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Natural Capital Platforms and Tools for Green Growth Planning

GGKP Expert Group on Natural Capital
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The Green Growth Knowledge Partnership (GGKP) is a global community of organizations and experts committed to collaboratively generating, managing and sharing green growth knowledge. Led by the Global Green Growth Institute (GGGI), Organisation for Economic Co-operation and Development (OECD), United Nations Environment Programme (UNEP), United Nations Industrial Development Organization (UNIDO) and the World Bank Group, the GGKP draws together over 60 partner organizations. For more information, visit www.greengrowthknowledge.org.

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The Green Growth Knowledge Partnership (GGKP) convenes inter-institutional expert groups to identify and address critical knowledge gaps in green growth theory and practice. The neutral, collaborative expert groups focus on knowledge generation, synthesis and on-the-ground application by partners and in-country stakeholders.

This report was prepared under the guidance of the GGKP Natural Capital Expert Group (hereinafter "Expert Group"). The Expert Group aims to push the knowledge frontier, mainstream natural capital in global green growth activities and support stronger implementation of natural capital commitments in national economic plans. In its deliberations, the group identified a key knowledge gap in the provision of natural capital data to inform national green growth plans.

To clarify this gap and identify pathways to address it, the Expert Group, with support from the GGKP Secretariat, commissioned the United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC) to prepare this report. UNEP-WCMC is the specialist biodiversity centre of the United Nations Environment Programme (UNEP), the world's foremost intergovernmental environmental organization. The centre has been in operation for 40 years, combining scientific research with practical policy advice.

This publication was produced with Expert Group guidance and synthetic research by Alex Ross, James Vause and Katie Leach at UNEP-WCMC. The Expert Group was led by Co-Chairs Paul Ekins (Professor at University College London and Director of the Institute for Sustainable Resources) and Joe Grice (Chairman of the United Kingdom Office for National Statistics Economic Experts). The Expert Group is composed of members from various organizations, including Charles Akol (United Nations Economic Commission for Africa), SoEun Ahn (Korea Environment Institute), Alessandra Alfieri (United Nations Statistics Division), Carter Brandon (World Resources Institute), Raouf Dabbas (Jordan Friends of Environment Society), Gitika Goswami (Development Alternatives), Salman Hussain (UNEP The Economics of Ecosystems and Biodiversity), Katia Karousakis (OECD), Pushpam Kumar (UNEP), Glenn-Marie Lange (World Bank Group), Markus Lehmann (Convention on Biological Diversity), Anil Markandya (Basque Centre for Climate Change), Geoff McCarney (Smart Prosperity Institute), Edwin Muchapondwa (Environment for Development Initiative), Rosimeiry Portela (Conservation International), Mary Ruckelshaus (Natural Capital Project), Oyun Sanjaasuren (Green Climate Fund), Mark Schauer (Economics of Land Degradation (ELD) Initiative/Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)), Tim Scott (United Nations Development Programme), Juha Siikamäki (International Union for Conservation of Nature), Kevin Urama (African Development Bank), Annawati van Paddenburg (Global Green Growth Institute) and James Vause (UNEP-WCMC).

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SUMMARY

To incorporate natural capital in green growth planning at national scales, decision makers require access to information that reflects the quality, quantity and spatial configuration of natural capital assets and allows these to be understood in the context of their contribution to human well-being. The utility of natural capital analysis for policymaking is ultimately dependent on the availability of information, which can be provided through data platforms and tools. Natural capital data of varying types and quality is dispersed through a number of data platforms and can be visualized and modelled through an array of tools. In this report, we present the findings of a study to scope out and analyse platforms and tools for accessing, visualizing and manipulating natural capital data, with a particular focus on their value to national level integrated decision-making.

A set of criteria were developed to compare and contrast platforms and tools identified as having the potential to support integration of natural capital in green growth planning. Detailed reviews against the criteria were undertaken for 28 data platforms and tools. As well as providing a baseline analysis of the coverage platforms and tools, this can help narrow down the choice of platform/tools depending on the objective of the assessment. Interviews with natural capital data experts and tool providers were then used to further assess the strengths, weaknesses and limitations of the natural capital data platforms and tools in a green growth planning context, and critically how the field could upscale the accessibility and impact of natural capital information.

Our research highlighted how the utility of natural capital platforms and tools for supporting policymaking is affected by several qualities. These qualities included the:

- **Relevance** of outputs and the clarity with which they are communicated;
- **Accessibility** of the information for a general audience;
- **Transparency** of the information; and
- **Flexibility** of the platform or tool to be used with different data and metrics to suit specific user requirements.

Gaps were identified impeding the use of platforms and tools for green growth planning. The identified gaps were related to both incompleteness in certain aspects of the information provided (including both data and its interpretation through platform and tool outputs), and a lack of user uptake and application of the information that is currently available. These gaps, and recommendations for how the Green Growth Knowledge Partnership, GGKP knowledge partners and associated institutions might address them, are summarized in the table below:

Summary of identified gaps limiting the utility of available platforms and tools for integrating natural capital approaches in green growth planning and policy processes, and recommendations to address them. In some instances a single recommendation relates to a single gap, while others are applicable to addressing multiple gaps, or multiple recommendations can apply to the same gap.

Gaps	Recommendations
Information	
▪ Lack of data relating to ecosystem service flows and consistent approaches for linking biophysical and socioeconomic data ▪ Lack of outputs directly related to international commitments limiting application of data to reporting against them ▪ Missing datasets on specific natural capital assets potentially limiting their incorporation into policy decisions ▪ Lack of information about sector dependencies on natural capital ▪ Lack of capacity to interpret big data preventing information from being made available to decision makers through platforms and tools	▪ Drive incorporation of socioeconomic datasets into natural capital platforms and tools to aid modelling of ecosystem service flows ▪ Support efforts to link data to indicators for reporting against international commitments to assist policymakers in measuring progress against defined objectives and policies ▪ Define outstanding data needs to address gaps in natural capital asset, sector dependency and ecosystem service data ▪ Engage with providers of big data to understand how new data sources can be used to address policy needs ▪ Support scaling up of artificial intelligence to extract useful information from large datasets, e.g. satellite remote sensing data
User uptake	
▪ Lack of ability to integrate learning from previous natural capital assessments into platforms and tools to aid future efforts ▪ Lack of interoperability and standardized output language and format between platforms and tools, limiting application of previous analyses to related policy questions ▪ Lack of capacity to use spatial data and natural capital data in governments, preventing platform and tool uptake ▪ Limited use of natural capital language preventing potential users from identifying the value of platforms and tools	▪ Promote interoperability between platforms and tools and re-usability of outputs and models to make high-quality information available to a wider range of users, assist new modelling approaches in building on previous work and avoid duplicated effort ▪ Develop decision support guidance to link platforms and tools with natural capital frameworks, policy questions and a common natural capital data language ▪ Increase capacity to use public domain platforms and tools in governments through workshops, communities of practice and/or platform and tool-supporting material

CONTENTS

LIST OF ACRONYMS

AIRES	Artificial Intelligence for Ecosystem Services
ENCORE	Exploring Natural Capital Opportunities, Risks and Exposure
EO4EA	Earth Observation for Ecosystem Accounting
EVL	Environmental Value Look-Up Tool
EVT	Ecosystem Valuation Toolkit
GGKP	Green Growth Knowledge Partnership
GIS	Geographic Information System
IBAT	Integrated Biodiversity Assessment Tool
InVEST	Integrated Valuation of Ecosystem Services and Trade-offs
IUCN	International Union for the Conservation of Nature
LUCI	Land Utilisation Capability Indicator
NASA	National Aeronautics and Space Administration
NCPT	Natural Capital Planning Tool
NDCs	Nationally determined contributions
NEVO	Natural Capital Valuation Online Tool
OPAL	Offset Portfolio Analyzer and Locator
ORVal	Outdoor Recreation valuation tool
SDGs	Sustainable Development Goals
SENCE	Spatial Evidence for Natural Capital Evaluation
SolVES	Social Values for Ecosystem Services
UNEP	United Nations Environment Programme
UNEP-WCMC	United Nations Environment Programme World Conservation Monitoring Centre
UNSD	United Nations Statistics Division

1. CONTEXT

Natural capital is a way of thinking about nature as a stock of renewable and non-renewable natural resources that combine (often with other capital) to yield a flow of benefits to people.[1] The goods and services that natural capital provides, such as food, water and climate regulation, are called ecosystem services.[2] Given the critical role that natural capital stocks and ecosystem services play in enabling economic growth, mainstreaming consideration of natural capital within national development planning will be key to achieving the United Nations (UN) Sustainable Development Goals (SDGs) by 2030.[3]

To incorporate natural capital in green growth planning at national scales, decision makers require metrics that allow them to understand how nature impacts, or has the potential to impact, human well-being.[4] The ability for natural capital to influence policymaking is ultimately dependent on the availability of information. The Data Information Flow project,[5] carried out by UNEP-WCMC on behalf of the Natural Capital Coalition, has set out a framework of challenges and potential solutions for the use of natural capital data (Figure 1). While primarily aimed at the private sector, many of the barriers and solutions that this project identified are equally relevant to use of natural capital data for green growth planning by national governments.

Other recent research—including work undertaken by UNEP-WCMC with the Natural Capital Finance Alliance as part of the Advancing Environmental Risk Management Project, and in collaboration with the United Nations Environment Programme (UNEP) to identify data related to marine natural capital—has highlighted the value of integrating biophysical and socioeconomic data. Biophysical datasets, on the extent of natural capital assets, their condition and the potential physical supply of ecosystem services, can be linked to socioeconomic data to understand how natural capital assets and ecosystem services are of benefit and value to humans. Important recent developments in natural capital data include provision of huge amounts of earth observation data from satellite imagery[6] as well as data gathered on site from new technologies such as sensors linked to internet enabled devices connected through the Internet of Things.[7,8]

Environmental economists can make use of these new and old forms of data for the purposes of natural capital accounting and assessment to better inform green growth planning, as well as to draw attention to human development issues associated with a lack of access to ecosystem goods and services. Furthermore, appropriate and high-quality datasets are required for reporting against countries' efforts to meet various international commitments such as the SDGs, the Aichi targets (and their successors), and Nationally Determined Contributions to tackle climate change under the Paris Agreement.

1 Natural Capital Coalition. 2016. Natural Capital Protocol. (Online) Available at: www.naturalcapitalcoalition.org/protocol (as of June 2019).
2 Hassan, R., Scholes, R., Ash, N. (eds). 2005. Millennium Ecosystem Assessment: Ecosystems and Human Wellbeing, Volume 1, Current Status and Trends. Island Press, Washington.
3 Ruijs, A., van der Heide, M. van den Berg, J. 2018. Natural Capital Accounting for the Sustainable Development Goals. Current and potential uses and steps forward. PBL Netherlands Environmental Assessment Agency. The Hague, Netherlands.
4 Mace, G., Hails, R. Cryle, P., Harlow, J., Clarke, S. 2015. Towards a risk register for natural capital. Journal of Applied Ecology, 52(3), 641-653.
5 Natural Capital Coalition. 2019. Data use in natural capital assessments. Assessing challenges and identifying solutions. Full report.
6 O'Connor, B., & Allison, H. 2019. View from the sky – the contribution of Earth observation to the Sustainable Development Goals and selected indicators. Policy Brief.
7 https://www.link-labs.com/blog/iot-environmental-monitoring (as of June 2019)
8 Beier, G., Niehoff, S., Xue, B. 2017. More Sustainability in Industry through Industrial Internet of Things? Applied Sciences, 8(2).

