions, erring towards the positive impacts of PPE provisioning while ignoring the negative environmental impacts that could themselves have negative impacts on human health.

Furthermore, including environmental impacts in the evaluation of PPE provisioning during the COVID-19 pandemic can inform decision-making to go beyond framing choices in terms of trade-offs that permit environmental harm to ensure human health in the short-term. Instead, it can lead to identifying better solutions and better outcomes for human health, equity, and the environment.

About this case study

This case study is not a comprehensive evaluation of PPE provisioning but a scoping of how it might be done. The case study considers how an evaluation of PPE provisioning during the Covid-19 pandemic can include health, environmental and equity outcomes.

The case study begins by demonstrating how the theory of change can be broadened to take both human and natural systems into account by mapping the elements of the intervention. It then shows how key evaluation questions can be adapted to include environmental sustainability. The following section builds on a study by Rizan et al. (2021), which presented a life cycle assessment of PPE in England during the COVID pandemic to demonstrate that assessing environmental impacts is feasible. The use of a typology and rubrics are suggested as a way of synthesising and communicating evidence into an overall evaluative judgement. The final section summarises the implications of mainstreaming environmental sustainability in an evaluation of PPE provisioning. Appendix 1 details the evidence and likely impacts at each stage of the life cycle.

The case study demonstrates how to broaden the evaluation frame by:

- Using a PPE provisioning life cycle framework to understand and map the nexus between human and natural systems for each intervention element. In addition to the life cycle stages assessed by Rizan et al. (raw material extraction, manufacture, use, transport and waste disposal), this case study adds preparedness and procurement to the life cycle of PPE products.
- Mapping possible outcomes for human and natural systems at each step in the life cycle.
- Identifying factors that need to be considered in constructing a theory of change that takes both human and natural systems into account
- How to formulate key evaluation questions and evaluation criteria such as the OECD DAC that consider both human and natural systems
- The value of engaging with other knowledge domains that utilise specific methods for articulating and estimating environmental effects, effects that may be new and important to evaluators seeking to include sustainability in evaluations
- How evidence from media can usefully complement formal research evidence, especially in rapidly changing areas
- How applying a footprint evaluation approach would generate knowledge about options for the equitable achievement of important health outcomes in ways that do not impair environmental sustainability.

The case study is informed by the understanding that:

- Human and natural systems are intertwined in the provisioning of PPE; decisions that affect human health and the provision of PPE also affect the environment and equity.
- It is important to strive for win-win solutions that benefit both human and natural systems.
- In the case of PPE provisioning, improved pandemic preparedness could have reduced the risk that human health was prioritised over the health of the environment.
- Harm to the environment has negative effects on human health - permitting environmental harm as a trade-off necessary for ensuring human health is based on a false either/or dichotomy.

Using a typology matrix and rubrics that consider both natural system and equity effects is a useful way of synthesising and communicating evaluation findings. The nexus between equity and environmental sustainability is clear. The matrix below illustrates that both need to be considered rather than considered in terms of trade-offs. As the evaluation field has well-developed methods and approaches for evaluating human systems, this case study focuses on how natural systems could be integrated into an evaluation of PPE provisioning.

The evidence would likely show impacts are in the grid's top left – destructive or sustainability aware but still harmful and exploitative or aware of exploitation but still inequitable.

Figure i: A matrix to consider both the environment and equity

Human System Effects	Natural System Effects: Destructive /plundering natural system	Sustainability aware but still harmful	No net harm to the natural system	Restorative (repair harm so system thrives)
Exploitative of some countries and groups				
Aware of exploitation but still inequitable				
Equitable system – no disadvantage between and within countries				
Reparations rebalance multi-generational disadvantages				**Ultimate aim: Both systems thriving for all**

1. Introduction

The provision of personal protective equipment (PPE) is situated clearly at the nexus of human and natural systems[1]. PPE provisioning during the COVID-19 pandemic involves a complex interplay between human and natural systems. It affects both these systems in the short and long term and can negatively affect the environment and equity globally. This highlights the importance of considering the intersection of human and natural systems in evaluating PPE provisioning during the pandemic.

The COVID-19 pandemic and the subsequent provisioning of PPE happened when the world was already lagging in achieving important 2030 goals related to climate, biodiversity, and sustainable development, to which most countries had committed. Additionally, emerging crises like pandemics are often accompanied by high levels of uncertainty and ambiguity, which lead to heightened risks to personal safety, both real and perceived. This situation can generate concerns about the efficacy of guidelines, such as the reuse of PPE and appropriate responses to the crisis.

It is likely that an evaluation of a national PPE provisioning strategy would focus on public health and economic outcomes. While equity would possibly also be considered within both health and economic outcomes, the track record of evaluation (Rowe and DeLancey, 2021; Todd, 2020) is that environmental outcomes are very unlikely to be included and, if included, would be in the class of unintended or unexpected results.

The responses to the COVID-19 pandemic have highlighted that when an immediate threat to human health is prioritised, it is often done so at the expense of broader human health and environmental considerations, as is demonstrated in the case of PPE provisioning. One of the functions of evaluation is to consider whether this trade-off is necessary, or whether there are win-win solutions that benefit human health and the environment.

1.1 Context of PPE use in the COVID-19 pandemic

During early 2020, when COVID-19 infections were rapidly spreading, there was a massive demand for personal protective equipment (PPE) and its associated waste. This demand for PPE happened despite most countries having global and national environmental commitments already in place, and many had previously made preparedness arrangements and stocked up on supplies in case of possible pandemics following the SARS outbreak.

1.1.1 Rapid spread of COVID-19

The first reported breakout of COVID-19 was in Wuhan city, China, in November 2019. The virus spread rapidly worldwide, and the World Health Authority (WHO) declared the coronavirus outbreak a Public Health Emergency of International Concern on January 30, 2020. By February, many countries had introduced border restrictions and quarantine arrangements, and the WHO described the coronavirus outbreak as a global pandemic on March 11. By March 13, the global death toll exceeded 5,000; by the end of March, nearly a third of the world population was living

[1] This is in addition to the origin of zoonotic diseases through human intrusion into natural systems via nexus connections.

under COVID-19 restrictions, and the WHO warned that there was a significant shortage of medical supplies. Three years later, by February 2023, over 757,000,000 cases have been reported globally, and over 6,850,000 deaths have been recorded (World Health Organization, n.d.).

1.1.2 Massive increase in the waste generated through PPE use

In June 2020, it was estimated that 1.6 million tonnes per day of plastic waste were generated worldwide and globally, around 3.4 billion single-use facemasks or face shields were discarded daily due to COVID-19 (Benson, Bassey, & Palanisamic, 2021). Most PPE is polypropylene, which can persist in the environment for up to 450 years. Writing in 2021, Long, Nghiem, Iqbal, & Zdarta estimated that polypropylene waste from single-use face masks and gowns could amount to 1 million tonnes monthly and that "since the beginning of the COVID-19 pandemic, over 4 million tonnes of polypropylene PPE waste has been disposed into the environment in uncontrolled manner causing significant and long-term ecological damage."

In a 2020 discussion of options for recycling PPE in an Advanced Textiles Association publication (Cobb, 2020), the scale of the burden of the UK provisioning strategy to disposal channels was discussed: "In the U.K. alone an average 2.5 kg [5.5 pounds] of additional waste is being created during the pandemic by nurses discarding PPE after treatment of every patient and care home visit, every day."

In addition to the immediate impacts of this rapid and environmentally disastrous use of PPE and, more broadly, single-use plastics[2], these can lead to long-term shifts in PPE usage from habits created during the pandemic. These issues are stimulating efforts to provide good methods for estimating the scale of continuing discard of PPE (Hague, Sharif, Masnoon, & Rashid, 2021).

1.1.3 Pre-pandemic environmental commitments

In evaluating the provisioning of PPE, it's essential to consider the environmental commitments that existed before the pandemic. Governments and organisations in England were keenly aware of the climate and sustainability crises and had committed to taking action. National policies on the environment, climate, and sustainability, as well as international commitments made by the British government[3], are relevant to evaluations of the pandemic response.

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[2] This report only addresses PPE use, however the tremendous increase in single use plastics for take-outs and other purposes is another direct result of the pandemic.

[3] International treaties signed by the UK include (bold are most relevant to PPE provisioning): **Air Pollution**, Air Pollution-Heavy Metals, Air Pollution-Multi-effect Protocol, Air Pollution-Nitrogen Oxides, Air Pollution-Persistent Organic Pollutants, Air Pollution-Sulphur 94, Air Pollution-Volatile Organic Compounds, Antarctic-Environmental Protection, Antarctic-Marine Living Resources, Antarctic Seals, Antarctic Treaty, **Biodiversity, Climate Change, Climate Change-Kyoto Protocol, Climate Change-Paris Agreement**, Comprehensive Nuclear Test Ban, Desertification, Endangered Species, Environmental Modification, **Hazardous Wastes**, Law of the Sea, **Marine Dumping-London Convention, Marine Dumping-London Protocol, Marine Life Conservation**, Nuclear Test Ban, Ozone Layer Protection, Ship Pollution, Tropical Timber 2006, Wetlands, Whaling. Source: World Factbook (Central Intelligence Agency, 2021)

Procurement[4] policies occur within a national setting, and there is no doubt that the provisioning strategy for providing PPE, especially during the initial response to supply shortages, will have made it more difficult to achieve these environmental commitments and goals.

1.1.4 Lack of pandemic preparedness

The COVID-19 pandemic caught most countries off guard, despite the demonstrated risks and lessons from previous pandemics and the importance of preparedness being acknowledged globally[5]. Pandemics are characterised by several closely linked conditions but vary in intensity[6]. These include a significant increase in the need for protective equipment like masks, gloves, and gowns, economic stress, short-term improvement in environmental conditions such as reductions in commuting and air travel, inequities in access to and quality of treatment, and uneven distribution of non-health-related effects. Despite knowledge of these effects and calls for preparedness, most countries were not well equipped to handle the COVID-19 pandemic.

