

Technical annex: Measuring infrastructure performance

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**NATIONAL
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Introduction

Measuring the quality of the UK's current infrastructure systems can reliably inform the assessment of the UK's future infrastructure needs, and in turn enable the delivery of high quality infrastructure. Currently the assessment of how well infrastructure is doing too often focuses on the amount of money being spent. But infrastructure has a long lifetime, and so its performance should consider the quality of service delivered by the whole infrastructure system, including its impact on the built and natural environment. Understanding how the performance of each system changes over time could form an important part of the Commission's decision making in future.

The Commission created a framework to assess the quality of the UK's infrastructure services.¹ The measures in the framework work across most sectors, allowing the Commission to compare different infrastructure systems. They have also been designed to measure the performance of infrastructure against the Commission's objectives. These measures were developed from an earlier set published in the Commission's interim report, *Congestion, Capacity, Carbon: Priorities for national infrastructure*.² They were identified through a review of current sector, national and international measures, consultation with a wide range of external stakeholders and analysis from JBA working with SDG Economic Development, Temple and GreySky.³

The Commission further consulted on these measures in the interim report and received 62 responses. This feedback was considered, and the Commission produced the amended framework and set of performance measures shown in **Table 1**, which were also published in the National Infrastructure Assessment.⁴ The Commission has also gathered data on most of the existing measures, which has been published on its website alongside this technical annex.

This annex provides further detail on the consultation responses received and how these informed the updated framework and measures. It also sets out how the Commission intends to fill gaps by developing performance measures that do not yet exist, including measures linked to design quality and resilience. The measures in the framework are not a definitive list, and the Commission expects to update them over time as new measures are developed or better data becomes available.

Although the Commission intends to use these measures to assess the performance of infrastructure over time, as well as its own performance against its objectives, the Commission's recommendations ultimately reflect the judgment of Commissioners. The measures are one of many inputs that inform decisions made by the Commission.

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Domain	Sub-domain	Transport	Energy	Waste	Water and wastewater	Flood risk	Digital comms
Volume	Volume of consumption	Passenger/tonne km travelled (e)	Energy consumed (e)	Total waste generated (e)	Water consumed (e)	N/A	GB of data consumed (fixed and mobile) (e)
		Number of trips (e)		Residual waste generated (e)			Wastewater produced (n)
Resilience	Resilience to large shocks	Stress test (n)	Stress test (n)	Stress test (n)	Security of supply index (e)	Risk of flooding and coastal erosion (e) Standard of protection (n)	Stress test (n)
			Capacity margin (e)		Probability of drought (n)		
	Everyday resilience	Travel time reliability (n)	Time that properties lose access to energy (e)	N/A	Time that properties lose access to water (e) Number of sewer flood events (e)	Number of properties flooded (n)	Number of serious incidents reported to Ofcom (e)
Quality	Service quality	Connectivity (n)	N/A	GVA from waste material recovery (e) Recycling rates (e)	Number of water quality incidents (e)	N/A	Coverage by technology (e)
							Actual speed at peak time (n)
	Quality of user experience	Satisfaction derived from survey (e)	Satisfaction derived from survey (c)	Design quality (n)	Satisfaction derived from survey (e)	Design quality (n)	Satisfaction derived from survey (e)
		Design quality (n)	Design quality (n)		Design quality (n)		Design quality (n)
						Percentage of all 90-second calls completed without interruption (e)	
						Percentage of mobile data connections which deliver a speed of at least 2 Mbps (e)	
Cost	Cost		Cost per kWh of energy (c)	Cost per tonne of waste collected	Cost of water per litre (c)	Cost per property protected (c)	Cost per GB of data (fixed and mobile) (e)