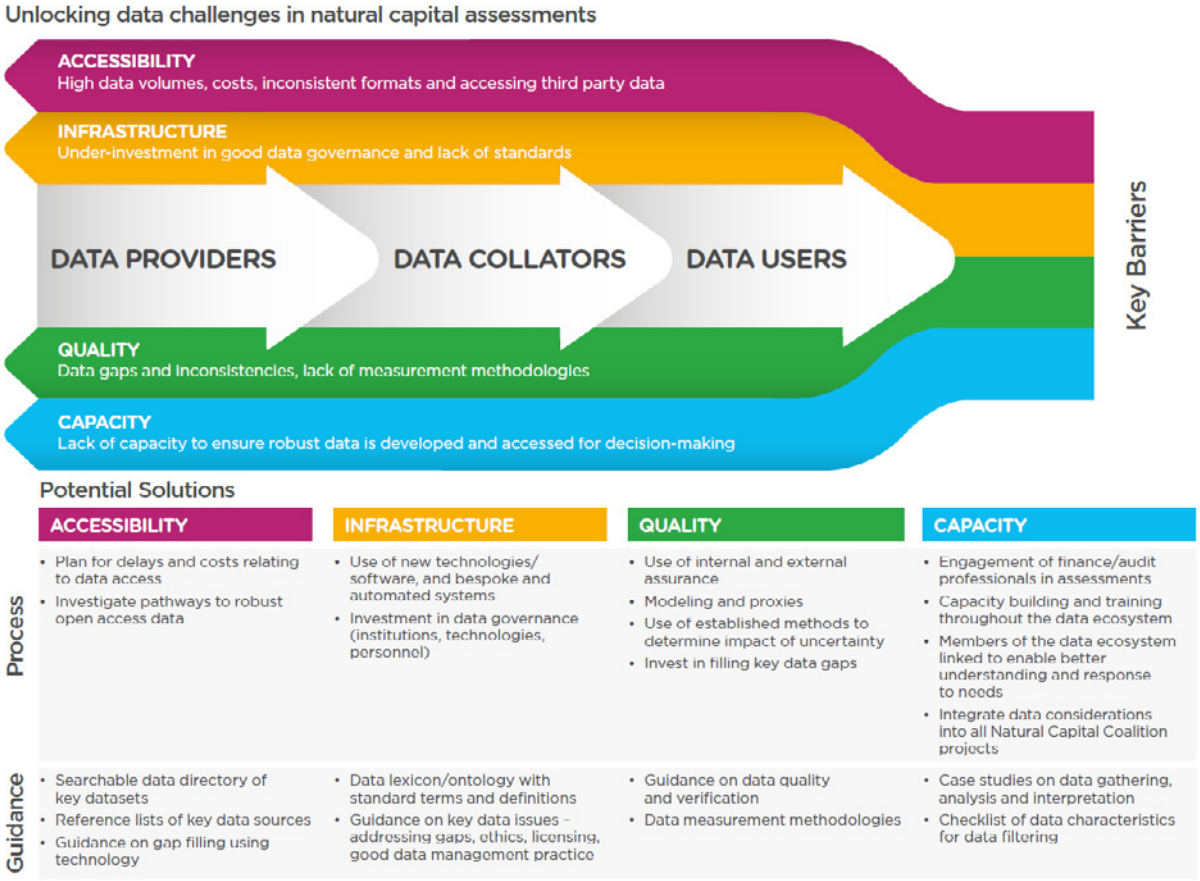

Figure 1. Key barriers limiting the use of natural capital data for business needs and potential solutions to address each barrier, taken from the Data Information Flow project.9 Many of these key barriers and solutions are also relevant to the use of natural capital data by the public sector in green growth planning and policy processes.

Natural capital data of varying types and quality is dispersed through a number of data platforms and can be visualized and modelled through an array of tools.[9] Platforms for accessing data, and tools for integrating data into decision-making are required to bring natural capital information to decision makers for use in green growth planning and policy processes. In this context, a clear need has been articulated by the Green Growth Knowledge Partnership's Natural Capital Expert Group to identify suitable tools and platforms providing access to data on natural capital and ecosystem services. The data that platforms and tools provide should be fully integrated and utilized within a green growth policy framework and empower national and sub-national entities to make decisions that respond to the role and value of natural capital and ecosystem services across economic sectors.

In the rest of this report, we present the approach and findings of a short study to scope out and analyse platforms and tools for accessing, visualizing and manipulating natural capital data. This will enable the Green Growth Knowledge Partnership Natural Capital Expert Group and partner organizations to apply relevant insights directly into their national green growth activities, and to assess further priorities to help catalyse progress towards filling knowledge gaps and reducing barriers to using natural capital information. The study first identifies natural capital data requirements, and then analyses how well these requirements are met by available platforms and tools. We then provide recommendations for further platform and tool developments to meet identified data gaps, drawing on desk-based research and expert interviews alongside findings from recent related studies.[10, 11]

9 https://shift.tools (as of June 2019)

10 Natural Capital Coalition. 2019. Data use in natural capital assessments. Assessing challenges and identifying solutions. Full report.

11 BID-REX. 2019. Better data, better decisions: increasing the impact of biodiversity information. Technical report of phase 1 of the project BID-REX – from biodiversity data to decisions: enhancing natural value through improved regional development policies. Interreg Europe.

2. APPROACH

2.1. REVIEW OF NATURAL CAPITAL DATA PLATFORMS AND TOOLS

A broad set of environmental sustainability data platforms and tools were identified through searching online databases, including the MIT SHIFT tool,[12] Web of Science, Google Scholar and the basic Google search engine. Twelve search terms were used, in turn combining the phrases "natural capital", "green growth", "environmental assessment" and "environmental monitoring", with "tools", "platforms" and "data". The platforms and tools identified through online searches were added to a list identified during the Green Growth Knowledge Partnership Expert Group Metrics and Data Workshop in Stanford University in 2018.

A non-exhaustive subset of the identified platforms and tools, which were accessible and directly considered natural capital and/or ecosystem services, was then reviewed in more detail. The platforms and tools selected for detailed review were limited to those with which the user could interact to produce direct outputs (e.g. online databases, data visualization tools and modelling tools). Theoretical frameworks were not included as they would require use of other platforms, tools and data sources to implement. Please note that more platforms and tools applicable to integrating natural capital in green growth planning and policy processes may be identified through further research.

A set of common criteria was developed to compare the data platforms and tools selected for review. The review criteria built on recent related work to identify the current and emerging data sources, platforms and tools for addressing natural capital metrics and data needs. This included research undertaken by UNEP-WCMC with the Natural Capital Coalition, UNEP Natural Capital Finance Alliance and European Space Agency.

The criteria illustrate qualities of the platforms and tools which might affect their utility in the context of integration of natural capital approaches in green growth policy and planning processes at national and sub-national levels. They provided information on the following platform and tool attributes: overview (including descriptive summary, type and provider), purpose, versions, access, documentation, data, indicators, ecosystem services, spatial information, temporal information and online information.

Several more specific criteria under some of these attributes were also developed, for example detailed information on the spatial and temporal characteristics and extent of data was extracted, as data must be available at the correct scale, resolution and timeframe for the analytical uses and policy questions that natural capital assessments and accounts are intended to inform. The criteria do not explicitly assess the quality of different platforms and tools as this was beyond the scope of this review, but do indicate which platforms and tools may be applicable to different user groups and applications, including decision-making at national and sub-national levels.

2.2. EXPERT INTERVIEWS

A series of interviews with natural capital data experts and tool providers was carried out to further assess the strengths, weaknesses and limitations of the natural capital data platforms and tools in the context of supporting green growth planning and policy processes. Discussions were structured through questions addressing platform/tool main user groups, desirable qualities, gaps and requirements for further developments. For a list of experts interviewed as part of this scoping study, please refer to the Annex I.

Following review by the natural capital data experts and tool providers, the identified data platforms, tools and information extracted through application of the review criteria were summarized in the spreadsheet that accompanies this report.

12 https://shift.tools (as of June 2019)

3. AVAILABLE PLATFORMS AND TOOLS

Detailed reviews were undertaken for 28 data platforms and tools with potential to be used in integrating natural capital approaches in green growth policy and planning processes. These included databases of spatial and/or non-spatial information (in some instances coupled with data visualization interfaces) and modelling tools, for example through Geographic Information System plug-ins and in online environments. Most of the platforms and tools were supported by material stating intended uses. For the selection of platforms and tools reviewed, these intended uses included: assessing land use and/or land use change; environmental-economic accounting; natural capital assessment; spatial planning; reporting against international commitments; supporting policy and decision-making; and public engagement.

The following platforms and tools were assessed in detail:

- ARIES (Artificial Intelligence for Ecosystem Services)
- Benefit Transfer Toolkit
- Co$ting Nature
- Coastal Resilience Decision Support Tools
- Collect Earth
- Earth Online
- Ecosystem Valuation Toolkit (EVT)
- ENCORE (Exploring Natural Capital Opportunities, Risks and Exposure)
- Environmental Value Look-Up (EVL) Tool
- ENVISION
- IBAT (Integrated Biodiversity Assessment Tool)
- InVEST (Integrated Valuation of Ecosystem Services and Trade-offs)
- i-Tree Eco
- LUCI (Land Utilisation Capability Indicator)
- Moabi
- Natural Capital Asset Map and Decision Support Tool
- NCPT (Natural Capital Planning Tool)
- NEVO (Natural Capital Valuation Online) Tool
- OPAL (Offset Portfolio Analyzer and Locator)
- ORVal (Outdoor Recreation valuation tool)
- Resource Watch
- SENCE (Spatial Evidence for Natural Capital Evaluation)
- SolVES (Social Values for Ecosystem Services)
- Trends Earth
- UN Biodiversity Lab
- UNdata
- United Nations Global SDG Database
- Viridian

Data platforms and tools are often applied to address different, but complementary natural capital information needs. Platforms, such as UNdata and the United Nations Global SDG Database from the United Nations Statistics Division (UNSD) and Earth Online from the European Space Agency, are typically used to access natural capital data and information, whereas tools are used for visualizing, integrating and manipulating data and producing secondary data through modelling. Ecosystem modelling tools, such as InVEST (Integrated Valuation of Ecosystem Services and Trade-offs) and ARIES (Artificial Intelligence for Ecosystem Services) are of particular relevance to answering questions about changes in ecosystem service provision. A number of data platforms, such as UN Biodiversity Lab and Resource Watch, also include capacity to visualize data directly in their own interfaces, allowing users to create novel overlays, and even upload and integrate their own data, bridging the distinction between platforms and tools.

Our research and interviews found that the utility of these platforms and tools for supporting policymaking is affected by several factors, including the:

- **Relevance** of outputs and the clarity with which they are communicated;
- **Accessibility** of the information for a general audience;
- **Transparency** of the information; and
- **Flexibility** of the platform or tool to be used with different data and metrics to suit specific user requirements.

3.1. RELEVANCE

The usefulness of information provided by a platform or tool depends on both the underpinning data and how the data is communicated. Platform and tool outputs are imperative to integration of natural capital in green growth planning and policy. Through our interviews, it was noted that displaying information spatially was a key means of increasing applicability to real-world problems, as all natural capital assets, and almost all human activities, have a geographical context.

We found that it was common for data platforms and tools to provide users with access to spatial information, with over 70% of reviewed natural capital data platforms and tools providing some form of spatial output (Figure 1). A number of these, for example, IBAT (the Integrated Biodiversity Assessment Tool) and Collect Earth (a high-resolution satellite image viewing platform), allowed data to be used outside of a Geographic Information System environment, but downloaded for use in Geographic Information Systems should greater flexibility be required.

Over 80% of the platforms and tools reviewed could provide some form of quantified output (Figure 2), with almost half providing monetary outputs. For example, the Benefit Transfer Toolkit is focused exclusively on compiling economic values for resources not priced in conventional markets (although only for the USA), while the Ecosystem Valuation Toolkit (EVT) is comprised of a searchable database of ecosystem service values. A small number of tools, including LUCI (Land Utilisation Capacity Indicator), OPAL (Offset Portfolio Analyser and Locator) and SENCE (Spatial Evidence for Natural Capital Valuation), provide recommendations and guidance for decision makers. For example, SENCE is a modelling tool which creates maps showing the existing value of the environment and recommendations for the best locations to enhance ecosystem services.