The lack of preparedness led to a desperate rush to put measures in place to manage the outbreak, including acquiring and distributing PPE, medical interventions to treat patients, developing and deploying vaccines, and implementing public health measures like mask mandates, social distancing, and lockdowns. This process was politically charged, heavily scrutinised, and embedded in a public discourse that included harmful challenges to scientific knowledge and public policy actions, yet also provided opportunities for individuals or entities to take advantage of the circumstances and unfairly benefit financially through capture of inappropriate economic rents.[7]

[4] Here we use procurement to refer to the policies, procedures, and strategic approaches to obtaining PPE. Provisioning is used to refer to actions required to supply goods and services including preparedness, procurement, manufacture and product design, distribution, use, and disposal.

[5] WHO Member States adopted the Pandemic Influenza Preparedness (PIP) Framework in 2011 (World Health Organization, 2019).

[6] Varying in intensity from location, for example Ebola in rural Africa would be unlikely to result in much reduction in GHG.

[7] In simple terms, economic rent is an excess where there is no enterprise or costs of production (Wikipedia, n.d.). The Economist (n.d.) describes rent seeking as: “Cutting yourself a bigger slice of the cake rather than making the cake bigger. Trying to make more money without producing more for customers. For example, a cartel of firms agreeing to raise prices or lobbying the government for tax, spending or regulatory policies that benefit the lobbyists at the expense of taxpayers or consumers or some other rivals.”

1.2 About this case study

1.2.1 Scope of the PPE Case Study

The focus of this case study is on scoping how an evaluation of an important element of a national response to COVID-19 - the provision of Personal Protective Equipment (PPE) - can address environmental sustainability. Other elements of a national response, such as lockdowns, restrictions on public movement, national border closures, testing kits and vaccinations that would likely be included in a complete evaluation of responses to COVID-19, are not included in this case study. All of these would have different but also important environmental effects.

The case study does not attempt to evaluate PPE provisioning. Rather it illustrates how the scope of an evaluation of PPE provisioning can, and arguably should, be expanded to include consideration of environmental impacts. While some negative equity outcomes are identified, the primary focus of this case study is on the impact of PPE on environmental sustainability.

1.2.2 Why focus on the provisioning of PPE?

The provisioning of PPE provides a useful example of a situation where the consideration of environmental sustainability by interventions and evaluations may not be deemed feasible or relevant, given the urgency of the situation. One of the arguments against this inclusion is that taking the time to consider environmental sustainability would slow down the response and lead to choices that compromise health and equity outcomes. This case study explores whether these concerns are justified or if it is possible and useful to consider environmental sustainability in PPE provisioning.

It is challenging to consider environmental and equity effects in the midst of a pandemic, where the primary goal is to understand and reduce transmission, infection, illness, and death. However, it is feasible to consider these factors as part of a provisioning strategy prepared, implemented and adapted in advance as part of integrated preparedness and risk management actions of government, relevant institutions, and enterprise. Absent these integrated preparations, as in most countries, the immediate response to the need for PPE in a pandemic is likely to ignore environmental impacts.

No technical reasons are standing in the way of addressing environmental sustainability and equity as core criteria in an evaluation of PPE provisioning. The reasons for not addressing these factors lie in the social, cultural, economic, historical, and political realms of evaluation, all of which are within reach of evaluation and evaluators to change. Including the costs of environmental effects in evaluations could contribute to arguments for establishing and maintaining preparedness capacities that do not harm natural systems and which enhance human well-being and national economies. As the bulk of evaluation practice and methods have been developed for the human system, the primary consideration of this case study is whether it would be possible to also address natural system effects as part of an evaluation.

1.2.3 Purpose of the PPE Case Study

The PPE case study has two linked purposes:

- Firstly, to assess the feasibility and value of the underlying premise of the Footprint Evaluation Initiative - that environmental sustainability must and can be addressed in all evaluations.
- Secondly, offer suggestions for how an evaluation of PPE provisioning can address health, equity and environmental sustainability.

The case study demonstrates the following:

- The provision of PPE is a nexus matter – human and natural systems are intertwined; decisions that affect human health and PPE provisioning also affect the environment.
- High-quality methods for assessing environmental sustainability in an evaluation are available and feasible.
- Existing evaluation methods can be used to incorporate environmental sustainability into evaluations – in particular, extending the frame of the evaluand and tailoring key evaluation questions to include environmental considerations.
- The value of engaging with other knowledge domains that utilise specific methods for estimating environmental effects that may be new and important to evaluators seeking to include sustainability in evaluations.
- The merit of credible investigative journalistic reporting in identifying and addressing emerging issues.
- Broadening the scope of an evaluation to include consideration of environmental impacts would generate knowledge about options for the equitable achievement of important health outcomes in ways that do not impair environmental sustainability.

1.2.4 Methodology

The methodology used to develop this case study was to consider how evaluators can adapt existing evaluation methods and draw on existing expertise in other disciplines to include health, equity and environmental sustainability in an evaluation of PPE provisioning. The intention was not to conduct an evaluation of the environmental impact of PPE but to explore the feasibility of doing this. This involved broadening the frame of the evaluand to include both human and natural systems by:

- Using an expanded life cycle framework to identify nexus connections between human and natural systems in the various intervention elements
- mapping potential health, equity and environmental outcomes that can be used to expand the theory of change
- crafting appropriate evaluation questions incorporating sustainability and environmental effects
- exploring methods that have been used in previous studies of PPE, including the use of an expanded life cycle assessment and scenario modelling
- introducing a typology matrix and rubrics that consider both natural system and equity effects as a useful way of synthesising and communicating evaluation findings

The case study was fortunate to be able to draw on the paper "Environmental impact of personal protective equipment distributed for use by health and social care services in England in the first six months of the COVID-19 pandemic" by Chantelle Rizan, Malcolm Reed and Mahmood F. Bhutta (2021). This paper demonstrates the feasibility of evaluating environmental impacts and how this can be done given appropriate resourcing and expertise. The Footprint Evaluation case study expands on the Rizan et al. paper by broadening the framework for considering the life cycle of PPE products by including preparedness and procurement as well as the environmental impacts of raw material extraction, manufacture, use, transport and waste disposal that were quantified in the Rizan et al. research.

In addition, relevant sources informing this case study include:

- academic papers,
- government policy documents,
- news articles, and
- websites that tracked government responses and PPE supply issues during the pandemic, such as the World Health Authority

A key methodological finding from this case study is the important contribution that quality journalism can make to the evaluation process. Several important issues related to the PPE provisioning process were initially brought to light through reputable news publications such as The Guardian, New Yorker, and other global media. Particularly in rapidly-evolving crises, well-researched news articles can serve as valuable sources for evaluating emerging interventions and conducting early evaluations. As evaluation evolves and becomes more adaptive and responsive to time-sensitive concerns, these sources may become increasingly important.

1.2.5 Structure of the case study

The following section (**section two**) uses a life cycle framework to expand the evaluand and include consideration of environmental sustainability. This involves mapping the environmental implications of the important stages in PPE provisioning (preparedness, procurement, design and manufacture, distribution, consumption and disposal) and mapping potential outcomes for both human and natural systems. Implications for developing a revised theory of change to include the nexus between human and natural systems are outlined.

Section three discusses how natural systems can be incorporated into existing evaluation approaches with particular attention to revising key evaluation questions.

Section four profiles a laudable evaluation of PPE provisioning in England that clearly shows that it is technically feasible to address environmental impacts as part of evaluating PPE provisioning.

Section five presents a typology matrix and rubrics that consider both natural system and equity effects is a useful way of synthesising and communicating evaluation findings

Section six summarises the implications for mainstreaming environmental considerations.

Appendix one provides further detail about the nexus between human and natural systems at each step in the PPE provisioning chain and walks through possible alternative strategies for reducing the environmental harm caused by PPE provision.

2. Broadening the theory of change to explore nexus

An evaluation of PPE provisioning that only focuses on the intended outcomes for human systems and follows a "business as usual" approach would neglect to consider the impimpact on natural systems. Such an evaluation might mention natural systems only as an afterthought or unintended effects not considered in the strategy. However, evaluators have a responsibility to consider unintended effects. As noted in the Footprint Evaluation Community Discussion Group (2021), this is especially so when these effects might be better described as "ignored effects" rather than “unintended” or “unexpected”.

As Juha Uitto, Director of the Independent Evaluation Office of the Global Environment Facility, has stated:

“It is important for evaluators to place the evaluand into the context in which it operates and, specifically, in which it interacts with human and natural systems. This will require an open theory of change that pays attention to unanticipated consequences – to the environment; to different groups of people, especially the most vulnerable; to incentives and disincentives for sustainability – and whether the intervention makes a positive difference in the problem it was established to address.” (Uitto, 2021)

An intervention theory of change (ToC) explains how the activities of an intervention are expected to lead to desired outcomes. To evaluate the impact of the intervention on both human and natural systems, it is essential to broaden the scope of the ToC[8]. This includes identifying the direct inputs (resources and activities used) and consequences (short and long-term outcomes), as well as any key assumptions and mechanisms (causal factors) in both human and natural systems.

To begin this process, it's important to map the different elements, the reach of the intervention, and the intended and potential outcomes for both human and natural systems. Ideally, this should be done collaboratively with all key parties who can affect the success of the intervention or are affected by it. This collaborative process also provides an opportunity to broaden engagement in the evaluation, which can promote its use. This approach results in a ToC that differs from those of traditional evaluations that focus solely on the stated intended outcomes of one system and prioritise accountability and responsibility frames.

[8] For more information, see the Footprint Evaluation thematic page at www.betterevaluation.org/methods-approaches/themes/footprint-evaluation (Footprint Evaluation Initiative, n.d.)