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		Cost per passenger/tonne km (c)	Average annual energy bill (e)	and disposed/treated (c)	Cost of wastewater treated per population equivalent (c) Average annual water and sewerage bill (e)	Cost incurred on flood risk insurance claims (e)	Average monthly bill (fixed and mobile) (e)
Environment	Emissions	CO2e emissions per passenger/tonne km (e)(c)	CO2e emissions per kWh used (c)	CO2e emissions per tonne of waste produced (c)	CO2e emissions per litre of water consumed (e)	N/A	CO2e emissions per GB of traffic used (n)
		Total CO2e emissions from transport (e)	Total CO2e emissions from energy (e)	Total CO2e emissions from waste (e)	Total CO2e emission from water and wastewater (e)		Total CO2e emissions from digital comms (n)
	Environmental externalities	Air quality (e)	Air quality (e)	Waste generated per capita (e)	Number of serious pollution incidents caused by water companies (e)	Measure of habitat improved or created (e)	N/A
		Noise (e)		Ground pollution from waste (n)	Percentage of water bodies with unsustainable levels of abstraction (e) Average concentration of reactive phosphorus in rivers (e)		
Natural capital		To be developed	Value of energy services provided by natural environment (e)	To be developed	Value of water services provided by natural environment (e)	To be developed	To be developed
			Cost that energy services impose on the natural environment (e)				
Efficiency	System efficiency	Congestion (e)	Energy efficiency of buildings (e) Transmission/distribution losses (e) Ratio of average to peak demand (c)	Reject rates from sorting facilities (e) Capture rate of recyclable materials (e)	Leakage (e)	N/A	N/A

Table 1 – Performance measures

Updates to the performance measures framework

The framework and measures created and published for the interim report is shown at **Table 2**. The Commission asked stakeholders how this set of metrics could be improved, and for methodological suggestions where measures do not currently exist. The Commission was grateful for the wide range of responses received⁵ and made a number of changes to the framework as a result. This section sets out the new domains which were added to the framework and why.

Efficiency domain

Several stakeholders questioned the chosen service quality measures, particularly in the energy sector. They questioned, for example, how the energy efficiency of buildings was a measure of service quality and whether the Commission planned to set out a minimum required level of efficiency. The Commission concluded that certain metrics were not well suited to the quality or cost domain but were nevertheless important indicators of infrastructure performance. A new efficiency domain was created and measures in the energy and water sectors considered to be better suited to this domain than to service quality were moved into it. Additional efficiency metrics for the other sectors were also included, where relevant measures could be found. The Commission further engaged informally with stakeholders to obtain views on some of the new additional measures.

Volume domain

A volume domain was also created, and new measures attributed to it within each sector. These measures provide the volume of infrastructure services provided and are a good first step to understand how some of the other measures indicate performance. For example – total water consumption and cost per litre consumed can give an understanding of total costs, and are often used to give a sense of scale to changes and policy interventions.

Natural capital sub domain

The Commission expressed its intention in the interim report to include one or more measures of the interaction between infrastructure and natural capital in the performance framework. There was significant support from consultation respondents for this work.

The Commission would like to thank the Natural Capital Committee, officials from the Office for National Statistics, the Department for Environment, Food and Rural Affairs, the Environment Agency and Natural England for initial input on its environmental measures. Following this engagement, and further research, natural capital measures in the energy

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Domain	Sub domain	Transport	Energy	Waste	Water	Flood Risk	Digital Comms
Resilience	Resilience to large shocks	Stress test	Capacity margin	Capacity margin	Risk of drought	Risk of flooding and coastal erosion	Stress test
			Expected loss of load			Standard of protection	
Resilience	Everyday resilience	Travel time reliability	Diversity of energy sources	N/A	Time that properties lose access to water Number of sewer flood events	Number of properties flooded	Time that properties lose access to digital signal
			Time that properties lose access to energy				
Quality	Service quality	Connectivity	Energy efficiency of buildings	Recycling rates	Number of water quality incidents	N/A	Maximum possible speed
			Peak-load shifting				Energy from waste
			Smart meters in operation	Satisfaction derived from survey	Satisfaction derived from survey		
	Quality of user experience	Design quality	Design quality			Design quality	Design quality
Cost	Cost	Cost per passenger/tonne km	Cost per kWh of energy	Cost per tonne of waste collected and disposed/treated	Cost per litre of water abstracted	Cost per property protected	Cost per GB of data
			Average annual energy bill				Average annual water and sewerage bill
Environment	Emissions	CO2e emissions per passenger/tonne km	CO2e emissions per average kWh used per person	CO2e emissions per average kg of waste produced per person	CO2e emissions per average L of water consumed per person	N/A	CO2e emissions per average GB of traffic used per person
		Air quality					
Environment	Environmental externalities	Noise					

Table 2 – Performance measures published in *Congestion, Capacity, Carbon: Priorities for national infrastructure*

and water sectors already published by the Office for National Statistics have been added to the list. More work is still needed in this area to develop a full set of natural capital measures. Further details on the environmental measures within the framework are provided at the end of this annex.