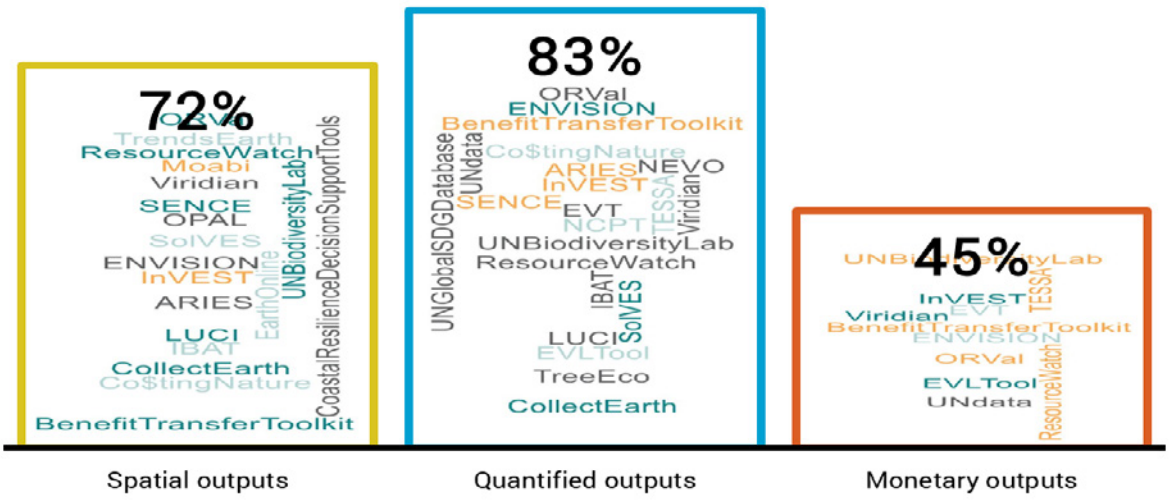

Figure 2: Proportion of reviewed natural capital data platforms and tools providing spatial, quantified and monetary outputs. Note that in some instances the output will depend on user input data or on selections made in the platform or tool interface. Many platforms and tools provide outputs that fall under more than one of these categories. Acronyms for platform and tools names used in this figure are defined in full in the spreadsheet that accompanies this report.

Several data platforms linked to data visualization interfaces are beginning to incorporate both biophysical and socioeconomic datasets. This increases their potential relevance to policymakers through promoting understanding of how natural capital assets and ecosystem services are of value to humans. For example, UN Biodiversity Lab, launched in 2018, and Resource Watch, currently in beta testing, bring together a large number of biophysical and socioeconomic datasets in an easy-to-use online interface outside of a Geographic Information System environment, and allow users to overlay multiple datasets. Both platforms are regularly updated with new datasets, and allow users to upload and overlay their own data. This collation of spatial information has strong potential to enable non-biodiversity specialists to apply natural capital data in their work. Furthermore, blending of socioeconomic and biophysical data through these platforms could foster cross-disciplinary working in large multifaceted organizations, such as between national government departments and ministries. Other developing platforms have a stronger focus on collating biophysical information and providing interpretation to inform specific questions and policies. For example, Nature Map Earth aims to provide an integrated map allowing decision makers to identify priority areas to operationalize targets for conservation and restoration of nature.

Earth observation is also a promising source of data for application to environmental decision-making. However, platforms and tools are needed to communicate information from these large and complex datasets. To be of use in green growth planning and policy, natural capital platforms or tools need to balance user ability to interact with these datasets, with extraction and communication of key patterns.

Satellite remote sensing data is increasingly available through free online data platforms, such as Earth Online from the European Space Agency. Some remote sensing data can be viewed through online platforms such as Collect Earth, which is specifically intended for use in projects that require land cover and/or land use reference data. Furthermore, efforts are underway to use satellite remote sensing data in open access free modelling tools. For example, ARIES is an ecosystem modelling tool that uses artificial intelligence to pair ecosystem service and spatial data to quantify ecosystem service flows.

3.2. ACCESSIBILITY

Payment barriers and a requirement for specialist software (and the skills to use it) will limit the accessibility of platforms and tools beyond a specific target audience. Intuitive front-end interfaces broaden the range of users able to visualize and manipulate information. Readily available documentation – providing information on how to use the platform/tool and its underlying algorithms and calculation methodologies – will assist both specialist and non-specialist users in extracting valuable information and ensure that limitations for informing decisions are clear. Furthermore, our interviews highlighted the value of case studies documenting previous platform and tool applications (and the impact they have had) as a powerful means to engage new audiences, such as governments.

Many natural capital data platforms and tools are freely available through non-specialist and non-licensed software. However, commercial restrictions on a subset of datasets available through a platform are not uncommon. Based on our interview discussions, two broad approaches are employed by decision makers at the national level seeking to understand natural capital: employing consultants who use their own proprietary modelling tools, or using models available in the public domain.

Natural capital tools used by consultants typically produce clear recommendations as outputs. For example, Viridian shows what type of habitat to create and where to create it in order to provide nature-based solutions to local problems. Several consulting companies, including TruCost (part of S&P Global) and PwC have their own platforms and tools. The methodologies and data underlying these tools are often unclear; however, efforts to make methodologies more accessible and transparent have occurred. For example, PwC has published detailed methodology papers outlining how they value business impacts on natural capital. [13]

Models in the public domain, by contrast, are typically accompanied by extensive documentation explaining how to use them, and the algorithms underlying their calculations. Almost all public domain models reviewed included both user guidance and methodological documentation. However, this was variable in level of detail. Some tools, such as InVEST (Box 1), are accompanied by numerous case studies demonstrating how they have been used and the impact they have had. This can be highly effective in making the policy case for use of a platform or tool, promoting uptake by new users. InVEST is also accompanied by strong training material and user support, facilitating this uptake.

13 Valuing corporate environmental impacts. 2015. PwC methodology document. (Online) Available at: https://www.pwc.co.uk/sustainability-climate-change/assets/pdf/pwc-environmental-valuation-methodologies.pdf (as of June 2019).

Box 1. InVEST – an example of a modelling tool

InVEST (Integrated Valuation of Ecosystem Services and Trade-offs)

Description: InVEST is a suite of free, open-source software models used to map and value the goods and services from nature that sustain and fulfil human life. InVEST enables users to assess trade-offs associated with alternative management choices and to identify areas where investment in natural capital can enhance human development and conservation.

Strengths: can be used to show implications of policy choices, starting to bridge the gap between natural capital data and policy; open access and free; strong training and user support materials; numerous case studies documenting applications and impact of the tool; flexible for use with a variety of data; has been applied over a long time period by many different users.

Limitations: specific ecosystem service models are not always accurate due to site-level complexities; requires specialist skills and a significant time investment to learn to use.

The capacity to store data, outputs and calculation algorithms for re-use in future analyses adds further breath to the range of users able to apply natural capital platforms and tools to green growth policy and planning processes. Storage and re-use of information within platforms and tools also has the potential to streamline analysis and prevent duplicated effort. The majority of ecosystem service modelling tools currently available do little to make data and models available for re-use. However, this opportunity is being recognized with modelling tools such as ARIES, attempting to make information findable for application to future analyses.

Large datasets, such as those created through earth observation, pose specific accessibility and usability challenges. Ensuring these datasets are useable is a computational and communication challenge. Powerful computational platforms (not necessarily specific to natural capital) are required to access and interpret the data, and developments in this area have begun. For example, Sentinel Hub, which is hosted on Amazon Web Services, provides a cloud based Geographic Information System platform for processing petabytes of satellite data. It aims to make Sentinel, Landsat and other Earth observation imagery more easily accessible for browsing, visualization and analysis, increasing the accessibility of this information for policy and planning processes.

3.3. TRANSPARENCY

Information used to inform policymaking must be able to be verified. Data platforms should support users in tracing information to its source, while in tools the algorithms for data manipulation should be transparent. Transparency and openness are also key to allowing learning between assessment efforts, and re-use of information and models in further analyses, reducing the time taken to carry out assessments and reducing duplication of effort. The accuracy of data, and how it has been manipulated and validated, is unclear in some platforms and tools. Other platforms focus on providing only datasets with a high level of quality assurance. For example, IBAT (Box 2) provides access to only the World Database on Protected Areas, the World Database of Key Biodiversity Areas and the IUCN Species Red List.

UN Biodiversity Lab provides a far larger number of datasets, and accompanying metadata to assist with understanding the data sourcing and collection methodology. UNdata focuses on compilation of official statistics, which have an inferred high level of accuracy. However, broad-scale statistics applied over a large geographic area do not allow users to accurately assess trade-offs at sub-national spatial scales. The scale and resolution of data provided/generated through the platforms and tools studied is recorded in the analytical spreadsheet, which accompanies this document.

Box 2. IBAT – an example of a data tool

IBAT (Integrated Biodiversity Assessment Tool)

Description: IBAT (Integrated Biodiversity Assessment Tool) allows decision makers to access and use three global biodiversity datasets in a web-based map and reporting tool to provide fast, easy and integrated access to critical biodiversity information.

Strengths: uses globally recognized datasets; the World Database on Protected Areas, World Database of Key Biodiversity Areas and IUCN Red List are compilations of consistently collected national databases, providing both global coverage and suitability for decision-making at national levels; enables screening against internationally recognised best practice; easy to use online interface and reports (in PDF, image and csv format); spatial outputs which can support spatially explicit policy.

Limitations: report and data download functionality through subscriptions; no quantification of the value of natural capital assets, so needs to be used alongside other platforms, tools, data or algorithms; global level data has limited accuracy at sub-national scales.

Blockchain technology has the potential to be applied for data provenance and as a guide to authenticity and quality. Blockchain would allow data to be traced through a decentralized infrastructure based on distributed ownership, therefore allowing any processing or manipulation of data to be recorded. The additional layer of transparency that blockchain technology could provide might be a key enabling factor for integration of natural capital data from a range of dispersed sources in policy and planning processes.

Regularly repeated validation is important where artificial intelligence has been used to extract information from large datasets, as relationships between features of the data and inferences drawn from it may not remain constant through time. Citizen science projects, for example making use of apps on smartphones, provide a promising potential avenue for verification of remotely sensed and modelled data. Due to the huge potential numbers of data collectors available, this could provide a means of verification on suitable scale to be applied to national, or even global-scale, satellite imagery. In support of this, a number of citizen science platforms and tools are coming online with potential for use in validation of information extracted from remotely sensed imagery. For example, Moabi provides a collaborative mapping system, which uses crowdsourcing to find and update spatial information related to development activity. It is currently being trialled for monitoring natural resource use in the Democratic Republic of Congo (where it has potential applications beyond validation of remote sensing data, such as empowering civil society involvement in resource management and conservation). Furthermore, it is possible for sensors on internet-enabled devices to be set up to report measurements for validation of remote sensing data automatically, alleviating the need for a human user to be directly involved with each data collection event.

3.4. FLEXIBILITY

Policy processes involve assessing the interests of various stakeholders. In this context, our research highlighted flexibility, i.e. tools and platforms supporting a wide range of input data, and reporting against several different metrics, as an advantage. Highly flexible tools and data platforms will allow solutions to be optimized to user-specific limitations, such as financial cost, demand for a particular ecosystem service or natural capital asset, or time constraints to produce a specified outcome.

The majority of data platforms and databases, including the Benefit Transfer Toolkit, Earth Online, UNdata and the United Nations Global SDG Database, act as portals to provide access to data. These platforms do not provide the flexibility to begin interpreting natural capital data. Some platforms, such as ENCORE (Box 3), focus on providing interpretation and highlighting patterns in data, with this interpretation itself forming a structured database through which to search for information. In addition, ENCORE provides links to underlying datasets, allowing it to simultaneously serve as a portal signposting key datasets related to specific natural capital assets and ecosystem services.

Box 3: ENCORE – an example of a data tool adding value through helping interpretation

ENCORE (Exploring Natural Capital Opportunities, Risks and Exposure)

Description: ENCORE (Exploring Natural Capital Opportunities, Risks and Exposure) enables users to visualize how the economy depends on nature and how environmental change creates risks for business. Starting from a business sector, ecosystem service, or natural capital asset, ENCORE can be used to start exploring natural capital risks. These risks can be explored further to understand location-specific risks with maps of natural capital assets and drivers of environmental change.

Strengths: links biophysical and socioeconomic data; comprehensive coverage of industry processes, natural capital assets and ecosystem services; provides clear interpretation of datasets and links to sources of more detailed information; freely available online; simple and intuitive user interface.

Limitations: does not quantify ecosystem services, natural capital assets and their economic value; limited detail provided through tool so needs to be used alongside other information sources, such as the datasets that it provides links to; most data provided at a global-level so less suitable for national and sub-national level decision-making.

Several platforms also enhance the potential for interpretation by allowing users to upload their own data in a secure environment. Examples include UN Biodiversity Lab and Resource Watch; Resource Watch also allows users to explore data by topic—water, climate, cities, forest and food—displaying versatility and relevance this way. IBAT provides a secure environment in which users can interrogate datasets within the tool to create bespoke reports. Modelling tools such as ARIES, ENVISION, Trends Earth and InVEST have the highest level of flexibility, as models can be used with a wide variety of users' own data, allowing them to be applied to a range of policy questions across various temporal and spatial contexts. In addition, some models based on Geographic Information System plug-ins, including ENVISION, Trends Earth and InVEST, can be downloaded for use in secure desktop environments.