2.1 Mapping the intervention elements: Stages of PPE provisioning

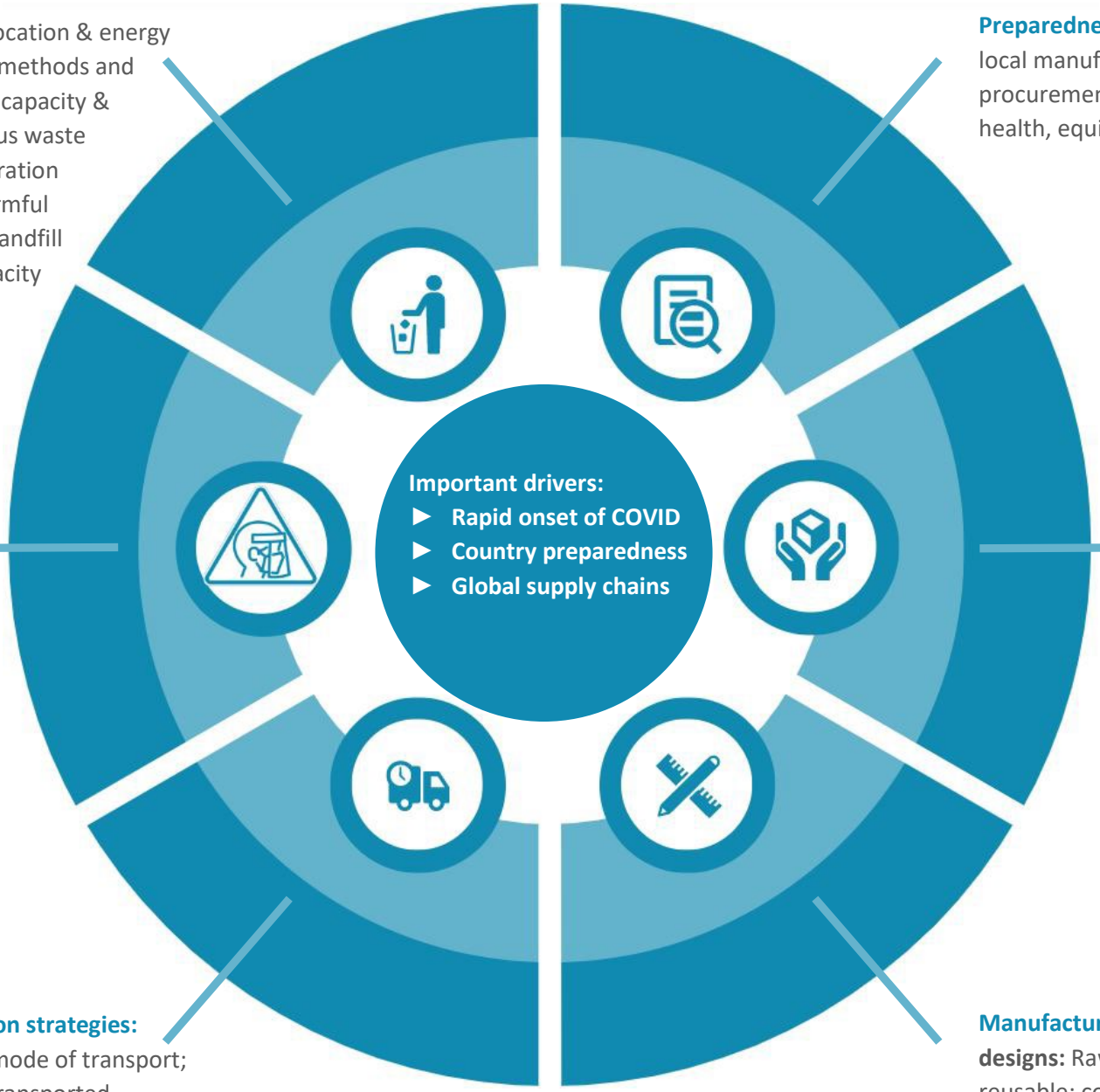
An evaluation of PPE provisioning can be made more comprehensive by looking at the entire process of PPE provisioning, including how it affects both human and natural systems. To demonstrate this, we mapped out the different steps in the PPE provisioning chain and the decisions made at each step that contributed to outcomes for human health, equity, and environmental sustainability. This helped us identify potential environmental impacts at each step in the chain and highlighted the role of procurement in achieving sustainability and equity. It is a useful illustration of the importance of procurement to sustainability (and equity) and points to the importance of including procurement in evaluations.

Figure 1 illustrates the key stages in the PPE provisioning process and the factors that affect outcomes for both human and natural systems. It is important to note that the process is not linear, and there are feedback loops between stages. For example, the availability of PPE can impact consumption, affecting future procurement. The diagram also highlights the environmental impacts of decisions made at each stage in the provisioning process, emphasising that PPE provisioning is a complex issue with consequences for both human and natural systems. A more detailed exploration of the contributing factors, environmental and equity implications, and options for reducing environmental harm at each stage is provided in Appendix 1.

Figure 1. Example of factors influencing the environmental impact of PPE

Disposal: choice, location & energy source of disposal methods and facilities; recycling capacity & practices; hazardous waste regulations; incineration temperature & harmful particle filtration; landfill management; capacity to keep PPE out of waterways

Preparedness: adequacy of PPE stockpile; local manufacturing capacity; procurement strategies that consider health, equity and environmental impacts



Consumption: policies & practices; capacity & incentives for reuse; user knowledge & attitudes; compliance; community expectations

Procurement – priorities and decisions: availability of PPE; type of PPE prioritised (single use vs reusable) manufacturing capacity; procurement strategies that consider health, equity and environmental impacts

Distribution strategies: urgency; mode of transport; distance transported

Manufacture – decisions and product designs: Raw materials used; single use or reusable; compostable or persists in environment; ease of recycling

2.1.1 Preparedness

To be adequately prepared for a pandemic, it's important to have stockpiles of essential supplies and strategies to increase local production. This can prevent the need to compete with other countries for supplies of PPE during disruptions to the global supply chain, as occurred at the start of the COVID-19 pandemic. A lack of stockpiling, or an assured source of rapid supply of PPE, will create a setting where environmental harm is inevitable.

A pandemic preparedness strategy can also address sustainability by having policies and processes in place for the procurement, manufacture, transport, consumption and disposal of PPE that minimise harm to the environment, for example:

- seeking suppliers with good labour and environmental records
- stockpiling reusable rather than single-use PPE when appropriate
- reducing the need for high volumes of air freight (because immediate needs can be met from the stockpile)
- having plans for ramping up local manufacture of PPE
- adopting technologies that recycle PPE, including product designs that facilitate recycling

2.1.2 Procurement

Without an adequate strategy, procurement practices can cause significant adverse effects on the environment, such as air and water pollution and increased greenhouse gases. These effects are often overlooked due to three factors:

- Purchasing decisions that prioritise cost over the value of natural systems and the impact on human and natural health. Equity is also unlikely to be considered a priority.
- Partitioned procurement and costing, where the downstream effects of procurement decisions on natural systems are not considered. This can lead to disregard for environmental sustainability in favour of cost-effectiveness.
- Temporal frames that fail to consider the well-being of future generations. PPE provisioning strategies that harm the environment today, such as increased greenhouse gas emissions and harmful landfills, will negatively affect future generations.

2.1.3 Product design and manufacture

Product design[9] has a major impact on a product's environmental footprint, as it determines the choice of materials, manufacturing processes, packaging, and the potential for recycling or repurposing. However, these decisions often do not consider or prioritise environmental considerations. For instance, during the lockdowns imposed by the COVID-19 pandemic, the reduced demand for oil led to a decline in oil prices, making it less economically viable to produce plastics from recycled materials instead of raw petroleum.

[9] The International Resources Panel (https://www.resourcepanel.org) is a useful source for sustainability and product design

This illustrates the challenges of achieving sustainability when economic factors dominate decision-making.

2.1.4 Distribution

Two key factors in the environmental impact of distribution are the distance of transportation and the mode of transport used. Provisioning supplies nationally is less harmful than from distant places. Environmental effects also depend on the mode of transport. In the early stages of the pandemic, air freight was heavily used due to the urgent needs, resulting in significant GHG emissions. Without advance preparation, distribution is likely to have a significant environmental impact.

Scenario modelling by Rizan et al. (2021) concluded that domestic manufacture of the PPE products used in health care would have reduced the carbon footprint by 12%. Rizan's modelling eliminated international transport (shipping) but used the same road travel assumptions, with UK electricity grid inventory process data to inform estimates of the carbon footprint for domestic manufacture.

2.1.5 Consumption

The quantity of PPE used is crucial in determining the environmental costs of manufacturing, distributing, and disposing of used PPE products. The volume and types of PPE used in medical settings are influenced by clinical guidelines, practice systems that dictate the duration and frequency of PPE changes, reuse practices after disinfection, the level of compliance with PPE use and reuse guidelines and financial policies that incentivise or discourage reuse.

PPE use in health settings can be minimised by only using PPE where it is needed for safety and reducing "hygiene theatre" (wearing PPE in non-clinical settings). Simple practice measures such as having "clean" runners fetch equipment and drugs reduce the amount of PPE used (Fang, Pinder, Cooper, McGrath, & Shelton, 2021).

In community settings, trust in public health advice and attitudes towards government mandates influence behavioural responses such as using masks in public (to reduce transmission) and vaccinations, with low vaccination rates increasing infections and the severity of illness, leading to higher use of PPE in health settings.

2.1.6 Disposal

Disposal became a significant challenge due to the large volume of PPE consumed (including single-use PPE and PPE that has reached its reuse limit). This was particularly so in dealing with non-degradable plastic waste that is difficult to repurpose. The different disposal methods for PPE can have different environmental impacts. In England, various disposal options are available, including recycling, landfill, low-temperature incineration, and high-temperature incineration. The environmental cost of each method is influenced by several factors, including the ability to sort waste efficiently, the distance and mode of transportation of waste to processing facilities, the amount of energy consumed during the disposal process, and the environmental damage caused by the various disposal methods, such incineration or landfill. Another critical factor is the ability of waste management systems to prevent waste from entering waterways or oceans.