Updates to the measures

This section sets out changes made to specific measures and new measures added in each sector, as well as the reasoning behind these changes. It also explains why the Commission chose not to include certain measures suggested by stakeholders.

For all metrics shown in **Tables 3 to 8**: (e) denotes an existing metric, (c) denotes a metric which can be calculated with existing published data and (n) denotes a new metric which would need to be developed.

Transport

Table 3 shows the updated performance measures for the transport sector. There has only been one change in this sector, in addition to the new domains and their associated metrics.

Environment – emissions

- **Total emissions** – a stakeholder pointed out that total emissions should also be measured, as they are also a factor in infrastructure performance. Total emissions have been added to all sectors.

Measures that have changed since the interim report are in orange.

Domain	Sub-domain	Performance measure
Volume	Volume of consumption	Passenger/tonne km travelled (e)
Resilience	Resilience to large shocks	Stress test (n)
	Everyday resilience	Travel time reliability (n)
Quality	Service quality	Connectivity (n)
	Quality of user experience	Satisfaction derived from survey (e)
		Design quality (n)
Cost	Cost	Cost per passenger/tonne km (c)
Environment	Emissions	CO ₂ e emissions per passenger/tonne km (e)(c)
		Total CO ₂ e emissions from transport (e)
	Environmental externalities	Air quality (e) Noise (e)
	Natural capital	To be developed
Efficiency	System efficiency	Congestion (e)

Table 3 – Updated performance measures for transport

Other stakeholder suggestions

A few stakeholders suggested that measures of safety should be included for the transport sector. While the Commission recognises the importance of this measure, this framework aims to be cross sectoral as far as possible and safety would look very different across sectors. Safety is also predominant in transport, and safety measures in the sector are already collected and widely reported.

Energy

Table 4 shows the updated set of measures for energy. There have been a few changes in addition to the new domains and their associated metrics:

Resilience – resilience to large shocks

- **Diversity of energy sources** – the Commission considered that although this measure currently gives a reasonable indication of resilience, the energy landscape is likely to change significantly over the next few years. In a world with more renewables, spatial diversity may be as important as technological diversity. This measure was therefore removed as it was not considered future proof.

Quality – service quality

- **Energy efficiency of buildings** – a stakeholder pointed out that there was no direct link between service quality and the energy efficiency of buildings. This partly prompted the creation of the efficiency domain and the move of the efficiency of buildings metric to it.
- **Peak load shifting** – a stakeholder also questioned the link between this measure and service quality. The Commission agreed with this point and removed the measure entirely, as it does not naturally fit in any other domain.

Domain	Sub domain	Performance measures
Volume	Volume of consumption	Energy consumed (e)
Resilience	Resilience to large shocks	Stress test (n) Capacity margin (e) Expected loss of load (e)
	Everyday resilience	Time that properties lose access to energy (e)
Quality	Service quality	N/A
	Quality of user experience	Satisfaction derived from survey (c) Design quality (n)
Cost	Cost	Cost per kWh of energy (c) Average annual energy bill (e)
Environment	Emissions	CO2e emissions per kWh used (c) Total CO2e emissions from energy (e)
	Environmental externalities	Air quality (e)
	Natural capital	Value of energy services provided by the natural environment - energy generated (e) Cost that energy services impose on the natural environment - depletion of natural resources used to generate energy (e)
Efficiency	System efficiency	Energy efficiency of buildings (e) Transmission/distribution losses (e)

Table 4 – Updated performance measures for energy

Other stakeholder suggestions

Some stakeholders suggested including a measure of energy saving or demand reduction. This is within scope of the efficiency domain, but is difficult to measure consistently.

Solid waste

Table 5 shows the updated performance measures for solid waste. The new domains have been added and metrics attributed to each. The following additional changes have been made to the previous set of metrics:

Resilience – resilience to large shocks

- **Capacity margin** – after finding that this measure does not exist for the entirety of the waste sector, the Commission concluded that it is not an appropriate measure of resilience for waste, in the same way it is for energy. This is because waste supply-demand do not need to be balanced instantaneously like energy. The measure was removed entirely.