The most effective tools for informing a specific decision will depend upon the spatial and temporal context in which they need to be used, with different tools applicable to different situations. Platforms providing key datasets, including UN Biodiversity Lab and Resource Watch, often have a global-level focus with more limited data available at the national and sub-national levels. In contrast, ecosystem service modelling tools such as InVEST are more applicable to the site level (if used with appropriate site-level data). Some tools also exist that are specific to certain locations, such as the Natural Capital Asset Map and Decision Support Tool, which maps and values natural capital assets for the South Platte River watershed in Colorado.

4. GAPS IN AVAILABLE PLATFORMS AND TOOLS

Gaps were identified in available platforms and tools that are limiting the ability of users to integrate natural capital approaches in green growth policy and planning processes. These can be categorized as gaps in the information, data provided by the range of available platforms and tools ("information gaps"), or gaps in user uptake and application ("user uptake gaps").

4.1. INFORMATION GAPS

- **Lack of datasets relating to ecosystem service flows/ benefits:** Data on natural capital assets is available for an increasing number of countries. Even where national datasets are not available, natural capital asset maps are often available through global datasets on open access data platforms. However, it is less common for natural capital asset data to be quantitatively linked to the provision of ecosystem services and the associated benefits to people. While several platforms and tools are beginning to bring biophysical and socioeconomic datasets together, the socioeconomic data available is often limited in comparison to biophysical data, and there is a lack of consistently applied analytical methods and algorithms for linking this data to estimate flows of many ecosystem services and their benefits. Furthermore, measured on-the-ground data to validate models against is lacking for many countries and ecosystem services.
- **Lack of outputs directly related to international commitments:** Few tools currently interpret natural capital data directly in terms of its relevance to national contributions to international commitments, such as the UN SDGs or Aichi targets.
- **Missing natural capital asset datasets:** High-quality spatial data on many natural capital assets and ecosystem services is lacking. For example, data on soil organic carbon and inshore bathymetry (depth of water in lakes) is not available for many countries. There also remains a challenge with marine data compared to terrestrial data at a global scale and across all types of natural capital assets and ecosystem services. Data relating to some natural capital assets is only available from a fixed point in time, so is not well suited for use in assessing change through time.
- **Lack of information about sector dependencies on natural capital:** Far more information is available regarding impacts on natural capital than dependencies on natural capital. While some tools, such as ENCORE, are beginning to address this gap, consolidated guidance on natural capital dependencies for decision makers is sparse relative to information on impacts. This is particularly important in the context of integrated planning, as different economic sectors have shared dependencies on natural capital assets, and some sectors may impact on natural capital assets that other sectors depend upon. Furthermore, lack of datasets monitoring resources on which society is dependent may prevent recognition of activities causing social harm for short-term economic gain.
- **Lack of capacity to interpret big data:** Huge amounts of data are available through sources such as remotely sensed satellite imagery. However, in many instances the amount of data available exceeds current capacity to interpret and relate it to natural capital and provision of ecosystem services. Artificial intelligence techniques and cloud computing platforms are being developed to address this gap, but refining these and bringing earth observation data into a usable format to decision makers requires continued ongoing development. New technologies to interpret big data are likely to be inaccessible to many users in developing countries, who lack the means to track, engage with and benefit from technological developments.

4.2. USER UPTAKE GAPS

- **Lack of ability to integrate learning from previous natural capital assessments into platforms and tools to aid future efforts:** Few tools can integrate updates to data and algorithms which have been developed for bespoke assessments and make them available for future users. This inability to access and build upon past analysis pose a barrier to the development of high-quality modelling approaches and information that are available to a wide range of users. Lack of re-usability in platform and tool outputs and models represents a missed opportunity in reducing the time and financial costs associated with carrying out assessments.
- **Lack of interoperability between platforms and tools:** Many of the available natural capital platforms and tools draw users based on familiarity of use, rather than suitability for specific policy questions. Shared and broadly applicable data terminology, metrics and formatting for knowledge representation are lacking from available platform and tool outputs, creating confusion and posing a barrier to policymakers when engaging with new platforms and tools. Furthermore, standardized output language and formats, which can be read by both human users and computer software within other platforms and tools, would increase the potential to re-use data to address different policy questions. The MIT SHIFT tool[14] has taken a first step towards enabling users to search for and find the most suitable platforms and tools by compiling them in a single online location. However, greater interoperability between the outputs and models in different platforms and tools, to allow information generated in different systems to be integrated, would increase efficiency and have potential to strengthen understanding of natural capital by decision makers.
- **Lack of capacity:** Initial feedback from data platform and tool providers has suggested that they are being heavily applied in countries that have capacity to understand and interpret spatial data, such as Costa Rica, South Africa and Colombia. There is a need to strengthen the policy case for natural capital data platform and tool use in countries that have a limited background in spatial data, and to engage in capacity-building activities around the use of natural capital data. Detailed case studies outlining how natural capital platforms or tools have been used to address policy questions, and the impacts they have had, are not provided for most platforms or tools. These case studies would be useful to help policymakers understand the value of using information provided by platforms and tools.
- **Limited use of natural capital language:** While many platforms and tools can provide information to support aspects of natural capital integration, such as conducting natural capital assessments, compiling environmental-economic accounts and reporting against international commitments, fewer phrase the value of nature explicitly in terms of natural capital. This poses a barrier to identification and uptake of these platforms and tools by decision makers aiming to integrate natural capital in green growth policy and planning.

14 https://shift.tools (as of June 2019)

5. RECOMMENDATIONS

5.1. INFORMATION

Decision makers require comprehensive information to understand the links between natural capital and benefits for people, and to evaluate policies, regulations and progress towards goals. Platform and tool providers need to identify the end goals for which data will be used, and understand the complete information requirements of policymakers, including spatial and temporal characteristics. Engagement from data users, such as governments, to define and communicate information needs, will be essential for developing a detailed understanding of requirements. In the context of natural capital, data of many types is abundant, and new data sources such as earth observation can help meet the growing demand for bulk environmental information from the local to the planetary scale.

Drawing from our desk research, expert interviews and recent related research, several recommendations to address information gaps related to platforms and tools that could be undertaken by the Green Growth Knowledge Partnership are outlined below:

- **Drive incorporation of socioeconomic datasets into natural capital data platform and tools:** Many platforms and tools are starting to provide access to socioeconomic data and a means to link and visualize it alongside biophysical data. Comprehensive additions of socioeconomic data to these platforms and tools will strengthen the range of insights that can be drawn, and may bring a more diverse array of users to platforms and tools providing natural capital information.
- **Link data to indicators for reporting against international commitments:** Policymakers need to measure progress against defined natural capital objectives, including the Aichi targets, SDGs and Nationally Determined Contributions. UN Biodiversity Lab allows users to filter datasets based on their relevance to specific Aichi targets. New sources of data, including earth observation data, have been found to be applicable to reporting against a range of both biophysical and socioeconomic indicators (Table 1). Platform and tool outputs covering of a wider range of international commitments would likely promote uptake for green growth planning and reporting.
- **Define outstanding data needs:** A wide range of data is required to comprehensively map natural capital and ecosystem services. Working with data users to define outstanding data needs linked to natural capital use cases for green growth policymaking will address gaps related to missing information, such as those identified relating to sector dependencies, ecosystem services, and specific natural capital assets in biomes and realms with a sparsity of data, such as the oceans. Furthermore, data gaps should be considered alongside gaps in the metadata accompanying existing datasets, and identify areas where data infrastructure (including governance processes and standards)[15] needs to be improved to increase the accessibility and transparency of information for policy processes.
- **Engage with providers of big data:** Organizations such as the European Space Agency and the National Aeronautics and Space Administration (NASA) hold vast and increasing quantities of Earth observation data, and are also often at the forefront of developing algorithms to interpret it. Engaging with these organizations to understand how the data that they provide can meet the needs identified with decision makers could help to make this information more accessible to policy and planning processes. This could build on initiatives like Earth Observation for Ecosystem Accounting (EO4EA) and the UN Global Platform (Big Data for Official Statistics), which are trying to raise the value of remote sensed data by connecting it to specific end uses.
- **Support scaling up of artificial intelligence:** Artificial intelligence algorithms are necessary to extract useful meaning from huge datasets provided by new technologies such as high-resolution satellite imagery and the Internet of Things. Scaling up current site-level approaches, and funding research seeking to address challenges such as non-stationary relationships (for example through machine learning), could promote the use of this high-quality and comprehensive information in decision-making at the regional, national and even global level. While artificial intelligence and machine learning models offer huge potential to interpret new sources of data and create useful and unexpected insights, some caution is required as models can operate outside of frameworks grounded in ecological theory, and so produce unexpected results. Validation of model outputs against on-the-ground measurements (requiring comprehensive natural capital and ecosystem service data) is important to increase confidence in information generated through artificial intelligence.

15 Natural Capital Coalition. 2019. Data use in natural capital assessments. Assessing challenges and identifying solutions. Full report.

Table 1: Examples of the biophysical and socioeconomic Sustainable Development Goal indicators which earth observation data can support. Indicators are categorized by relevance of Earth observation as a data source (assessed based on readiness and adequacy of earth observation data); green: highly relevant; amber: potentially relevant. Adapted from O'Connor & Allison 2019.[16] Note that reporting against some indicators will require data of other types to be used in addition to Earth observation data.

Biophysical Sustainable Development Goal indicators	**Socioeconomic** Sustainable Development Goal indicators
2.4.1 Sustainable agriculture 6.3.2 Ambient water quality 6.4.1 Water use efficiency 6.4.2 Water stress 6.6.1 Water-related ecosystems 11.6.2 Urban air quality 14.1.1 Coastal marine pollution 14.3.1 Ocean acidification 15.1.1 Forest areas 15.2.1 Sustainable forest management 15.3.1 Land degradation 15.4.2 Mountain green cover	1.5.2 Disaster damage 7.1.1 Access to electricity 9.9.1 All-season roads 11.1.1 Informal settlements 11.3.1 Land consumption
6.3.1 Safe waste water treatment 11.7.1 Public access to green space 14.4.1 Sustainable fishing 15.1.2 Terrestrial biodiversity 15.4.1 Mountain biodiversity	1.1.1 International poverty line 1.2.1 National poverty line 1.4.1 Access to basic services 2.3.1 Agricultural productivity per sector 3.3.3 Malaria incidences 3.4.1 Diseases induced mortality 3.9.1 Mortality due to air pollution 4.a.1 School facilities 6.1.1 Safe drinking water 11.2.1 Access to public transport 11.5.2 Damage to infrastructure 13.1.1 People affected by disasters

5.2. USER UPTAKE

The plethora of information available through different platforms and tools can sometimes act as a barrier to decision-making processes. Identifying and locating the most relevant platforms and tools for specific contexts can be challenging. Therefore, connecting decision makers to key platform and tool providers, networks, activities and projects can support understanding of the information available and facilitate access to it.

Drawing from our desk research, expert interviews and recent related research, several recommendations to address user uptake gaps related to platforms and tools that could be undertaken by the Green Growth Knowledge Partnership are outlined below:

- **Promote interoperability between platforms and tools, and re-usability of outputs and models:** Interoperability and re-usability have been identified as gaps in available platforms and tools. However, initiatives are ongoing to address these issues, for example The UN Global Platform is seeking to bring together data platforms and tools, and experts in different fields, to better understand the niche of different tools and how they can be used in parallel, or adapted, to maximise impact, and ARIES has a strong emphasis on making data from past analyses findable and re-usable. Promoting these initiatives within networks of both platform and tool providers and information users will help to align them with the needs of policymakers and increase uptake in green growth planning. The FAIR Data Principles[17] outline how data should be findable, accessible, interoperable and re-useable are also applicable to the platforms and tools providing access to information. While they primarily consider data itself, platforms and tools should be developed in alignment with these principles.
- **Increase capacity to use public domain data platforms and tools:** This could include documenting case studies of policy applications and impacts of key identified platforms and tools to promote use, setting up workshops and/or international communities of practice to showcase how platforms and tools have been used, and developing or supporting online training and case studies to use alongside platforms and tools.

16 O'Connor, B., & Allison, H. 2019. View from the sky – the contribution of Earth observation to the Sustainable Development Goals and selected indicators. Policy Brief.