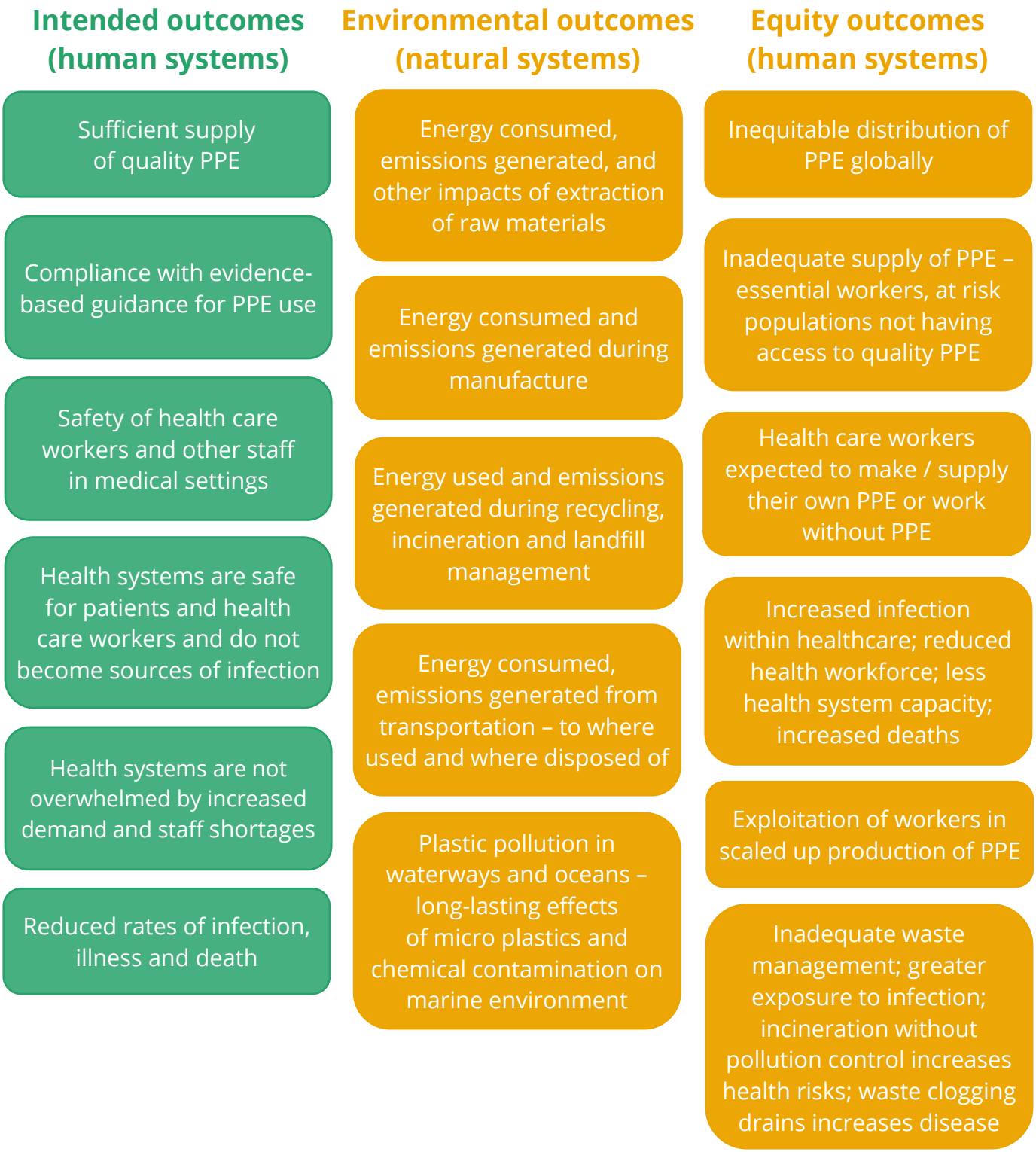
2.1.7 Summary

To better understand the environmental impact of PPE, we must look at each stage of its provision. Each of these stages is a nexus setting, with decisions made in these various stages playing a significant role in determining the impact of human systems on natural systems.

By implementing a sustainable procurement strategy and stockpiling essential materials before the pandemic, much of the environmental harm that occurred during the COVID-19 crisis could have been avoided. Additionally, the lack of consideration for natural systems and life cycle sustainability in product design and manufacture further contributed to this harm. The urgency of distribution resulted in significant negative effects on natural systems, especially due to the mode and distance of transport necessary to obtain PPE quickly. More single-use PPE was consumed than necessary due to the lack of reuse guidelines and minimisation practices. Finally, disposal of the large volume of single-use PPE that was largely non-degradable plastic waste became a major challenge.

Mapping the PPE life cycle helped to identify likely negative outcomes for the environment and equity, as shown in Figure 2 alongside the intended outcomes of PPE provisioning.

Figure 2: Intended outcomes of PPE provisioning and likely outcomes for environment and equity of PPE provisioning



2.2 Expanding the theory of change

This initial scoping of a potential evaluation of the national provisioning strategy for the pandemic illustrates the need for an evaluation to ensure the theory of change addresses effects such as:

- **The connectivity and feedback loops between the various provisioning stages**, i.e. manufacture, consumption, reuse, and disposal. For example, guidelines for the use and reuse of PPE affect consumption levels of PPE, which in turn affects the demand for manufacturing and the number of PPE units requiring disposal.
- **The environmental effects of all provisioning stages**, including the emissions from increased petroleum needed for manufacturing, transporting, and disposing of PPE. It's important to consider a broad spatial framing (expanding the TOC beyond a specific 'site' to the broader landscape) and temporal framing (expanding the TOC beyond the short time frame of an intervention to consider longer-term impacts in natural systems and for future generations of humans).
- **Important external effects that prevail in a pandemic**; for example, economic downturns that reduce demand for petroleum products make it cheaper to create new plastic from raw petroleum than from recycled sources.
- **Important contextual factors**, such as the global concentration of critical manufacturing facilities in a small number of countries, the inability to meet massive increases in global demand for PPE and the vulnerability of supply chains.
- **National and international environmental commitments, policies and strategies**. A TOC for PPE provisioning should identify how pre-existing national and international environmental commitments influenced PPE provisioning strategies and decisions.
- **Effects of behavioural responses**, for example, the level of compliance with PPE use and reuse guidelines and the effects of widespread attitudes and beliefs, for example, a distrust of vaccinations that causes higher infection levels, which results in higher use of PPE.
- **Equity effects** - for example, the dramatic increase in the cost of PPE disadvantaged poorer countries; this was exacerbated by wealthy countries not maintaining PPE inventories which increases global demand for PPE during crises. Other equity effects include the major problems for healthcare systems and the wider community caused by a lack of PPE, including significant mortality and sickness that disproportionately affects at-risk groups and healthcare professionals.

Identifying points of nexus between human and natural systems at each stage of PPE provisioning, considering unintended and intended outcomes for both human and natural systems, and considering relevant contextual and systemic factors will inform a theory of change that explicitly considers impacts on environmental sustainability.

Armed with this expanded theory of change, an evaluation could apply counterfactual thinking, such as scenario modelling. This could be framed as if preparation policies and guidelines had been followed.[10] Another scenario would be, absent preparation and following the early free-for-all stage of provisioning, application of policies, guidelines and supports to mitigate more severe adverse effects of provisioning such as developing domestic manufacture, less environmentally damaging product and manufacturing design, and introducing requirements for recycled plastics in product design.

[10] For example the scenario-based counterfactual approach used by Rizan et al. (2021)

3. Incorporating environmental sustainability and natural systems into key evaluation questions

This section demonstrates how key evaluation questions in an evaluation of PPE provisioning can include consideration of natural as well as human systems.

The Footprint Evaluation Initiative has adapted Jane Davidson's Key Evaluation Questions (KEQs) (Davidson, 2013) to incorporate natural systems and sustainability into each question. The seven Footprint Evaluation KEQs each easily accommodate this change, and their use will significantly reduce the built-in (usually positive) biases in evaluations that result from their exclusion (Rowe 2019).

- **KEQ 1 – Relevance and coherence:** How relevant is the evaluand to the population/sector *and* the natural environment – and how well does it complement other efforts in the context?
- **KEQ 2 – Design and adaptation:** How well does the design address the strengths, needs, and aspirations of both human *and* natural systems — in ways that enable both to thrive?
- **KEQ 3 – Implementation:** How well has the evaluand prioritised and managed the delivery of support so that the right people and natural system elements receive what is most needed at the right times and places and in the right ways?
- **KEQ 4 – Outcomes and impacts:** How good, valuable, and important are the outcomes and impacts for both the target population/environment and anyone or anything else substantially impacted.?
- **KEQ 5 – Patterns, outliers and links:** Where, when, for whom, under what conditions, and why did the evaluand deliver the most and least valuable outcomes for coupled human and natural systems?
- **KEQ 6 – Durability:** How environmentally, systemically, politically, and financially durable are the changes the evaluand has contributed to?
- **KEQ 7 – Overall value:** How good, valuable, or worthwhile is the evaluand overall, given its relevance and coherence, design and implementation, the value of outcomes and impacts, their durability, and what it costs to achieve them? This question is the synthesis step, which takes into account all of KEQs 1 to 6, plus costs to both systems.

Below, this list of KEQs has been designed so that it can apply in any sector, type of evaluand, level of analysis, etc. As such, the list is deliberately generic; each evaluation team should rewrite/interpret the questions for the particular sector, context, culture, population/community, evaluand, and evaluation audience, using wording that makes sense for that application.

In the following table, we sketch some important implications of considering natural systems and sustainability as part of each of the KEQs and illustrate that this does not require significant retooling of existing evaluation approaches beyond expanding the reach of the evaluand.

KEQ 1: Relevance and coherence

How relevant is the evaluand to the population/sector *and* the natural environment – and how well does it complement other efforts in the context?

PPE provisioning in the early stages of the pandemic did not consider the natural environment at all. The focus was on obtaining a sufficient supply of appropriate PPE as quickly as possible. Governments were under intense public scrutiny and without procurement infrastructure and inventories. The scramble for PPE became very competitive between and within nations.

The procurement strategy ignored international environmental commitments and national initiatives.

There is a continuing need for PPE for the current pandemic and to be ready for future pandemics. Continuation of harm to the natural system is not tenable given the increasingly dire climate assessments and other environmental issues, including biodiversity and pollution. The need to consider the environment has been recognised in later procurement strategies.

This question is highly relevant for the evaluation. It directly involves important sustainability issues and can be fully addressed without difficulty using existing materials, such as documentation about the procurement approach and global, national and local environmental commitments and initiatives.

KEQ 2: Design and adaptation

How well does the design address the strengths, needs, and aspirations of both human and natural systems – in ways that enable both to thrive?