Quality – service quality

- **Energy from waste** – a stakeholder pointed out that energy from waste may not be the most economically or carbon efficient waste treatment, so the value of all recovery was considered more appropriate. This metric was replaced with a measure of all gross value added (GVA) from waste material recovery (including recycling and material recovery, as well as energy recovery).

Domain	Sub domain	Performance measures
Volume	Volume of consumption	Total waste generated (e)
		Residual waste generated (e)
Resilience	Resilience to large shocks	Stress test (n)
	Everyday resilience	N/A
Quality	Service quality	GVA from waste material recovery (e)
		Recycling rates (e)
	Quality of user experience	Design quality (n)
Cost	Cost	Cost per tonne of waste collected and disposed/treated (c)
Environment	Emissions	CO ₂ e emissions per kg of waste produced (c)
		Total CO ₂ e emissions from waste (e)
	Environmental externalities	Waste generated per capita (e)
		Ground pollution from waste (n)
	Natural capital	To be developed
Efficiency	System efficiency	Total recyclate rejected (e)
		Capture rates of recyclable materials (e)

Table 5 – Updated performance measures for solid waste

Water and wastewater

Table 6 shows the updated measures for water and wastewater. Many changes, in addition to the new domains and their measures, have been made:

Resilience – resilience to large shocks

- **Risk of drought** – a stakeholder suggested that the security of supply index published by the Environment Agency would be a better measure of risk of drought. This measure compares forecast supply available with actual consumer demand. The Commission felt it was important to also include the probability of drought as a measure of risk so both indicators are in the framework.

Cost

- **Cost of wastewater treated per population equivalent** – a stakeholder suggested that to have a complete picture a cost metric for wastewater should be included.

Environment – environmental externalities

- **Quality of rivers and sea** – this measure was replaced by two new measures, based on stakeholder input:
 - **Number of serious pollution incidents** – a stakeholder suggested that the measures in the Environment Agency’s Environmental Performance Assessment (EPA) should be looked at for environmental externalities. The EPA contains a measure of the number of serious pollution incidents caused by water companies. As the quality of rivers and the sea cannot be directly attributed to water companies, the Commission decided that this was a more appropriate measure. The Commission also recognises that non-serious pollution incidents can have cumulative effects on water quality.
 - **Average concentration of reactive phosphorus in rivers** – a stakeholder suggested that a sewage treatment works compliance metric should be included. The Commission agrees that it is important to consider the externalities of sewage, which are also reflected by the EPA indicator. The concentration of pollutants in rivers mainly attributed to sewage is a useful addition to the number of serious pollution incidents measure as it allows for the assessment of the severity of pollution.

Domain	Sub domain	Performance measure
Volume	Volume of consumption	Water consumed (e)
		Wastewater produced (n)
Resilience	Resilience to large shocks	Security of supply index (e) Probability of drought (n)
	Everyday resilience	Time that properties lose access to water (e)
		Number of sewer flood events (e)
Quality	Service quality	Number of water quality incidents (e)
	Quality of user experience	Satisfaction derived from survey (e)
		Design quality (n)
Cost	Cost	Cost of water per litre (c)
		Cost of wastewater treated per population equivalent (c)
		Average annual water and sewerage bill (e)
Environment	Emissions	CO ₂ e emissions per litre of water consumed (e) Total CO ₂ e emissions from water (e)
	Environmental externalities	Number of serious pollution incidents caused by water companies (e) Average concentration of reactive phosphorus and in rivers (e) Percentage of water bodies with unsustainable levels of abstraction (e)
	Natural capital	Value of water services provided by the natural environment - value of water abstracted (e)
Efficiency	System efficiency	Leakage (e)

Table 6 – Updated performance measures for water and wastewater

Flood risk

Table 7 shows updated measures for flood risk. One measure has been added:

Cost

- **Cost incurred on flood risk insurance claims** – a stakeholder pointed out that the cost of flood risk insurance was also relevant for performance in the sector. A measure of the total costs of claims paid by insurers (excluding any excess payments paid by customers) is available and was included to reflect this.