17 The Fair Data Principles, https://www.force11.org/group/fairgroup/fairprinciples (as of June 2019).

- **Link platforms and tools with natural capital frameworks and a common natural capital data language:** Many platforms and tools need to be used as part of broader frameworks to promote an understanding of the value of natural capital approaches in decision-making, and then implement these approaches in planning and policy processes. Developing a tiered information tree to indicate which frameworks are applicable to which policy questions, and the strengths and limitations of platforms and tools that can support their implementation, will support decision makers in understanding the information required for green growth planning and where to access it. The framework should be developed in line with the recommendations from other initiatives for bridging the gap between natural capital data and decision-making, such as the Natural Capital Coalition report *Data use in natural capital assessments. Assessing challenges and identifying solutions*[18] and the Interreg Europe project *From biodiversity data to decisions: enhancing natural value through improved regional development policies,*[19] and aim to create clarity on the data and information needed to answer natural capital policy questions. Furthermore, it could identify where the same information and processes can be used by decision makers in different contexts, such as policy and business (drawing on frameworks such as the Natural Capital Protocol[20]), and differences in the information required to support each user group.

  Activities to promote uptake of the best available platforms and tools are essential to integrate natural capital in green growth planning and policy processes. However, the quality of information underpinning policy decisions is ultimately dependent on the quality of the data available. It is therefore important that recommendations related to addressing information gaps and user uptake gaps are applied simultaneously, with engagement from both data users and data providers. National governments will differ in their capacity to make use of the information provided by platforms and tools, and recommendations to promote integration of natural capital in green growth plans need to be tailored to the circumstances of specific countries. The recommendations in this report were developed largely through consultation with platform and tools providers (in the expert interviews); however, strong engagement with data users is also needed to help identify the most effective means to support greater integration of natural capital in green growth policy and planning across developed and developing countries. Building on these recommendations, platforms and tools bringing tailored information to national decision makers will leave them well-placed to implement greater consideration of natural capital in national economic plans and policies.

  An underpinning issue – that cannot be addressed wholly through data tools and platforms – is the context in which natural capital information is used. Government institutions and policymaking tend to focus on specific sectors/issues, which does not align well with a natural capital approach aimed at understanding the multiple values of natural capital assets across sectors. As such, there is further work to do in highlighting the value of natural capital approaches where policy development might be – even inadvertently – siloed. Similarly, where the SDGs and the increasing recognition of the value of Nature-Based Solutions (especially in the climate context) are encouraging better integration, it will be important to communicate how a natural capital framing can support this.

18 Natural Capital Coalition. 2019. Data use in natural capital assessments. Assessing challenges and identifying solutions. Full report.

19 BID-REX. 2019. Better data, better decisions: increasing the impact of biodiversity information. Technical report of phase 1 of the project BID-REX – from biodiversity data to decisions: enhancing natural value through improved regional development policies. Interreg Europe.

20 Natural Capital Coalition. 2016. Natural Capital Protocol. Available at https://naturalcapitalcoalition.org/natural-capital-protocol (as of June 2019).

5.3. POTENTIAL PRACTICAL NEXT STEPS FOR DISCUSSION BY THE GGKP NATURAL CAPITAL EXPERT GROUP

The aim of this report was to provide an impartial overview of the current situation with regard to natural capital platforms and tools for green growth planning. The recommendations as such try to avoid being too prescriptive to avoid inadvertently biasing the response to this report.

However, the expert interviews as part of this project and feedback from the GGKP Natural Capital Experts Group on the first draft of this report added enormous value of the work, and yielded a number of (relatively near-term) potential actions which the GGKP could encourage to help move the field forward. These are reported to help stimulate ideas on potential responses in addition to the research conclusions:

On the quality/availability/accessibility of information:

- Developing—initially through a meeting of technical specialists (i.e. the model and tool developers)—a community committed to making natural capital data and information more rapidly and readily accessible. There did not seem a collective perception of need/desire to develop a new tool, but there was a strong call for a mechanism to permit interoperability between models and learning from previous efforts. This might, for example, be a platform which would allow previously collated data and previously used algorithms to be shared. This could significantly reduce the time taken to carry out an initial assessment and encourage harmonization in how underlying data is translated into benefits for people as methods and approaches are shared and built upon. This idea also responds to the "FAIR" Data Principles – a set of guiding principles in order to make data findable, accessible, interoperable and reusable.
- Work with consultancy companies/intermediaries who sell "black box" natural capital assessments to open up their approaches in line with the point above. This would aim to improve the consistency of assessment and the confidence that can be placed upon them. The value proposition for such companies/intermediaries would need to evolve in this case from generating numbers to interpreting and generating response options to these. Intermediaries were highlighted as an important part of the community above as they understand both end-user needs and data limitations'; they provide an important role in making natural capital assessments more accessible, especially where internal capacity is limited.

On promoting wider uptake:

- An "entry level" set of overlays that could be used to catalyse policy discussions was seen as potentially useful, especially if such maps could highlight connections; for example, to the SDGs. This would aim to enhance understanding of the value of looking at development through a natural capital lens, and help policymakers identify issues/problems that more detailed natural capital assessments may help them to solve.
- Building on this, coordination of training/capacity building around the use and interpretation of spatial analysis to develop policy responses could be useful. Training and capacity building is happening, but it is not necessarily consistently across all countries. Coordination would help ensure no countries are left behind and could stimulate South-South exchanges through regional leaders/centres of expertise. Consistent regional use and understanding could also support countries ability to work together from a common starting point to tackle transboundary issues.

  A further scoping study could look at the potential for and impact of having requirements to carry out natural capital assessments as part of industrial standards associated with for example investments in infrastructure/construction.

ANNEX I: INTERVIEWEES

The experts listed below were interviewed as part of this scoping study.

Jamison Ervin
United Nations Development Programme

Ivo Havinga, Mark Craddock, Ronald Jansen
United Nations Statistics Division

Glenn-Marie Lange
World Bank

Kenneth Bagstad
United States Geological Survey

Daniel Juhn, Timothy Max Wright
Conservation International

Helen Ding (written input)
World Resources Institute

ANNEX II: PLATFORMS AND TOOLS

Annex II provides information on 28 existing natural capital platforms and tools which have the potential to be used in green growth planning, compiled by UNEP-WCMC on behalf of the Green Growth Knowledge Partnership. The tables here show compiled information for a set of platforms and tools potentially relevant to green growth planning, structured according to a number of different criteria. The complete spreadsheet which can be used as a tool is available online.

TABLE A1. LEGEND OF THE TABLES

CATEGORY	CRITERION	DESCRIPTION	ACCEPTED VALUES
Overview	Name	Name of the platform/tool	Open text
	Provider name	Name of the organization or author that distributes and provides the platform/tool	Open text
	Description	Description of the platform/tool	Open text
	Tool type	Platform/tool type and capabilities	Database of non-spatial information; database of spatial information; database of spatial information, coupled with data visualization; modelling; modelling (GIS plug-in); modelling (online interface)
	Data type	Type of data presented in platform/tool outputs	Primary non-spatial data; primary spatial data; secondary data (modelled or post-processed primary data)
	Link	URL of the platform/tool, if it and/or information about it is available online	Open text
Purpose	Target applications	Main intended uses and applications stated in platform/tool supporting materials	Assessing land use and/or land use change; environmental-economic accounting; increasing information transparency and/or public engagement; natural capital assessments; not stated; research; reporting against international commitments; spatial planning; supporting policy and/or decision-making
	Target audience	Main intended users stated in platform/tool supporting materials	Conservationists; farmers; financial institutions; general decision makers; government policy-makers; journalists; not stated; planners and/or developers; public; researchers; specific organization – open text

CATEGORY	CRITERION	DESCRIPTION	ACCEPTED VALUES
Versions	Current version	The current supported version of the platform/tool (February 2019)	Open text
	Other supported versions	Other versions of the platform/tool currently supported by the provider (February 2019)	No other versions supported; yes – open text; unknown
	Version history	Information on past versions of the platform/tool	Open text
	Future updates	Information about anticipated future versions and/or updates to the platform/tool	Open text
Access	Open access	Whether the platform/tool is available to any potential user	No; unknown; yes – full functionality; yes – limited functionality
	Free	Whether the platform/tool is free or whether is there a financial cost associated with its use	No – financial cost; unknown; varies with access level; yes – free
	Access levels	Whether the platform/tool has various levels of functionality available to different users	No – single level of functionality for all users; unknown; yes – different levels of functionality available
	Access levels information	Information about the levels of functionality available to different users	N/A; open text
Documentation	User guides	Whether resources are made available explaining how to use the platform/tool	No; unknown; yes
	Methodology	Whether resources are made available explaining the methodology and algorithms used by the platform/tool (modelling tools only)	N/A – not a modelling tool; no; unknown; yes

CATEGORY	CRITERION	DESCRIPTION	ACCEPTED VALUES
Data	Input type	Type of input required by the platform/tool	Earth observation data; selection from tool interface; site field data; spatial data; unknown
	Output type	Type of output provided by the platform/tool	Maps (GIS); maps (image files); maps (online); numeric data (statistics, tables, model predictions); recommendations and/or guidance; reports; unknown
	Quantified outputs	Whether the platform/tool is able to provide quantified outputs (note that whether it actually provides these may depend on data used or selections made in the platform/tool interface)	No; unknown; yes
	Monetary outputs	Whether the platform/tool is able to provide monetary outputs (note that whether it actually provides these may depend on data used or selections made in the platform/tool interface)	No; unknown; yes
	Spatial outputs	Whether the platform/tool is able to provide spatial outputs (note that whether it actually provides these may depend on data used or selections made in the platform/tool interface)	No; unknown; yes
Indicators	Biophysical	Whether biophysical indicators are used by the platform/tool	No; unknown; yes
	Socioeconomic	Whether socioeconomic indicators are used by the platform/tool	No; unknown; yes
Ecosystem services	Supporting	Whether the platform/tool can be used to give information about supporting ecosystem services	No; unknown; yes
	Regulating	Whether the platform/tool can be used to give information about regulating ecosystem services	No; unknown; yes
	Provisioning	Whether the platform/tool can be used to give information about provisioning ecosystem services	No; unknown; yes
	Cultural	Whether the platform/tool can be used to give information about cultural ecosystem services	No; unknown; yes
	Specific information	Whether the platform/tool is designed for use to give information about specific ecosystem services	No – general or aggregated information; unknown; yes – specific information
	Focus areas	Specific ecosystem services that the platform/tool can be used to give information about	Open text; N/A

CATEGORY	CRITERION	DESCRIPTION	ACCEPTED VALUES
Spatial information	Specific locations	Whether the platform/tool is designed for use in a specific location	No – global; yes
	Location	Specific location for which the platform/tool is designed	Open (web text)
	Terrestrial	Whether the platform/tool can be used to give information about terrestrial ecosystems	No; unknown; yes
	Freshwater	Whether the platform/tool can be used to give information about freshwater ecosystems	No; unknown; yes
	Marine	Whether the platform/tool can be used to give information about marine ecosystems	No; unknown; yes
	Scale	Spatial scales that the platform/tool is most applicable to	Local/site; regional; national; international; global
	Resolution	Information about the resolution of information provided by the platform/tool	Open (web text)
Temporal information	Set time point	Whether the platform/tool can be used to assess condition at a set point in time	No; unknown; yes
	Change over time	Whether the platform/tool can be used to assess change over time	No; unknown; yes
	Backward-looking	Whether the platform/tool can be used to assess past condition in comparison to present condition	No; unknown; yes
	Forward-looking	Whether the platform/tool can be used to assess future condition in comparison to present condition (typically through scenario analysis)	No; unknown; yes