The need for PPE was urgent for the human system and this trumped exploration of more sustainable approaches. The procurement was global, and urgency trumped developing more local sources of supply

Procurement did not seem to follow guidelines for gowns, masks and gloves, and seemed to respond to perceived and perhaps correct view that overuse of PPE would provide a sense of security to key interests (e.g. hospital staff). As a result, gowns and masks were changed more frequently than required in guidelines, and there is some advice that gloves were not needed at all (the need for gloves differs between guidance sources).

Disposal does not seem to have been considered in procurement or use.

This question is highly relevant for the evaluation and directly involves important sustainability issues.

KEQ3: Implementation

How well has the evaluand been implemented?

Existing policies and guidance would have provided a stockpile of PPE that would have eased conditions during the onset of the pandemic. However, these were not applied and stockpiles were not maintained, resulting in an emergency at the onset and the following period. This is prima facia evidence that the response was poorly implemented, and many of the harmful effects the evaluation will observe flow from that.

However, given reality, without preparation and stockpiles, there is another question about how well provisioning was undertaken, given the failure to prepare. This could potentially yield insights valuable for preparing for and responding to the next pandemic.

The approach largely ignored the environment, and there is no doubt that the response has caused serious net harm to natural systems, making the challenges of meeting the 2030 and 2050 goals and other international and national commitments even more challenging.

A dramatic increase in local PPE manufacturing capacity in response to supply shortages will reduce environmental damage attributable to international transport.

Some ignored or seriously under-fulfilled aspects were quite influential, for example, compliance with guidance on the use and non-use of PPE. It also appears that coordination was insufficient, so scarce materials were not actively managed to respond to emerging serious needs. No doubt other implementation aspects would appear from the evaluation that would hopefully be cast in a "next time, let's do it a lot better" message.

This question is highly relevant for the evaluation and directly involves important sustainability issues.

KEQ 4: Outcomes and impacts

How good, valuable, and important are the outcomes and impacts?

There will not be a lot of good news in the answers addressing this question, but for the efforts of the NHS staff and similar.

The expanded ToC (as discussed in section 2) will be critical in bringing value to this question. Business-as-usual evaluations would ignore effects in natural systems or treat them as unexpected.

KEQ 5: Patterns, outliers and links

Where, when, for whom, under what conditions, and why did the evaluand deliver the most and least valuable outcomes for coupled human and natural systems?

Given the urgency heralded by the 2030 and 2050 climate, biodiversity and sustainability goals evaluation will need to provide more rapid and improvement-focused insights. The coupling of human and natural systems and the patterns that this generates are central topics for the kind of evaluation that will beneficially contribute to achieving those goals.

KEQ 6: Durability

How environmentally, systemically, politically, and financially durable are the changes the evaluand has contributed to?

Under the well-documented changes occurring in key natural systems, such as through climate change, no evaluative effort at durability will have meaning if it fails to consider durability in terms of environmental durability and durability under conditions of global environmental change.

KEQ7: Overall value

How good, valuable, or worthwhile is the evaluand overall, given its relevance and coherence, design and implementation, the value of outcomes and impacts, their durability, and what it costs to achieve them?

This question is the synthesis step, which takes account of KEQs 1 to 6, plus costs to both systems. Incorporating natural systems and sustainability into KEQs 1 through 6 will provide a more valid assessment of the intervention's value and durability, especially considering well-documented changes in climate, biodiversity, and other important systems.

The Footprint Evaluation Key Evaluation Questions (KEQs) demonstrate that sustainability and natural systems fit within the intent of existing standard evaluation criteria and questions. This shows that it is feasible to adapt existing evaluation superstructures in the form of evaluation questions and criteria to bring sustainability and natural systems into the purview of an evaluation.

4. Feasibility of evaluating environmental outcomes

Evaluating nexus settings requires attending to how human and natural systems couple, interact and affect each other. In the case of PPE, this can be explored through the six elements in the procurement chain: preparedness, procurement, manufacture and product design, distribution, use, and disposal. In the above sections, we describe how existing evaluation superstructures in the form of theories of change and evaluation questions and criteria can be adapted to bring sustainability and natural systems into the purview of evaluation. This section demonstrates how methods from other knowledge domains can be adapted to enhance evaluation methods to successfully evaluate the value of interventions in coupled systems.

4.1 Assessing environmental impacts using a life cycle analysis and scenario modelling

One of the arguments often used against incorporating environmental sustainability into evaluations is that it is technically difficult. However, the recent assessment of the environmental impacts of PPE provisioning in the healthcare sector in England by Chantelle Rizan, Malcolm Reed and Mahmood F. Bhutta (2021) provides solid confirmation that addressing national PPE provisioning as a nexus matter is entirely feasible from a technical perspective.

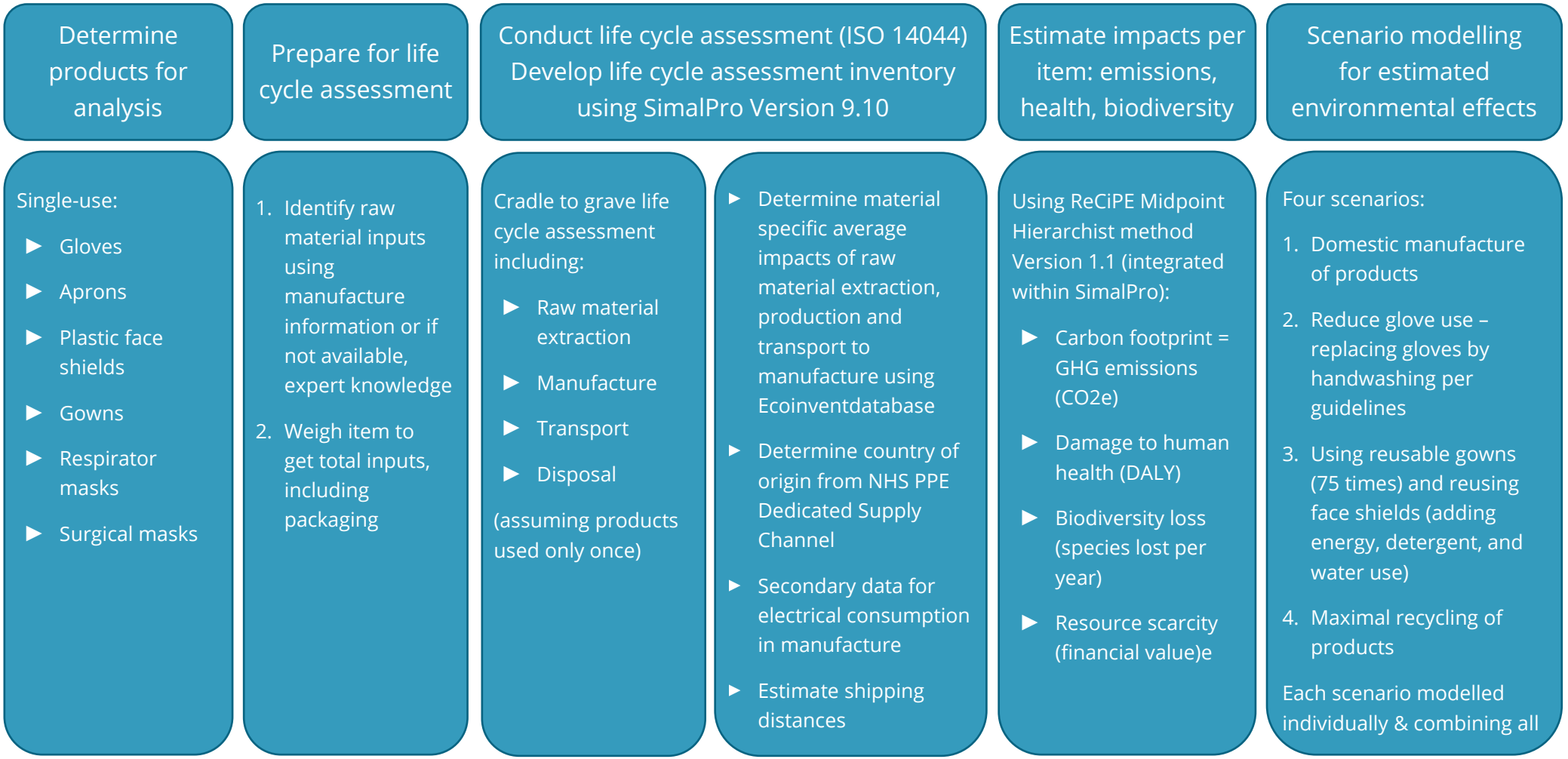
In 2021, Rizan et al. (2021) quantified the environmental impact of PPE use by the health and social care system in England in the first six months of the pandemic and modelled strategies for mitigating environmental impacts. They used a life cycle assessment and scenario modelling approach, as shown in Figure 3, to assess the environmental impact of each stage of PPE provisioning.

In the Rizan et al. study, the authors gained the expertise and obtained technical advice to be able to undertake the life cycle assessment themselves. Other feasible options include bringing in external assistance to apply existing estimates or conduct the analysis.

This life cycle assessment determined the environmental impact of the production, transport, and disposal of single-use PPE in terms of CO2 emissions, estimated damage to human health in disability-adjusted life years (DALYs), ecosystem species loss and the cost of resource depletion. Scenario modelling then explored the reduced environmental impact of four strategies: UK production to eliminate international transport; eliminating the use of gloves; reusing gowns and face shields; and maximising recycling. The analysis found that a combination of these strategies may have reduced the English PPE carbon footprint by 75% and saved an estimated 183 Disability Adjusted Life Years (DALYS), 0.34 species per year, and US $7.4 (GBP £5.4) million due to resource depletion.

The central provisioning of PPE to health care services in the UK meant that data on the quantity, sources and types of PPE was available. In countries where each organisation individually procured PPE the task of gathering data on the type, volume and source of PPE consumed would be more complicated and time consuming.

Figure 3: Rizen et al. (2021)'s life cycle and scenario modelling approach



Source: Derived by authors from Rizan et al. (2021)

4.1.1 Conducting a life cycle assessment

The life cycle methods are well-established and have an ISO code *Environmental management - Life cycle assessment - Requirements and guidelines* (International Organization for Standardization, 2006). The life cycle approach is straightforward: identify the products, estimate their volume and raw material content, and estimate the associated environmental impact.