Domain	Sub domain	Performance measure
Volume	Volume of consumption	N/A
Resilience	Resilience to large shocks	Risk of flooding and coastal erosion (e) Standard of protection (n)
	Everyday resilience	Number of properties flooded (n)
Quality	Service quality	N/A
	Quality of user experience	Design quality (n)
Cost	Cost	Cost per property protected (c) Cost incurred on flood risk insurance claims (e)
Environment	Emissions	N/A
	Environmental externalities	Measure of habitat improved or created (e)
	Natural capital	<i>To be developed</i>
Efficiency	System efficiency	N/A

Table 7 – Updated performance measures for flood risk

Other stakeholder suggestions

Stakeholders suggested the Commission consider a measure of the protection of assets such as transport and energy infrastructure, as well as properties. The Commission intends to explore this as part of the stress tests within its resilience study.⁶

Digital communications

Table 8 shows the updated measures for digital comms. There have been two changes in the sector, in addition to the new domains and their measures:

Resilience – everyday resilience

- **Time that properties lose access to digital signal** – a stakeholder pointed out that this measure only provides a snapshot, and suggested using the number of serious incidents reported to Ofcom instead. Serious incidents are those where access to emergency services (999) are cut off. It was agreed that this is a more appropriate measure of resilience.

Quality – quality of user experience

- **Sold speed experienced** – Ofcom are developing a metric which reflects maximum speed at peak time. As this provides similar information to sold speed experienced, and will be reported on soon, the Commission felt that it would make sense to align with Ofcom on this measure.
- **Percentage of all 90-second calls completed without interruption and percentage of mobile data connections which deliver a speed of at least 2 Mbps** – the Commission recommended in the Connected Future⁷ report that mobile coverage should be measured in a meaningful way. As a response, Ofcom changed the way it measures mobile coverage to include these indicators, and the Commission has now incorporated them into its framework.

Domain	Sub domain	Performance measure
Volume	Volume of consumption	GB of data consumed (fixed and mobile) (e)
		Voice minutes (fixed and mobile) (e)
		4G subscriptions (e)
		Full fibre subscriptions (e)
Resilience	Resilience to large shocks	Stress test (n)
	Everyday resilience	Number of serious incidents reported to Ofcom (e)
Quality	Service quality	Coverage by technology (e)
		Actual speed at peak time (n)
	Quality of user experience	Satisfaction derived from survey (e)
		Design quality (n)
Cost	Cost	Percentage of all 90-second calls completed without interruption (e)
		Percentage of mobile data connections which deliver a speed of at least 2 Mbps (e)
		Cost per GB of data (fixed and mobile) (e)
Environment	Emissions	Average monthly bill (fixed and mobile) (e)
		CO ₂ e emissions per GB of traffic used (n)
	Environmental externalities	Total CO ₂ e emissions from digital comms (n)
		N/A
Efficiency	System efficiency	N/A
		N/A

Table 8 – Updated performance measures for digital communications

Cross cutting

Local/regional considerations

The need to consider regional and local aspects was highlighted by many stakeholders. The Commission recognises the importance of this, and intends to publish aggregate data on

these measures in the first instance, but will consider incorporating geographically disaggregated data later.

Economic impacts

Many respondents felt that the framework should include economic impacts of infrastructure. The Commission agrees with the importance of this, but also recognises that measuring the impact of infrastructure on GDP is not straightforward. This theoretical framework has been created to provide an understanding of the things impacted by infrastructure which can be measured directly.

Whole life costs

Stakeholders highlighted the need to look at whole life costs. This framework sets out to measure the performance of infrastructure services, rather than assets or financial data. The Commission intends to look at these wider dimensions of data as part of its follow up work to the *Data for the public good*⁸ report. The Commission also continues to do work on public private partnerships, which will consider whole life costs.

Further work

The Commission will continue to work on specific elements of the performance measures, set out below.

Resilience

There was stakeholder support for the resilience measures proposed in the interim report, and for the Commission's commitment to do further work on resilience. The Commission intends to pick up the stress test measures as part of the resilience study and follow up with stakeholders who expressed an interest in getting involved with this work.

Design quality

As referenced in the Commission's interim report, design quality measures will be considered in concert with the national infrastructure design group, to be established by the Commission.