A.1 OVERVIEW

Name	Overview				
	Provider name	Description	Tool type	Data type	Link
ARIES (Artificial Intelligence for Ecosystem Services)	An international network of scientists, led by Ferdinando Villa (Basque Centre for Climate Change, Leioa, Spain)	ARIES is a networked software technology that uses artificial intelligence to pair ecosystem service models and spatial data to quantify ecosystem service flows. It maps the agents of provision of ecosystem services, their beneficiaries, and any biophysical features that can deplete service flows.	Download version –Modelling ARIES Explorer –Modelling (online interface)	Secondary data (modelled or post-processed primary data)	http://aries.integrated-modelling.org/
Benefit Transfer Toolkit	U.S. Geological Survey	This toolkit compiles economic values estimates and other information on resources not priced in conventional markets. It includes nonmarket valuation databases, statistical forecasting models, and a recreation activities map for the US.	Database of spatial information	Secondary data (modelled or post-processed primary data)	https://my.usgs.gov/benefit-transfer/
Co$ting Nature	Kings College London; AmbioTEK; UNEP-WCMC	Co$ting Nature is a web-based tool for natural capital accounting and analysing the ecosystem services provided by natural environments, identifying the beneficiaries of these services and assessing the impacts of human interventions. It is a testbed for the development and implementation of conservation strategies focused on sustaining and improving ecosystem services. It also focused on enabling the intended and unintended consequences of development actions on ecosystem service provision to be tested in silico before they are tested in vivo.	Modelling (online interface)	Secondary data (modelled or post-processed primary data)	http://www.policysupport.org/costingnature
Coastal Resilience Decision Support Tools	The Nature Conservancy	The Coastal Resilience decision support system includes a visualization platform where ecological, social and economic information can be viewed alongside sea level rise and storm surge scenarios in specific geographies. In addition, a modular, configurable plugin architecture allows specific geographies to have apps designed specifically for geo-processing and display.	Database of spatial information	Primary spatial data	http://coastalresilience.org/tools/

Name	Overview				
	Provider name	Description	Tool type	Data type	Link
Collect Earth	SERVIR (a joint NASA and USAID programme) and the FAO.	Collect Earth Online is a high-resolution satellite image viewing system for use in projects that require land cover and/or land use reference data. It uses Google Earth's interface to facilitate assessment of deforestation and other forms of land use change by synchronizing high resolution satellite imagery from Google Earth, Bing Maps and Google Earth Engine. It is available for download, or can be used as Collect Earth Online.	Download version – Modelling Collect Earth Online – Modelling (online interface)	Primary spatial data	Download: http://www.openforis.org/tools/collect-earth.html Collect Earth Online: http://collect.earth/home
Earth Online	European Space Agency	ESA distributes Earth observation data from ESA EO Missions, Third Party Missions (TPMs), ESA Campaigns, the Copernicus Space Component (CSC), as well as sample and auxiliary data from a number of missions and instruments. Data distributed by ESA is available under different data policies and by various access mechanisms.	Database of spatial information	Primary spatial data	https://earth.esa.int/web/guest/data-access/how-to-access-esa-data
Ecosystem Valuation Toolkit (EVT)	Earth Economics	A comprehensible, searchable database of ecosystem service values. The EVT holds thousands of values gleaned from ecosystem service value databases and peer-reviewed academic journals, and the tool is constantly updated to keep on the cutting edge of this rapidly evolving field.	Database of non-spatial information	Primary non-spatial data	http://www.eartheconomics.org/ecosystem-valuation-toolkit/
ENCORE (Exploring Natural Capital Opportunities, Risks and Exposure)	Natural Capital Finance Alliance (NCFA)	A tool to help users better understand and visualize the impact of environmental change on the economy. By focusing on the goods and services that nature provides to enable economic production, it guides users in understanding how businesses across all sectors of the economy depend on nature, and how these dependencies might represent a business risk if environmental degradation disrupts them.	Database of non-spatial information Database of spatial information	Primary non-spatial data Primary spatial-data Secondary data (modelled or post-processed primary data)	https://encore.natural-capital.finance/

Name	Overview				
	Provider name	Description	Tool type	Data type	Link
Environmental Value Look-Up (EVL) Tool	Economics for the Environment Consultancy, developed for UK Government Department for Environment, Food and Rural Affairs (DEFRA)	The Environmental Value Look-Up (EVL) Tool is a searchable database which contains indicative monetary values for a range of environmental impacts. The unit values in the tool are based on a review of over 350 UK valuation studies that have been conducted since 2000.	Database of non-spatial information	Primary non-spatial data	https://www.eftec.co.uk/project/%20%09environmental-value-look-evl-tool
ENVISION	Oregon State University	A GIS-based tool for scenario-based community and regional integrated planning and environmental assessments. It provides a robust platform for integrating a variety of spatially explicit models of landscape change processes and production for conducting alternative futures analyses. ENVISION includes a powerful "multiagent modelling" subsystem that allows for the representation of human decision makers in landscape simulations. Envision "actors" make management decisions in parallel with landscape change models using a variety of decision models that can reflect actor values and incorporate landscape feedbacks.	Modelling (GIS plug-in)	Secondary data (modelled or post-processed primary data)	http://envision.bioe.orst.edu/
IBAT (Integrated Biodiversity Assessment Tool)	UNEP-WCMC; BirdLife International; Conservation International; IUCN	IBAT is a database compiling geographic data about global biodiversity in an easy-to-use online decision support and mapping tool.	Database of spatial information, coupled with data visualization tool	Primary spatial data	https://ibat-alliance.org/
InVEST (Integrated Valuation of Ecosystem Services and Trade-offs)	Natural Capital Project (Stanford University, The Nature Conservancy, World Wildlife Fund, University of Minnesota)	InVEST is a suite of free, open-source software models used to map and value the goods and services from nature that sustain and fulfil human life. InVEST enables users to assess trade-offs associated with alternative management choices and to identify areas where investment in natural capital can enhance human development and conservation.	Modelling (GIS plug-in)	Secondary data (modelled or post-processed primary data)	https://naturalcapitalproject.stanford.edu/invest/

Name	Overview				
	Provider name	Description	Tool type	Data type	Link
i-Tree Eco	i-Tree	i-Tree is a software application designed to use data collected in the field from single trees, complete inventories or randomly located plots throughout a study area along with local hourly air pollution and meteorological data to quantify forest structure, environmental effects and the value to communities.	Modelling	Secondary data (modelled or post-processed primary data)	https://www.itreetools.org/eco/
LUCI (Land Utilisation Capability Indicator)	Bethanna Jackson *et al.*, Victoria University of Wellington, New Zealand	LUCI is an ecosystem services modelling tool which illustrates the impacts of land use on various ecosystem services. It runs at fine spatial scales and compares the current services provided by the landscape with estimates of their potential capability. LUCI uses this information to identify areas where landscape usage change might be beneficial, and where maintenance of the status quo might be desirable.	Modelling (GIS plug-in)	Secondary data (modelled or post-processed primary data)	https://www.lucitools.org/
Moabi	Moabi, partnered with the World Resources Institute and the Carter Center (and local partners in the Democratic Republic of Congo)	Moabi are a non-governmental organization, who provide an online mapping tool for tracking information spatially. The tool works as a collaborative mapping system that builds a community of users to share, edit, and discuss issues that could affect the sustainability of critical ecosystems. Moabi uses crowdsourcing to find and update information related to existing and planned development activity. Moabi RDC is the first Moabi-based website, which aims to support civil society participation in the planned forest carbon market (REDD+) in the Democratic Republic of Congo.	Database of spatial information, coupled with data visualization tool	Primary spatial data	http://rdc.moabi.org/en/

Name	Overview				
	Provider name	Description	Tool type	Data type	Link
Natural Capital Asset Map and Decision Support Tool	Colorado State Forest Service, United States Environmental Protection Agency, US Forest Service Department of Agriculture, Urban Waters Partnership	The natural capital asset map, maps and valuates (ecosystem services valuation) the natural assets of the South Platte River watershed based on stakeholder identified assets of greatest importance (Natural Assets of Importance). The prioritization decision support tool supports stakeholder identified project prioritization based on the natural capital and ecosystem services valuation identified through the project.	Database of spatial information, coupled with data visualization tool	Secondary data (modelled or post-processed primary data)	https://pg-cloud.com/NaturalCapital/
NCPT (Natural Capital Planning Tool)	The Consultancy for Environmental Economics and Policy	The Natural Capital Planning Tool (NCPT) is a free site assessment tool developed specifically for the planning context. The NCPT allows the indicative but systematic assessment of the likely impact of proposed plans and developments on Natural Capital and the ecosystem services it provides to people such as recreational opportunities, air quality regulation and climate regulation.	Modelling	Secondary data (modelled or post-processed primary data)	http://ncptool.com/
NEVO (Natural Capital Valuation Online) Tool	The Land, Environment, Economics and Policy Institute, University of Exeter, in partnership with the UK Government Department for Environment, Food and Rural Affairs (DEFRA)	NEVO is a map-based decision support tool to inform decisions that affect the natural environment or England and Wales. It uses environmental and economic models to assess the value of ecosystem services relating to agriculture, recreation, forestry, carbon emissions, biodiversity and water quantity/quality.	Modelling (online interface)	Secondary data (modelled or post-processed primary data)	https://catchmentbasedapproach.org/learn/natural-capital-valuation-online-nevo-tool/
OPAL (Offset Portfolio Analyzer and Locator)	Natural Capital Project (Stanford University, The Nature Conservancy, World Wildlife Fund, University of Minnesota)	OPAL enables users to estimate the impacts of development activities on terrestrial ecosystems and several of the services they provide, and then to select offsets to efficiently mitigate losses. OPAL combines ecological and social data with the Natural Capital Project's InVEST ecosystem service models.	Modelling (GIS plug-in)	Secondary data (modelled or post-processed primary data)	http://130.211.163.122/opal_download.html

Name	Overview				
	Provider name	Description	Tool type	Data type	Link
ORVal (Outdoor Recreation valuation tool)	The Land, Environment, Economics and Policy Institute, University of Exeter	ORVal reports values and visit estimates for existing and new greenspaces that are derived from a sophisticated model of recreational demand in England and Wales. These numbers are predictions of a model and not actual counts of visits to a particular greenspace or actual measures of the welfare which that greenspace provides.	Modelling (online interface)	Secondary data (modelled or post-processed primary data)	https://www.leep.exeter.ac.uk/orval/
Resource Watch	World Resources Institute	Resource watch is a data visualization platform that serves as a repository for the world's best available data. It contains more than 200 datasets on diverse data related to the environment. Users can view data, share their own data, and create unique visualizations by overlaying datasets.	Database of spatial information, coupled with data visualization tool	Primary spatial data	https://resourcewatch.org/
SENCE (Spatial Evidence for Natural Capital Evaluation)	Environmental Systems	The Spatial Evidence for Natural Capital Evaluation (SENCE) tool uses spatial data and scientific knowledge to model ecosystem services. The maps show natural capital which is the existing value of the environment. SENCE modelling also shows the best places to enhance these services.	Modelling (GIS plug-in)	Secondary data (modelled or post-processed primary data)	https://www.envsys.co.uk/news/introducing-sence/
SolVES (Social Values for Ecosystem Services)	United States Geological Survey Geosciences and Environmental Change Science Center	A GIS Application for Assessing, Mapping, and Quantifying the Social Values of Ecosystem Services.	Modelling (GIS plug-in)	Secondary data (modelled or post-processed primary data)	https://www.usgs.gov/centers/gecsc/science/social-values-ecosystem-services-solves?qt-science_center_objects=0#qt-science_center_objects
Trends Earth	Conservation International	A platform for monitoring land change using earth observations in an innovative desktop (QGIS plugin) and cloud-based system.	Modelling (GIS plug-in)	Primary spatial data	http://trends.earth/docs/en/

Name	Overview				
	Provider name	Description	Tool type	Data type	Link
UN Biodiversity Lab	United Nations Development Programme (UNDP); United Nations Environment Programme (UNEP)	An online platform that allows policymakers and other partners to access global data layers, upload and manipulate their own datasets, and query multiple datasets to provide key information on the Aichi Biodiversity Targets and nature-based Sustainable Development Goals.	Database of spatial information, coupled with data visualization tool	Primary spatial data	https://unbiodiversitylab.org/
UNdata	United Nations Statistics Division (UNSD)	UNdata is a web-based data service for the global user community. It brings international statistical databases within easy reach of users through a single-entry point. Users can search and download a variety of statistical resources compiled by the UN statistical system and other international agencies. The numerous databases or tables collectively known as "datamarts" contain over 60 million data points and cover a wide range of statistical themes including agriculture, crime, communication, development assistance, education, energy, environment, finance, gender, health, labour market, manufacturing, national accounts, population and migration, science and technology, tourism, transport and trade.	Database of non-spatial information	Primary non-spatial data	http://data.un.org/
United Nations Global SDG Database	United Nations Statistics Division (UNSD)	This is the official website of the United Nations, which provides information on the development and implementation of an indicator framework for the follow-up and review of the 2030 Agenda for Sustainable Development. This platform provides access to data compiled through the UN system in preparation for the Secretary-General's annual report on "Progress towards the Sustainable Development Goals".	Database of non-spatial information	Primary non-spatial data	https://unstats.un.org/sdgs/indicators/database
Viridian	Viridian Logic	Viridian is an in-house tool run on a consultancy basis that shows what type of habitat to create and where to create it in order to provide nature-based solutions to local problems.	Modelling	Secondary data (modelled or post-processed primary data)	https://viridianlogic.com/