To evaluate the environmental impact of products and processes, life cycle assessment breaks them down to the level of material inputs. It uses established methods and data to generate the measures of interest. For example, if we want to know the GHG emissions from producing PPE using raw petroleum as the base for plastics, data tables and coefficients can be used to calculate emissions based on factors like the source of petroleum, logistics, and the manufacturing process. This knowledge infrastructure is a resource for engineering, product design, management, and other uses. Usefully this means that material inputs and environmental consequences can be estimated for alternative products using the same good quality information for counterfactual thinking as Rizan et al. applied in their scenario modelling.

Just as DNA analysis breaks down organisms into their individual genes and provides a blueprint for an organism's traits, life cycle assessment breaks down products and processes into their individual material inputs, which provide the blueprint for their environmental impact. The life cycle assessment conducted by Rizan et al. followed ISO Standard 14044 guidelines. It included raw material extraction, manufacture, transport, and disposal, using secondary data for different forms of electrical generation by country of origin[11]. Simulation modelling software, specifically SimaPro Version 9.10 (PRé Sustainability, 2020), was used to develop a life cycle inventory, and the ReCiPe Midpoint Hierarchist method version 1.1 (integrated within SimaPro) was used to estimate carbon equivalent emissions as well as human health, species lost, and resource scarcity impacts. These methods are well documented, and there is a strong pool of technical expertise in the environmental sciences that can be consulted and accessed for further guidance on how to use these.

4.1.2 Alternative scenario modelling

To better understand the environmental impacts of decisions made throughout the PPE provisioning process, Rizan et al. modelled several alternative scenarios. In the base scenario, which reflected actual PPE provisioning practices during the first six months of the pandemic, all PPE products were assumed to be single-use and disposed of via clinical waste. The authors then modelled four alternative scenarios that could have been plausibly applied to mitigate adverse environmental effects. These alternatives included domestic manufacture, adherence to usage advice, and existing disposal options. The alternative scenarios were:

[11] A more detailed example of this is the case study on Reducing Industry's Carbon Footprint in South East Asia in the Global Environment Facility Independent Evaluation Office's evaluation of programmatic approaches in the GEF (Volume II Technical Reports, 2017).

- Domestic (UK) manufacture of products, effectively eliminating international shipping but using the same road travel assumptions, with UK electricity grid inventory process data for manufacture.
- Replacing use of gloves (with subsequent hand washing), with hand washing alone (which can effectively destroy the virus).
- Reusable gowns and reusing face shields assuming that:
- Gowns were laundered and reused 75 times before disposal. The extracted energy, water and detergent requirements and transportation of linen to a laundering facility was calculated.
- Face shields were reused five times and cleaned by a disinfectant wipe between uses - the environmental impacts of disinfectant wipes were calculated.
- Maximal recycling of products, assuming it was possible to recycle all items and their components. Used the open-loop 'recycled content method' - allocates subsequent emissions and environmental impacts of the recycling process, and net reduction of virgin material acquisition.
- The environmental impact of combining all of the above mitigation measures.

The scenario modelling found that:

- UK manufacture would have reduced the carbon footprint by 12%,
- Eliminating gloves would have reduced the carbon footprint by 45%,
- Reusing gowns and gloves would have reduced the carbon footprint by 10%,
- Maximal recycling would have reduced the carbon footprint by 35%,

A combination of strategies may have reduced carbon footprint by 75% compared with the base scenario, and saved an estimated 183 DALYS, 0.34 species per year, and US $ 7.4 (GBP £ 5.4) million due to resource depletion." The authors concluded that "The environmental impact of PPE is large and could be reduced through domestic manufacture, rationalising glove use, using reusables where possible, and optimising waste management."

This work illustrates that existing and well-established methods are available for evaluating environmental effects from nexus interventions such as PPE provisioning and for plausible and feasible alternatives. A key step in the approach was developing what was in effect a expanded Theory of Change (ToC) that included environmental effects from existing and alternative provisioning approaches.

5. Making judgements about the net effect

Evaluations answer evaluative questions about the value of what has happened or of alternative options – whether it is good, bad, better or worse. Being able to understand and articulate the net effect of environmental impacts of PPE provisioning on the environment is an important part of whether this is a feasible thing to evaluate.

5.1 A typology for assessing net effects on the environment

A typology is a useful tool for synthesising the evidence and making an evaluative judgement about the environmental impacts of PPE. The following typology developed by Andy Rowe, a member of the Footprint Evaluation Initiative, clearly communicates to decision-makers the extent of damage to natural systems. The typology (shown in **Figure 4**, right) has four positions reflecting the likely net effect of environmental impact:

- **Beneficial** – Restores the natural environment so that it thrives
- **Neutral** – Practices cause no harm OR restoration offsets any harm
- **Harmful** – sustainability-aware aware practices limit environmental damage
- **Destructive** – Extractive and damaging practices cause serious harm

This typology reflects the urgency to significantly reduce the harm human activities are causing to threatened natural systems and the need to restore the health of these systems, and the need to go beyond 'do no harm' when making judgments about environmental impacts. This need is already recognised in the standards set by a number of global development organisations such as the UNDP, IFAD, and UNIDO adopting a 'do no harm' to natural systems minimum. Indeed, investments by these organisations are starting to move into restorative territory, actively restoring natural systems rather than simply avoiding further harm.

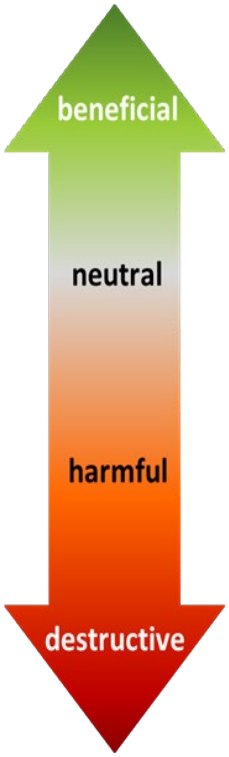


Figure 4. Source: IFAD

5.2 Understanding the net effect of PPE provisioning on human and natural systems

Using this typology, and informed by the application of the methods and processes described in sections 2 to 4, an evaluation of PPE provisioning in the immediate aftermath of the COVID-19 pandemic is likely to be judged as **destructive** or, at best, **harmful** (sustainability-aware) to the environment. An understanding of this net effect of past PPE provisioning practices, paired with the use of this typology to also evaluate future pandemic preparedness planning, will be valuable in assisting decision-makers in reducing negative environmental impacts in future health crises.

The typology could be applied to the overall process of PPE procurement, or applied separately to each individual provisioning stage in the provisioning process (preparedness, procurement, manufacture and product design, distribution, use, and disposal) to inform an overall judgement.

Rubrics that illustrate the impacts of PPE provisioning on both natural and human systems could also be developed to build on this typology to ensure that equity, as well as environmental impacts, are clearly communicated. This is particularly important given the interwoven nature of equity and environmental effects; PPE provisioning is but one demonstration of this.

Equity effects include equity of health and economic outcomes as well as considerations like the equity of supply chains and manufacturing processes and the disproportionate impacts of plastic pollution on marginalised communities. For example, Haque, Sharif, Masnoon, and Rashid (2021) reported that in Dhaka, Bangladesh designated waste handlers and an estimated 6,000 informal workers (including children) were exposed to the virus during the collection, handling and transportation of infectious waste. A 50% reduction in the waste handling workforce led to drains being clogged with discarded PPE, resulting in inundation in urban areas, increasing the risk of diseases like malaria and dengue fever. In the UK, a Channel 4 news investigation reported on the exploitation of migrant workers who manufactured PPE for companies that supply the NHS. (Miller, 2020).

Using a rubric such as Figure 5, the evidence is likely to show that impacts fall into the top left area of the grid – *destructive or sustainability aware but still harmful*, and *exploitative or aware of exploitation but still inequitable* – depending on the context and location of the evaluation.

Figure 5. Ensuring that evaluation stays relevant by speaking to our two biggest crises

Natural System Effects

Human System Effects	Destructive /plundering natural system	Sustainability aware but still harmful	No net harm to the natural system	Restorative (repair harm so system thrives)
Exploitative of some countries and groups				
Aware of exploitation but still inequitable				
Equitable system – no disadvantage between and within countries				
Reparations rebalance multi-generational disadvantages				**Ultimate aim: Both systems thriving for all**

6. Implications and Lessons for Mainstreaming Sustainability in evaluation

This case study has demonstrated that sustainability and natural systems can be incorporated into prevailing criteria and approaches for evaluation - in particular evaluation questions and the OECD DAC criteria? Even though it is technically feasible to incorporate them, would commissioners and evaluators accept this, and what would it look like? How difficult is it to adapt to incorporate natural systems and sustainability without having to retool existing evaluation approaches?Evaluations can readily expand the scope of the evaluand and the theory of change and include environmental considerations in key evaluation questions and evaluation criteria such as the OECD DAC criteria. It is technically feasible to include environmental outcomes in the evaluation of PPE, and evaluations would benefit from drawing on the expertise of relevant environmental scientists

The case study has also shown the value of doing this. Evaluations that consider environmental sustainability and health and equity outcomes can provide valuable information to inform PPE provisioning strategies and planning for future pandemics so that negative outcomes can be mitigated or, ideally, avoided.

An evaluation of PPE provisioning that did not consider environmental sustainability would be inaccurate and lead to misguided decisions about which options to choose (if evaluation is used summatively) or how to improve implementation (if it is used formatively). As demonstrated in the analysis by Rizan et al., the long-term environmental costs of PPE provisioning include negative impacts on climate, air and water quality, and human health. Including environmental sustainability in an evaluation of PPE provisioning clearly adds value and validity by considering the potential long-term impacts on human systems caused by damaging natural systems.

An evaluation that includes natural systems would help to identify and support options for reducing environmental harm at each step in the provisioning chain, as outlined in Appendix 1. It is possible to reduce short-term harm by minimising the amount of PPE used and recycling used PPE. In the longer term, alternatives to using polypropylene in the manufacture of PPE are being developed. As pointed out by Long et al. (2021): “It is questionable if highly durable and high carbon footprint polypropylene should ever be used for single use PPE that would persist in the environment for up to 450 years.”

The case study has also identified implications for the planning and conduct of evaluations that include environmental sustainability.