As well as developing a measure of design quality, the Commission is interested in incorporating design into appraisal, and welcomes input from stakeholders on both topics.

Transport connectivity

The Commission asked Prospective Labs to construct measures of transport connectivity within and between cities in Great Britain. The Commission has used this data (a ratio of peak to off-peak connectivity for towns and cities) to assess capacity constraints. Findings have already been used to inform recommendations in the Assessment, and Prospective’s methodological report was published alongside it.⁹ The Commission also plans to publish the connectivity data and a separate technical annex for transport connectivity later in the Autumn, including a short guide for utilising the measures and initial insights.

Natural capital

Infrastructure has both a direct impact on the environment through its footprint, and indirectly through people’s use of it – for example, the use of roads by vehicles leading to air pollution. The natural environment can also provide infrastructure services – for example, water is abstracted from the natural environment and is combined with other assets and components (eg pipes, pumping stations) to provide infrastructure services. The stock of natural assets that directly or indirectly produce value to people are called natural capital. Assets include forests, rivers, land, minerals and oceans. The benefits derived from these assets are known simply as natural capital benefits or ‘ecosystem services’.¹⁰

The Commission considered the interactions between the natural environment and infrastructure in a discussion paper published in 2017 – *The impact of the environment and climate change on future infrastructure supply and demand*.¹¹ **Figure 1Error! Reference source not found.** illustrates the Natural Capital Committee’s conceptual framework¹², of how the combination of natural capital with other inputs can deliver benefits to society.

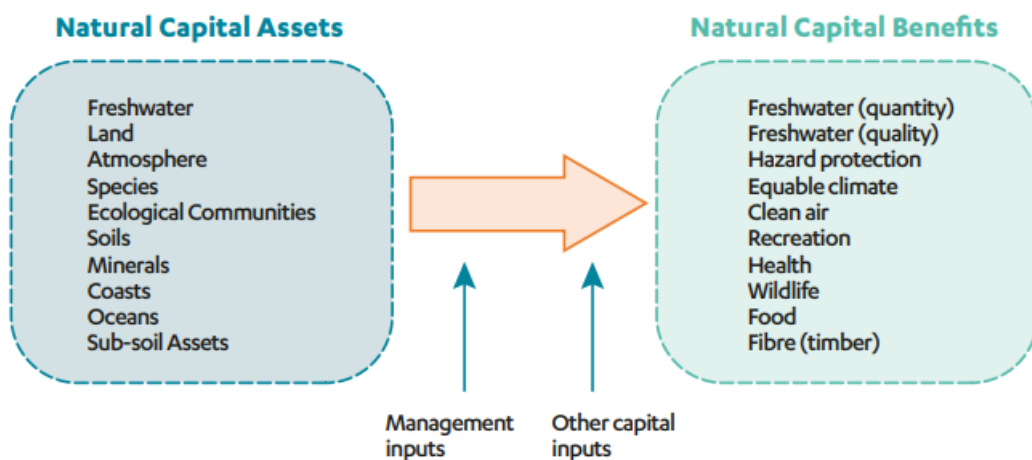


Figure 1 – Flow from natural capital assets to natural capital benefits

Although infrastructure has a relationship at the local scale with all natural capital assets in **Figure 1**, this isn't always significant at the national scale. The Commission identified the most important areas where infrastructure can affect the natural environment at the national scale as:

- Emissions of greenhouse gases that drive climate change (with impacts at the global as well as national scale)
- Freshwater quantity and quality
- Protection from hazards such as flooding
- Clean air
- Noise

These interactions have been incorporated into the Commission's performance measures framework shown in **Table 1 – Performance measures** within the 'environmental externalities' domain. Most of these externalities reflect the negative impacts that infrastructure can have on the natural environment (or on natural capital assets/benefits) but some reflect positive externalities, which can in themselves be natural capital benefits.

Several consultation respondents highlighted the importance of thinking about infrastructure land and seabed use and the impacts of infrastructure on biodiversity. The Commission will consider whether these elements can be incorporated into the natural capital measures in future.