A.2 PURPOSE AND VERSIONS

Name	Purpose		Versions			
	Target applications	Target audience	Current version	Other supported versions	Version history	Future updates
ARIES (Artificial Intelligence for Ecosystem Services)	Research Supporting policy and/or decision-making	General decision makers Planners and/or developers Researchers	ARIES standalone k.LAB software tool environment	No other versions supported	ARIES started in 2007, with demonstration, proof-of-concept and test releases available from 2008. A prototype web tool was available in 2012. The modelling platform technology (k.LAB) underlying ARIES is under constant development.	The main user interface for ARIES will be a web interface called ARIES explorer, which is expected to be available in 2019.
Benefit Transfer Toolkit	Environmental-economic accounting Spatial planning	Planners and/or developers Researchers	Online version	No other versions supported	The USGS Benefit Transfer Toolkit builds upon the Benefit Transfer and Use Estimating Model Toolkit originally developed at Colorado State University.	Unknown
Co$ting Nature	Environmental-economic accounting Natural capital assessments Research	Conservationists Government policymakers Researchers	Version 3	No other versions supported	Version 1, 2009 Version 2, 2011	Unknown
Coastal Resilience Decision Support Tools	Spatial planning Supporting policy and/or decision-making	Government policymakers Planners and/or developers Private sector	Apps adding functionality under continuous development	No other versions supported	Apps adding functionality under continuous development	Apps adding functionality under continuous development
Collect Earth	Assessing land use and/or land use change Reporting against international commitments	Not stated	Version 1.7.9 available for download Collect Earth Online available online	No other versions supported	Version 1.1.1 released 2015; frequent updates made to download and online versions	Unknown
Earth Online	Not stated	Not stated	Online database		Unknown	Unknown

Name	Purpose		Versions			
	Target applications	Target audience	Current version	Other supported versions	Version history	Future updates
Ecosystem Valuation Toolkit (EVT)	Environmental-economic accounting Spatial planning Supporting policy and/or decision-making	Specific organization - Earth Economics	Unknown	Unknown	Unknown	Unknown
ENCORE (Exploring Natural Capital Opportunities, Risks and Exposure)	Environmental-economic accounting Increasing information transparency and/or public engagement	Financial institutions	Online version	No other versions supported	First online version released December 2018, covering business dependencies on nature	Information on business impacts on nature scheduled to be added to the online tool in April 2019
Environmental Value Look-Up (EVL) Tool	Supporting policy and/or decision-making	Specific organization - UK Government Department for Environment, Food and Rural Affairs (DEFRA)	v4 - October 2015	No other versions supported	Unknown	Unknown
ENVISION	Natural capital assessments Spatial planning	Government policymakers Private sector	Unknown	Unknown	Unknown	Unknown
IBAT (Integrated Biodiversity Assessment Tool)	Spatial planning	Conservationists Private sector Researchers Specific organization - World Bank Group	IBAT 3.0	No other versions supported	Three versions were supported until January 2019: IBAT for World Bank Group; IBAT for Research and Conservation; and IBAT for Business	Under constant maintenance
InVEST (Integrated Valuation of Ecosystem Services and Trade-offs)	Spatial planning Supporting policy and/or decision-making	Conservationists Financial institutions Government policymakers Private sector	InVEST 3.6.0	No other versions supported	Version 1.0 released 13/10/2008 Version 2.0 released 16/02/2011 Version 3.0 released 24/03/2014 Version 3.6.0 released 01/02/2019	Model in development for “Urban InVEST”

Name	Purpose		Versions			
	Target applications	Target audience	Current version	Other supported versions	Version history	Future updates
i-Tree Eco	Research Supporting policy and/or decision-making	Government policy-makers Researchers	i-Tree Eco v6	i-Tree Eco v5	Unknown	Unknown
LUCI (Land Utilisation Capability Indicator)	Increasing information transparency and/or public engagement Research Spatial planning Supporting policy and/or decision-making	Farmers Government policymakers Planners and/or developers Public Researchers	Not yet released for general use; a small number of external users are being supported	No other versions supported	No previous versions	Timeline for tool's release currently unavailable
Moabi	Increasing information transparency and/or public engagement	Public	Beta testing monitoring natural resource use in the Demographic Republic of Congo at rdc.moabi.org	No other versions supported	No previous versions	Moabi RDC is the first Moabi-based website; the tool could potentially be rolled out across other locations and sectors in the future
Natural Capital Asset Map and Decision Support Tool	Spatial planning	Not stated	Unknown	Unknown	Unknown	Unknown
NCPT (Natural Capital Planning Tool)	Spatial planning	Government policymakers Planners and/or developers Private sector	NCPT v1.4	No other versions supported	NCPT version 1.4 was published in February 2019 The NCPT was first published in March 2018	There are plans to develop a NCPT2, with the ambition to harmonize with related tools and approaches developed/commissioned by Natural England such as the Biodiversity Offsetting approach
NEVO (Natural Capital Valuation Online) Tool	Increasing information transparency and/or public engagement	Not stated	The NEVO team are currently seeking case studies to test out the tool and report back on how it works in practice	No other versions supported	No previous versions	Date of release unknown

Name	Purpose		Versions			
	Target applications	Target audience	Current version	Other supported versions	Version history	Future updates
OPAL (Offset Portfolio Analyzer and Locator)	Increasing information transparency and/or public engagement Spatial planning	Government policymakers Planners and/or developers Private sector	OPAL 1.0.3	No other versions supported	OPAL 1.0.0 released 3 December 2014 OPAL 1.0.1 released 17 December 2014 OPAL 1.0.2 released 20 January 2015 OPAL 1.0.3 released 22 March 2015	Unknown
ORVal (Outdoor Recreation valuation tool)	Assessing land use and/or land use change Spatial planning	Government policymakers Private sector Public	Version 2.0	Version 1.0	Unknown	Unknown
Resource Watch	Increasing information transparency and/or public engagement Research Supporting policy and/or decision-making	Government policymakers Journalists Private sector Public	Currently in Beta testing, online	No other versions supported	No previous versions	Unknown
SENCE (Spatial Evidence for Natural Capital Evaluation)	Natural capital assessments Spatial planning	Government policymakers Private sector	Unknown	Available in English and Spanish	Published April 2014	Unknown
SolVES (Social Values for Ecosystem Services)	Natural capital assessments Supporting policy and/or decision-making	Government policymakers Private sector Researchers	SolVES 3.0 Requires ArcGIS 10	No other versions supported	SolVES 1.0 (ArcGIS 9.3) - 2010 SolVES 2.0 (ArcGIS 9.3) - 2012 SolVES 2.1 (ArcGIS 10 - 10.3) SolVES 3.0 (ArcGIS 10 - 10.3) - 2015	Unknown
Trends Earth	Assessing land use and/or land use change Reporting against international commitments	Financial institutions Government policymakers Public	0.63 (stable version) Compatible with QGIS version 2.18	Development version	Formerly called the Land Degradation Monitoring Toolbox	A version compatible with QGIS 3.0 will be released with future iterations of the project

Name	Purpose		Versions			
	Target applications	Target audience	Current version	Other supported versions	Version history	Future updates
UN Biodiversity Lab	Assessing land use and/or land use change Reporting against international commitments Spatial planning Supporting policy and/or decision-making	Government policymakers	Released late 2018 and continuously adding new data and new layers that can be viewed through an online platform	No other versions supported	Continuously adding new data and new layers that can be viewed through an online platform	Continuously adding new data and new layers that can be viewed through an online platform
UNdata	Increasing information transparency and/or public engagement	Public	Continuously adding new data that can be viewed through an online platform	No other versions supported	Launched as part of the "Statistics as a Public Good" project in 2005	Continuously adding new data that can be viewed through an online platform
United Nations Global SDG Database	Reporting against international commitments	Government policymakers	Continuously adding new data that can be viewed through an online platform	No other versions supported	Unknown	Continuously adding new data that can be viewed through an online platform
Viridian	Natural capital assessments Spatial planning	Government policymakers Planners and/or developers Private sector	Unknown	Unknown	Viridian Logic were formed in 2016	Unknown

A.3 ACCESS AND DOCUMENTATION

Name	Access				Documentation	
	Open access	Free	Access levels	Access levels information	User guides	Methodology
ARIES (Artificial Intelligence for Ecosystem Services)	Yes - full functionality	Yes - free	No - single level of functionality for all users	N/A	Yes	Yes
Benefit Transfer Toolkit	Yes - full functionality	Yes - free	No - single level of functionality for all users	N/A	No	N/A - not a modelling tool
Co$ting Nature	Yes - limited functionality	Varies with access level	Yes - different levels of functionality available	Scientist user level - free for non-commercial uses Super user - licensed Hyper user - licensed Mega user - licensed	Yes	Yes
Coastal Resilience Decision Support Tools	Yes - full functionality	Yes - free	No - single level of functionality for all users	N/A	Yes	N/A - not a modelling tool
Collect Earth	Yes - full functionality	Yes - free	No - single level of functionality for all users	N/A	Yes	Yes
Earth Online	Yes - some datasets require submission of project proposal	Yes - some datasets require submission of project proposal	Yes	Free and restrained dataset, both freely available in most cases but restrained data requires submission of project proposal	Yes	N/A - not a modelling tool
Ecosystem Valuation Toolkit (EVT)	No - for internal Earth Economics use only	Unknown	Unknown	N/A	No	N/A - not a modelling tool
ENCORE (Exploring Natural Capital Opportunities, Risks and Exposure)	Yes - full functionality	Yes - free	No - single level of functionality for all users	N/A	No	Yes
Environmental Value Look-Up (EVL) Tool	Yes - full functionality	Yes - free	No - single level of functionality for all users	N/A	Yes	N/A - not a modelling tool
ENVISION	Yes - full functionality	Yes - free	No - single level of functionality for all users	N/A	Yes	Yes

Name	Access				Documentation	
	Open access	Free	Access levels	Access levels information	User guides	Methodology
IBAT (Integrated Biodiversity Assessment Tool)	Yes - limited functionality	Varies with access level	Yes - different levels of functionality available	Free ($0) Basic ($5,000) Pro ($15,000) Enterprise (tbc)	Yes	N/A - not a modelling tool
InVEST (Integrated Valuation of Ecosystem Services and Trade-offs)	Yes - full functionality	Yes - free	No - single level of functionality for all users	N/A	Yes	Yes
i-Tree Eco	Yes - full functionality	Yes - free	No - single level of functionality for all users	N/A	Yes	Yes
LUCI (Land Utilisation Capability Indicator)	Unknown	Unknown	Unknown	Unknown	No - may become available once tool released for general use	No - may become available once tool released for general use
Moabi	Yes - full functionality	Yes - free	No - single level of functionality for all users	N/A	Yes	N/A - not a modelling tool
Natural Capital Asset Map and Decision Support Tool	Yes - full functionality	Yes - free	No - single level of functionality for all users	N/A	Yes	N/A - not a modelling tool
NCPT (Natural Capital Planning Tool)	Yes - full functionality	Yes - free (although the Consultancy for Environmental Economics and Policy can run the tool for a cost)	No - single level of functionality for all users	N/A	Yes	Yes
NEVO (Natural Capital Valuation Online) Tool	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
OPAL (Offset Portfolio Analyzer and Locator)	Yes - full functionality	Yes - free	No - single level of functionality for all users	N/A	Yes	Yes
ORVal (Outdoor Recreation valuation tool)	Yes - full functionality	Yes - free	No - single level of functionality for all users	N/A	Yes	Yes
Resource Watch	Yes - full functionality	Yes - free	No - single level of functionality for all users	N/A	Yes	N/A - not a modelling tool