Additional technical expertise is needed - either as part of the evaluation team or as advisors. Evaluations are more likely to be useful when used early in implementation, to guide choices, rather than as a retrospective look back at what was done.

Questions remain about whether or not evaluation commissioners and evaluators will accept this expansion of scope of evaluations to include natural systems, and what willl be needed to support this change.

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Appendix 1 – The nexus nature of steps in PPE provisioning

This section goes into more detail about each of the elements of PPE provisioning described in section 2.1.

7.1 Preparedness

Pandemics entail considerable uncertainty. Rapid onsets have the likely effect that prevailing procurement priorities will be set aside to obtain sufficient supply in what will likely be, and was, a highly competitive international scramble for PPE exacerbated by a lack of adequate stockpiles. The following extract describes the depletion of the UK PPE stockpile:

"In the wake of the Winter Willow exercise, and with the emergence of the swine flu pandemic two years later, the Department of Health, as it was then known, embarked on a procurement programme aimed at boosting stockpiles of medicines and PPE, according to departmental accounts and performance reports. By the end of the 2010-11 financial year, the value of the department's stockpile stood at £830m, an 80% increase from 2008-09…In 2016, after years of delays, the government staged another nationwide pandemic drill, codenamed Exercise Cygnus. The exercise, which simulated a deadly outbreak of so-called "swan flu", is believed to have shown that in the event of a deadly pandemic the NHS would be overwhelmed by a shortage of critical care beds and vital equipment… NHS plans drawn up in 2017 state that "the bulk of" the pandemic stockpiles available to the health service consisted of PPE, including FFP3 respirator masks, gloves and aprons. The stockpiled goods have shelf lives and so require frequent replenishment. According to the DHSC's financial accounts, between 2011 and 2019 depletions of the emergency stockpile significantly outstripped the amount spent on adding new supplies to the reserves" (Davies, Pegg, & Lawrence, 2020).

Provisioning practices for PPE may also increase inequity. Given that global and even national purchasing was highly competitive during the early phases the default will be that satisfaction of orders will be prioritised as a) country of manufacture demand, b) demand from nations in the Global North, such as England, Canada or the US, c) likely demand from other buyers such as institutions in the Global North, with greater price flexibility, and finally buyers from nations in the Global South. This was the scenario that played out in the Covid pandemic.

Procurement guidance and policies need not be focused on human health outcomes at the cost of environmental impacts. But they are, and so they are an important causal mechanism for subsequent stages in the provisioning process.

7.1.1 Options for reducing environmental harm

Preparation with stockpiles of essential supplies and strategies for ramping up local production can avoid this, address sustainability, and allow the time to seek suppliers whose labour and environmental records meet relevant standards. Preparation provides the opportunity to seek innovations in product design that can, for example, significantly reduce landfill burden and biodiversity threats through creative reuse, such as in paving stones, and to develop and build capacities and procedures to apply sustainability and safety-aware guidance on use.

7.2 Procurement priorities and decisions

Absent a provisioning strategy to the contrary, procurement has strong potential to generate adverse environmental effects, making the achievement of the 2030 Paris, biodiversity and SDG goals even less likely. Current procurement[12] strategies and guidance are hardwired against more sustainable options (Barker & Yesner, 2022). To illustrate this consider three factors:

- Least or lower-cost purchasing discourages the use of more sustainable product designs, such as those enabling higher levels of recycling or avoiding fossil fuel use. For – for example, permitting the use of plastics produced using raw fossil fuels rather than the slightly more costly recycled plastic inputs (discussed below).
- Partitioned procurement and costing mean that adverse natural systems effects resulting from the procurement decision accrue downstream from purchasing, such as PPE clogging waterways and piling up in landfills. These effects lie outside the remit of most purchasing responsibilities and continue to incentivise disregard for natural systems and sustainability.
- Temporal frames are also important. Sustainability is where the well-being of future generations (in human and natural systems) is not impaired by what we do today. Increasing GHG emissions, impaired air and water, reduced biodiversity, and harmful landfills are examples of direct effects of PPE provisioning strategies that will impair the well-being of future generations.

Procurement levels are tightly connected to the consumption of protective products (see below). Waste or use that exceeds requirements accelerates the draw on inventories. Rizan et al. (2021) point to the lack of consistent use guidelines for different PPE, which caused demand for PPE to be greater than needed, increasing adverse environmental effects and inequitable access to PPE resulting from supply shortages in part attributable to excessive use of PPE. And the environmental burden of PPE provisioning is directly contingent on the harm in each type of PPE and their design and manufacture.

PPE provisioning is a nexus matter with important human and natural systems effects. These effects were significantly heightened by the failure of the government to maintain adequate stockpiles. Product design and manufacture strongly affect environmental harm, and prevailing procurement strategies do not encourage sustainability. An evaluation of a national PPE provisioning effort would need to examine the extent to which procurement affects sustainability.

7.2.1 Options for reducing environmental harm

By September 2020, the UK released a PPE strategy outlining steps to build resilience into the provisioning of PPE (Department of Health & Social Care [UK], 2020). This included scaling up UK manufacturing to meet 70% of PPE demand, except for gloves, where the raw material is not unavailable. This strategy does consider environmental and equity concerns:

"We are therefore also considering how our tendering principles and criteria can ensure high environmental standards and ethical labour practices. The NHS Long Term Plan committed to reviewing

[12] Here we use procurement to refer to the policy and strategy directions of a general approach to obtaining goods and services directed towards achieving a broad public goal, such as preparing for very serious threats to public health. Provisioning is used to refer to specific actions to obtain goods and services, such as providing PPE to the health service.

and reducing the NHS's environmental footprint and we want to ensure that our use of PPE aligns with this wider goal" (Department of Health & Social Care [UK], 2020).

Strategies include the safe repurposing of single-use PPE in emergency circumstances, moving away from single-use PPE, particularly gloves and masks, and investigating alternative environmentally sustainable materials to produce plastic film and eye protection.

7.3 Manufacture decisions and product designs

As shown by the International Resources Panel (2018) and other sources, sustainability requires circular/regenerative economies contributing toward decoupling the link from resource use to well-being, economy and environment. The pandemic clearly showed this tight connection between the economy, well-being and environment to resource use. And as the IRP has noted, plastics are a priority (IRP, 2019, pp. 86-87; IRP, 2021; Adyel, 2020) which is more harmful to environment. In addition, policies aiming to reduce single-use plastic have been delayed or reversed in response to concerns about transmitting COVID-19. Significant increases in single-use plastics, in addition to PPE-related usage, occurred during the pandemic, such as in packaging for take-out meals.

Product design significantly influences the type and volume of harmful environmental effects, for example, facilitating or discouraging recycling and reuse. However, even where stockpiles do not exist and the onset is rapid and global, there were alternatives such as paying a (very modest) premium to ensure the use of recycled plastic in manufacture.

Understandably the priority was to secure supply in a highly competitive market with an initial scarcity of supply. However, a pandemic strategy and preparation should have considered sustainability, especially in product design, so product manufacture, distribution and disposal would minimise adverse environmental effects. In the absence of stockpiles, the question becomes one of the rapidity with which alternative suppliers could respond to demand, potentially reducing the environmentally harmful need to ship PPE great distances with attendant GHG and other emissions and for countries to capture the economic benefits of increased manufacture. The latter is important for all nations but especially for nations in the Global South.

Product cost and design do not generally value natural systems considerations such as scarcity, value or environmental harm. As a result, they do not enter product design and manufacturing decisions, and as a result, these decisions are inclined towards actions that are systematically harmful to natural systems. Manufacture has a direct connection to natural systems with harmful effects, as demonstrated by efforts of national environment agencies to regulate harm from manufacture, extraction and disposal. The IRP has done a commendable job in pointing to product design's importance to achieving a circular economy.

The urgent need for significantly more PPE and the associated corporate and national economic benefits for countries manufacturing PPE had the potential to increase negative environmental and equity outcomes in countries where PPE was manufactured with lower enforcement of environmental standards and working conditions.

7.3.1 Options for reducing environmental harm

Examples of more sustainable product design include:

- Compostable face shields (Mace, 2020) made from FSC paper board and PEFC cellulose from wood pulp are certified to circular economy standards. The visors are recyclable, home compostable, and can be collected from dedicated disposal bins to be recycled or composted in medical settings. Production capacity is more than a million visors per week.
- A sustainable medical suit that can be washed 50 times was developed by MEDU Protection, a social enterprise start-up in Mexico. The suits are embedded with QR technology which informs health workers, via a smartphone app, how often an item has been washed. After 50 washes, the garment is returned to MEDU, which disinfects it and converts it into cotton scrubs and bags for packaging its products ("Green PPE is gaining traction globally," 2021).
- Customised, reusable PPE developed by All India Institute of Medical Sciences is manufactured from water-impervious warp and weft fabrics made of polyester with the whole inner coverall equipped with N95 facemask, face shield, hand gloves, goggles, shoe covers and outer gown (Sureka, Sinha, Tak, Garg, Bhatia, & Bhardwaj, 2020).

In the longer term, alternatives to using polypropylene in the manufacture of PPE are needed. Long et al. (2021) reported on recent research into natural polymers such as cellulose, chitosan, polyisoprene and keratin as alternatives to polypropylene, including cellulose nanofibers that can meet standards for respiratory face masks.

7.4 4 Distribution

Distribution challenges are heightened by the extent to which demand exceeds supply, how demand and supply imbalances are managed, and the logistical options available and selected from manufacturer to end users, including the responsiveness of logistical networks to sudden increases in flows. Importantly distribution becomes a charged political matter in a rapid onset pandemic. The location of manufacture and distance to points of use is another way the environment is connected to PPE provisioning.

Globalisation and just-in-time supply chains are important underlying conditions affecting PPE distribution. Global infrastructure for production at scale of commodities such as PPE had become concentrated in Asia, most notably China. The supply chain was narrow, subject to price competition and political priorities and vast quantities of PPE needed to be shipped to countries of use, often resulting in the use of air freight given the urgency and lack of stockpiles (Burki, 2020). Likely the most important environmental effect from distribution is GHG emissions from transport. There are clear environmental costs from shipping, particularly by air.