The Office for National Statistics and the Department for Environment, Food and Rural Affairs are currently developing natural capital accounts for the UK, aiming to incorporate natural capital into the UK Environmental Accounts by 2020.¹³ The Office for National Statistics has already done work to estimate the value of UK natural capital. The Commission has included these measures, where they relate to infrastructure, in the natural capital domain of the framework in **Table 1 – Performance measures**. These are:

- Water
 - Annual monetary asset value of water (asset)
 - Annual monetary value of water abstracted (service)
- Energy
 - Annual monetary asset value of oil and gas (asset)
 - Annual monetary service value of oil and gas (service)
 - Annual monetary service value of renewable energy sources (service)

The Commission will continue tracking the development of the Office for National Statistics' and other natural capital measures, and will consider adding new measures to the framework where they relate to infrastructure. The Commission has a particular interest in

measures of infrastructure's land and seabed use, the aggregate impact of infrastructure on biodiversity¹⁴, as well as measures which reflect the interactions between natural capital costs and benefits.

Other new measures

The Commission will continue to develop the measures within the framework which are either entirely new (labelled 'n') or can be calculated using existing data (labelled 'c') and welcomes suggestions on ways of doing this. The Commission does not, however, intend to develop primary data as part of this exercise.

How to provide input

The Commission would welcome comments on this paper. In particular:

- References to additional data sources
- Suggestions for further refining the measures in the framework
- Suggestions for calculating measures in the framework which do not yet exist

Please send any comments to NICdiscussionpapers@nic.gov.uk by March 2019.

End notes

¹ The Commission's performance measure framework focusses on infrastructure systems and the services they deliver, rather than infrastructure projects or specific assets. The Infrastructure and Projects Authority (IPA) is undertaking work on measuring performance at the asset level. For further information on the IPA's work on performance see their *Transforming infrastructure performance* policy paper. Available here:

<https://www.gov.uk/government/publications/transforming-infrastructure-performance>

² Report available here: <https://www.nic.org.uk/publications/congestion-capacity-carbon-priorities-for-national-infrastructure/>

³ Report available here: <https://www.nic.org.uk/wp-content/uploads/Performance-measures-report.pdf>

⁴ Report available here: <https://www.nic.org.uk/assessment/national-infrastructure-assessment/>

⁵ A comprehensive analysis of all consultation responses was undertaken by Arup on behalf of the Commission and can be found here: <https://www.nic.org.uk/supporting-documents/interim-nia-report-on-consultation-responses/>

⁶ The Chancellor of the Exchequer formally announced that the Commission would be undertaking a study on resilience in his October 2018 Budget Statement. Further details available here: <https://www.nic.org.uk/our-work/resilience/>

⁷ Report available here: <https://www.nic.org.uk/publications/connected-future/>

⁸ Report available here: <https://www.nic.org.uk/publications/data-public-good/>

⁹ Report available here: <https://www.nic.org.uk/supporting-documents/prospective-july-2018-transport-connectivity-report/>

¹⁰ Natural England make a distinction between natural capital benefits and ecosystem services. They consider natural capital benefits to be derived from ecosystem services. The Commission follows the Department for

Environment, Food and Rural Affairs approach and treats these terms interchangeably. For more information on Natural England's natural capital indicators see their report *Natural Capital Indicators: for defining and measuring change in natural capital*. Report available here:

<http://publications.naturalengland.org.uk/publication/6742480364240896>

¹¹ For a more detailed discussion on the interactions between the natural environment and infrastructure see the Commission's paper *the impact of the environment and climate change on future infrastructure supply and demand*. Available here: <https://www.nic.org.uk/supporting-documents/the-impact-of-the-environment-and-climate-change-on-future-infrastructure-supply-and-demand-june-2017/>

¹² For further information on the Natural Capital Committee's framework see the report *The State of Natural Capital: Restoring our Natural Assets*. Available here: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/516698/ncc-state-natural-capital-second-report.pdf

¹³ For more information see UK Natural Capital: interim review and revised 2020 roadmap. Available here: <https://www.ons.gov.uk/economy/nationalaccounts/uksectoraccounts/methodologies/uknaturalcapitalinterimreviewandrevised2020roadmap>

¹⁴ Biodiversity is understood to be the variety of life on earth, including the diversity of genes, organisms, populations and species through to ecosystems, as per Natural England's strategic standard. More information available here: <http://publications.naturalengland.org.uk/publication/6802181?category=3769710>