The harmful effects on natural systems from distribution are importantly connected to distance and mode of transport. Thus, national provisioning is, by definition, less harmful than sourcing from distant places. Environmental effects also occur due to the mode of transport, and the early pandemic period included significant use of air freight due to the urgent need. Absent preparation, distribution is likely to result in significant GHG emissions.

Distribution decisions will directly and importantly affect the equity of access to PPE. In The UK, the Department of Health and Social Care (DHSC) created a parallel PPE supply chain to meet the unexpected challenges caused by the COVID-19 pandemic and to ensure PPE was delivered to the frontline. The procurement of PPE was centralised, and NHS trusts, adult social care providers, primary care and some other healthcare providers were provided with free access to PPE from central stocks

(Department of Health & Social Care [UK], 2022). However, in other countries where a competitive process occurs, hospitals serving poorer areas are likely to have more trouble securing supplies and spend more on PPE relative to their total budgets because their budgets are less relative to hospitals serving better-off populations (Cohen & Rodgers, 2020). And, of course, global inequity is heightened with international competition for materials.

7.4.1 Options for reducing environmental harm

Scenario modelling by Rizan et al. (2021) concluded that domestic manufacturing of PPE products in health care would have reduced the carbon footprint by 12%. The modelling eliminated international transport (shipping) but used the same road travel assumptions, with UK electricity grid inventory process data for manufacture.

7.5 Consumption

Clinical guidelines influence the amount of PPE consumed in medical settings; practice systems within medical settings that determine the duration of use and frequency of changing PPE; the extent of reuse after disinfection, and financial policies that encourage or act as a disincentive to reuse. Early in a pandemic, there is considerable uncertainty and ambiguity about transmission and other factors that affect use.

The disinfection and reuse of PPE, particularly gowns and face shields, also minimise PPE consumption. Gowns can be washed up to 75 times and face shields reused five times. However, single-use PPE was provided free to NHS trusts. Reusable PPE (particularly gowns) incurred decontamination costs, an inadvertent disincentive for trusts to move to reusable PPE (Nash, 2021).

This is an example of the dynamic character of coupled systems – excess consumption increases procurement requirements and associated adverse environmental effects from manufacture and distribution and reduces the capacity for more equitable sharing of PPE supplies. It also means that a greater volume of PPE must be transported and disposed of.

7.5.1 Options for reducing environmental harm

PPE use can be minimised by only using PPE where it is needed for safety and reducing "hygiene theatre" (wearing PPE in non-clinical settings). Simple practice measures such as having "clean" runners fetch equipment and drugs reduce the amount of PPE used (Fang et al., 2021). For example, the World Health Organization's interim guidance for the rational use of PPE (World Health Organization, 2020) recommended that all healthcare workers, cleaners and visitors in rooms with COVID-19 patients use masks (or respirators for some procedures) gowns and gloves and that healthcare workers also use eye protection. The same advice is applied to outpatient consultation rooms for patients with respiratory symptoms, isolation areas and ambulance healthcare workers.

WHO guidance recommended minimising the need for PPE by using telemedicine to evaluate suspected cases, using physical barriers to reduce exposure in administrative and triage areas, restricting healthcare workers in COVID-19 patient rooms to those providing direct care, and bundling activities to minimise the number of times rooms are entered. Adherence to guidance for PPE use, such as hand washing rather than using gloves where safe to do so and not using aprons, minimises PPE consumption.

Options modelled by Rizan et al. include substituting hand washing for gloves, a strategy that would have reduced the PPE carbon footprint by 45%. The World Health Organization advises the public that it is safer to wash hands frequently and not wear gloves (World Health Organization, n.d.b). Communications efforts towards understanding transmission and management of risk are an important mechanism to better align demand to actual need.

7.6 Disposal

Inadequate attention to environmental sustainability in all the above provisioning steps comes to rest with disposal: manufacture and design of PPE did not incorporate thoughtful life cycle design, consumption of PPE was greater than necessary due to cautious policy and processes, and disposal of PPE lacked a systematic best practice infrastructure, leaving it a largely local matter for institutions and waste managers.

The risks of damage to the environment and human health are likely to be greater in countries that lacked comprehensive waste management systems before the pandemic. Haque et al. (2021) studied the impact of the massive increase in contaminated plastic waste resulting from medical use and mandated PPE use in Bangladesh. The paper draws attention to equity issues; in Dhaka, designated waste handlers and an estimated 6,000 informal workers (including children) were exposed to the virus while collecting, handling, and transporting infectious waste. A 50% reduction in the waste handling workforce led to drains being clogged with discarded PPE resulting in the inundation of urban areas increasing the risk of diseases like malaria and dengue fever.

PPE disposal options in England include recycling, landfill, and low- and high-temperature incineration.

Factors that contribute to the environmental burden of different disposal options include:

- the capacity to effectively sort waste
- transportation of waste to processing facilities (whether landfill, incinerators or recycling)
- the energy consumed by different processes
- environmental damage associated with incineration or landfill
- the capacity of existing waste management systems to keep waste out of waterways and oceans.

7.6.1 Options for reducing environmental harm

Choice of waste stream – high temperature incineration vs low temperature incineration, landfill or recycling

The NHS has different waste streams, with different treatment and disposal processes for waste in healthcare settings. A study of the carbon footprint of waste streams in three UK hospitals (Rizan, Bhutta, Reed, & Lillywhite, 2020) estimated that the carbon footprint of hospital waste was lowest when waste was recycled, generating 21–65 kg CO2e. Low-temperature incineration with energy from waste generated 172–249 kg CO2e/t. If waste was decontaminated using an autoclave before low-temperature incineration with energy from waste, the carbon footprint would increase to 569 kg CO2e. Waste disposal via high-temperature incineration generated the highest carbon footprint, 1074 kg CO2e/ t.

PPE in the NHS disposed of via clinical waste streams uses high-temperature incineration. It was estimated that PPE disposal with decontamination before disposal through recycling, landfill or low-temperature incineration (with energy from waste) would at least halve the carbon footprint of PPE disposal.

Across all environmental impacts assessed, decentralised (local) incineration was preferable to centralised incineration or landfill, and opportunities to reduce waste transportation to such facilities should be explored. In addition, the financial cost of waste disposal was lower for options with lower carbon footprints.

Recycling and remanufacture

Remanufacturing using PPE waste in new products is also a viable disposal option. A thermal compaction machine has been developed that safely melts down used hospital gowns, masks, hairnets, tray wraps, and ward curtains into plastic bricks that can be used to manufacture a range of plastic products (Batha, 2021).

Eco-Eclectic Technologies in India manufactures building bricks made from disinfected and shredded masks and other PPE mixed with paper mill waste and binder. Thomson Reuters Foundation reported that, "the bricks were three times stronger than earth bricks, twice the size, and almost half the cost" (Batha, 2021).

Mixed plastics in PPE can be converted into liquid fuel using pyrolysis (Jain, Yadav Lamba, Kumar & Singh, 2020) as an alternative to incineration, dumping in landfills, or extracting raw oil. However, the net environmental impact would need to consider the energy used for the pyrolysis process and the CO2 and other emissions resulting from fuel use.

8. Appendix 2 Footprint Evaluation

8.1 What is Footprint Evaluation?

Footprint evaluation aims to embed consideration of environmental sustainability in all evaluations (and monitoring systems), not only those with explicit environmental objectives. Footprint evaluation is not a specific methodology or a tightly prescribed approach, but an emerging set of practices and principles developed through ongoing international collaboration and adaptation to suit different contexts. While the label comes from the notion of the 'footprint' humans make on the environment, footprint evaluation covers more than calculating the footprint of program interventions, it involves exploring different types of nexus (or 'connections') between human and natural systems.

8.2 Why do all evaluations need to consider environmental sustainability?

The world is faced with numerous environmental crises with the potential for global catastrophe, including climate change, pollution, loss of biodiversity, ocean warming and acidification, and deforestation. To avoid, mitigate and address these crises, decision-making must be informed by evaluations that explore the actual and likely environmental consequences of all programs, projects, policies, and strategies.

However, as recent stock takes have found (Todd, 2020; Rowe and DeLancy, 2021), most evaluations address interventions primarily intended to benefit humans and systematically fail to consider environmental sustainability. This is so even for evaluations using frameworks such as the OECD DAC evaluation criteria, which include "significant environmental impacts" in the scope of impact evaluation, and in countries with global environmental commitments. It is also true in national settings where environmental regulations, standards, and international commitments rarely find their way into evaluations even where governments have established national cross cutting environmental commitments and policies.

8.3 Environment and equity are inextricably linked

There is much evidence pointing to the many ways equity and environmental sustainability are intertwined (for example, the 2014 IPCC report on Sustainable Development and Equity (Fleurbaey et al., 2014); the 2022 IPCC Summary for Policymakers (IPCC, 2022) . The consequences of environmental harm, such as pollution and climate change or losing access to traditional territories, disproportionately affect people who are marginalised and disadvantaged. And attention to inclusive governance that prioritises equity and justice in adaptation planning and implementation leads to more effective and sustainable adaptation outcomes.

Evaluation as a field is slowly recognising the underlying assumptions underpinning evaluation practice and theory, but there is much work to do to deconstruct and address historical and ongoing systemic biases in how we think about human and natural systems. The two stocktakings mentioned above are early signposts that sustainability is becoming part of this emerging recognition of the underpinnings of practice and theory which by and large regards natural systems as comprised of resources for human

use. Evaluation needs to shake free of this extractive worldview and recognise that natural systems have value in their own right (Rowe & Uitto, forthcoming).

The result of this worldview is that planetary resources have been compromised and depleted and soon will be unable to support many species and systems rendering sustaining human life a question. By not incorporating the contributions of evaluated interventions to this evaluation actually reinforces continued harm to natural systems, Traditional owners and Indigenous communities with spiritual, economic, cultural historical, and other ongoing connections to and deep knowledge of the land are often excluded from decision-making processes about land, waters, air, plants and animals and management of human use of natural systems. Not considering the environmental effects of interventions on Indigenous and traditional communities evaluation ignores environmental injustice and harm to a central element in their worldviews, communities and mental and physical health. It's essential for evaluation to actively reject worldviews that place human systems over natural systems, recognise the interconnectivity of equity and environmental sustainability, and value the importance of a wide range of human and non-human interests.