Name	Access				Documentation	
	Open access	Free	Access levels	Access levels information	User guides	Methodology
SENCE (Spatial Evidence for Natural Capital Evaluation)	No	No - financial cost	No - single level of functionality for all users	N/A	No	No
SolVES (Social Values for Ecosystem Services)	Yes - full functionality	Yes - free	No - single level of functionality for all users	N/A	Yes	Yes
Trends Earth	Yes - full functionality	Yes - free	No - single level of functionality for all users	N/A	Yes	Yes
UN Biodiversity Lab	Yes - full functionality	Yes - free	No - single level of functionality for all users	N/A	Yes	N/A - not a modelling tool
Undata	Yes - full functionality	Yes - free	No - single level of functionality for all users	N/A	No	N/A - not a modelling tool
United Nations Global SDG Database	Yes - full functionality	Yes - free	No - single level of functionality for all users	N/A	No	N/A - not a modelling tool
Viridian	No	No - financial cost	No - single level of functionality for all users	N/A	No	No

A.4 DATA AND INDICATORS

Name	Data					Indicators	
	Input type	Output type	Quantified outputs	Monetary outputs	Spatial outputs	Biophysical	Socioeco-nomic
ARIES (Artificial Intel-ligence for Ecosystem Services)	Earth observation data Spatial data	Maps (GIS) Maps (online) Numeric data Reports	Yes	No	Yes	Yes	Yes
Benefit Transfer Toolkit	Selection from tool interface	Maps (online) Numeric data	Yes	Yes	Yes	No	Yes
Co$ting Nature	Spatial data	Maps (GIS) Maps (online) Numeric data	Yes	No	Yes	Yes	No
Coastal Resilience Decision Support Tools	Selection from tool interface	Maps (online) Numeric data Reports	Yes	Yes	Yes	Yes	Yes
Collect Earth	Earth observation data Selection from tool interface	Maps (online) Maps (image files) Numeric data	Yes	No	Yes	Yes	No
Earth Online	Selection from tool interface	Earth observation data	No	No	Yes	Yes	No
Ecosystem Valuation Toolkit (EVT)	Unknown	Numeric data	Yes	Yes	Unknown	Unknown	Unknown
ENCORE (Exploring Natural Capital Oppor-tunities, Risks and Exposure)	Selection from tool interface	Maps (online) Numeric data Recommen-dations and/or guidance	No	No	Yes	Yes	Yes
Environmental Value Look-Up (EVL) Tool	Selection from tool interface Site field data	Numeric data Reports	Yes	Yes	No	No	Yes
ENVISION	Spatial data	Maps (GIS)	Yes	Yes	Yes	Yes	Yes
IBAT (Integrated Biodi-versity Assessment Tool)	Selection from tool interface	Maps (image files) Maps (online) Numeric data Reports	Yes	No	Yes	Yes	No
InVEST (Integrated Valuation of Ecosys-tem Services and Trade-offs)	Spatial data	Maps (GIS) Maps (image files)	Yes	Yes	Yes	Yes	Yes
i-Tree Eco	Site field data	Numeric data Reports	Yes	No	No	Yes	No
LUCI (Land Utilisation Capability Indicator)	Spatial data	Maps (GIS) Numeric data Recommenda-tions/guidance	Yes	No	Yes	Yes	No

Name	Data					Indicators	
	Input type	Output type	Quantified outputs	Monetary outputs	Spatial outputs	Biophysical	Socioeco-nomic
Moabi	Spatial data Selection from tool interface	Maps (image files) Maps (online) Reports	No	No	Yes	Yes	Yes
Natural Capital Asset Map and Decision Support Tool	Selection from tool interface	Maps (online)	Yes	Yes	Yes	No	Yes
NCPT (Natural Capital Planning Tool)	Site field data	Numeric data	Yes	No	No	Yes	Yes
NEVO (Natural Capital Valuation Online) Tool	Selection from tool interface	Unknown	Yes	Unknown	Unknown	Unknown	Unknown
OPAL (Offset Portfolio Analyzer and Locator)	Spatial data	Recommendations and/or guidance	No	No	Yes	Yes	Yes
ORVal (Outdoor Recrea-tion valuation tool)	Selection from tool interface	Numeric data	Yes	Yes	Yes	Yes	Yes
Resource Watch	Selection from tool interface	Maps (online)	Yes	Yes	Yes	Yes	Yes
SENCE (Spatial Evidence for Natural Capital Evaluation)	Spatial data	Maps (GIS) Numeric data Recommenda-tions and/or guidance	Yes	Unknown	Yes	Yes	Yes
SolVES (Social Values for Ecosystem Services)	Spatial data	Maps (GIS) Numeric data	Yes	No	Yes	Yes	Yes
Trends Earth	Earth observation data	Maps (GIS) Numeric data	No	No	Yes	Yes	No
UN Biodiversity Lab	Selection from tool interface	Maps (online)	Yes	Yes	Yes	Yes	Yes
UNdata	Selection from tool interface	Numeric data	Yes	Yes	No	Yes	Yes
United Nations Global SDG Database	Selection from tool interface	Numeric data	Yes	No	No	Yes	Yes
Viridian	Spatial data	Maps (GIS) Maps (image files) Numeric data Recommendations and/or guidance	Yes	Yes	Yes	Yes	Yes

A.5 ECOSYSTEM SERVICES

Name	Ecosystem services					
	Supporting	Regulating	Provisioning	Cultural	Specific information	Focus areas
ARIES (Artificial Intelligence for Ecosystem Services)	Yes	Yes	Yes	Yes	Yes - specific information	Varies with dataset
Benefit Transfer Toolkit	No	No	No	Yes	Yes - specific information	Varies with dataset
Co$ting Nature	Yes	Yes	Yes	Yes	Yes - specific information	Timber (softwood, hardwood), Fuelwood (softwood, hardwood), Grazing/fodder, Non-wood forest products, Water provisioning (quantity, quality), Fish catch, Carbon, Natural hazard mitigation (flood, drought, landslide, coastal inundation), Culture-based tourism, Nature-based tourism services, Environmental and aesthetic quality services, Wildlife services (pollination, pest control), Wildlife dis-services (crop raiding, pests), Biodiversity, Pressure and threat
Coastal Resilience Decision Support Tools	No	Yes	No	No	Yes - specific information	Coastal protection
Collect Earth	No	No	No	No	No - general or aggregated information	N/A
Earth Online	No	No	No	No	No	No
Ecosystem Valuation Toolkit (EVT)	Yes	Yes	Yes	Yes	Yes - specific information	Varies with dataset
ENCORE (Exploring Natural Capital Opportunities, Risks and Exposure)	No	Yes	Yes	Yes	Yes - specific information	Animal-based energy, Bio-remediation, Buffering and attenuation of mass flows, Climate regulation, Dilution by atmosphere and ecosystems, Disease control, Fibres and other materials, Filtration, Flood and storm protection, Genetic materials, Ground water, Maintain nursery habitats, Mass stabilization and erosion control, Mediation of sensory impacts, Pest control, Pollination, Soil quality, Surface water, Ventilation, Water flow maintenance, Water quality
Environmental Value Look-Up (EVL) Tool	Yes	Yes	Yes	Yes	No - general or aggregated information	N/A
ENVISION	Yes	Yes	Yes	Yes	No - general or aggregated information	N/A

Name	Ecosystem services					
	Supporting	Regulating	Provisioning	Cultural	Specific information	Focus areas
IBAT (Integrated Biodiversity Assessment Tool)	No	No	No	No	No - general or aggregated information	N/A
InVEST (Integrated Valuation of Ecosystem Services and Trade-offs)	Yes	Yes	Yes	Yes	Yes - specific information	Carbon, Coastal blue carbon, Coastal vulnerability, Crop pollination, Fisheries, Habitat quality, Habitat risk assessment, Marine fish aquaculture, Offshore wind energy, Recreation, Reservoir hydropower production (water yield), Scenic quality, Sediment retention, Water purification, Wave energy
i-Tree Eco	No	Yes	No	Yes	Yes - specific information	Pollution removal and human health impacts, carbon sequestration and storage, hydrology effects (avoided run-off, interception, transpiration), building energy effects, tree bio-emissions, wildlife suitability (plot-based projects; limited to 9 bird species), ultraviolet radiation (UV) tree effects
LUCI (Land Utilisation Capability Indicator)	Yes	Yes	Yes	No	Yes - specific information	Agricultural production, Erosion risk and sediment delivery, Carbon sequestration, Flood mitigation, Habitat provision, Water quality - Nitrogen and phosphorus
Moabi	Yes	Yes	Yes	Yes	Yes - specific information	Varies with dataset
Natural Capital Asset Map and Decision Support Tool	Yes	Yes	Yes	Yes	Yes - specific information	Native forest resources, productive agricultural resources, wildlife habitat, clean drinking water, healthy waterways, access to nature, urban ecosystem resources & parks
NCPT (Natural Capital Planning Tool)	Yes	Yes	Yes	Yes	Yes - specific information	Harvested products, biodiversity, aesthetic values, recreation, water quality regulation, flood risk regulation, air quality regulation, local climate regulation, global climate regulation, soil contamination
NEVO (Natural Capital Valuation Online) Tool	Yes	Yes	Yes	Yes	Yes - specific information	Agriculture, recreation, forestry, carbon emissions, biodiversity, water quantity/quality
OPAL (Offset Portfolio Analyzer and Locator)	Yes	Yes	Yes	Yes	Yes - specific information	Includes modules to incorporate the results from InVEST carbon, sediment and nutrient retention ecosystem service models
ORVal (Outdoor Recreation valuation tool)	No	No	No	Yes	No - general or aggregated information	N/A
Resource Watch	Yes	Yes	Yes	Yes	Yes - specific information	Varies with dataset

Name	Ecosystem services					
	Supporting	Regulating	Provisioning	Cultural	Specific information	Focus areas
SENCE (Spatial Evidence for Natural Capital Evaluation)	Yes	Yes	Yes	Yes	Yes - specific information	Agricultural crops, agricultural livestock, energy, timber, soil carbon storage, vegetation carbon storage, sediment risk for water courses, water quality, pollination, land erosion risk, water quantity, biodiversity existing, biodiversity resilience networks, landscapes, local places/sense of place, historic and archaeological significance, recreation, aesthetic value
SolVES (Social Values for Ecosystem Services)	No	No	No	Yes	Yes - specific information	Varies with dataset
Trends Earth	Yes	Yes	No	No	Yes - specific information	Productivity, land cover, soil organic carbon
UN Biodiversity Lab	Yes	Yes	Yes	Yes	Yes - specific information	Varies with dataset
UNdata	Yes	Yes	Yes	Yes	Yes - specific information	Varies with dataset
United Nations Global SDG Database	Yes	Yes	Yes	Yes	Yes - specific information	Varies with dataset
Viridian	Yes	Yes	Yes	Yes	Yes - specific information	Water-flow services

A.6 SPATIAL INFORMATION

Name	Spatial information						
	Specific locations	Location	Terrestrial	Freshwater	Marine	Scale	Resolution
ARIES (Artificial Intelligence for Ecosystem Services)	No - global	N/A	Yes	Yes	Yes	Local/site Regional	Varies with dataset
Benefit Transfer Toolkit	Yes	U.S.	Yes	Yes	No	Regional	US region and state level information
Co$ting Nature	No - global	N/A	Yes	Yes	No	Local/site Regional National	1x1km or 1x1ha resolution provided by the tool; users can use their own datasets
Coastal Resilience Decision Support Tools	No - global	Most information currently available for North America and Australia	Yes	No	Yes	Local/site Regional	
Collect Earth	No - global	N/A	Yes	Yes	Yes	Local/site Regional	Google Earth - 15m resolution Landsat with some higher resolution imagery Bing Maps - imagery provided by Digital Globe from 3m to 30cm resolution Google Earth Engine - 30m resolution Landsat imagery
Earth Online	Varies with dataset	Varies with dataset	Yes	Yes	Yes	National International Global	Varies with dataset - 6m imagery minimum
Ecosystem Valuation Toolkit (EVT)	No - global	N/A	Yes	Unknown	Unknown	Local/site	Unknown
ENCORE (Exploring Natural Capital Opportunities, Risks and Exposure)	No - global	Particular focus on Columbia, South Africa, Peru and Indonesia	Yes	Yes	Yes	Regional National International Global	Varies with dataset
Environmental Value Look-Up (EVL) Tool	Yes	UK	Yes	Yes	Yes	Local/site	Site-level information
ENVISION	No - global	N/A	Yes	Yes	Yes	Dependent on user input data	Varies with dataset

Name	Spatial information						
	Specific locations	Location	Terrestrial	Freshwater	Marine	Scale	Resolution
IBAT (Integrated Biodiversity Assessment Tool)	No - global	N/A	Yes	Yes	Yes	Local/site Regional	Buffers around areas of biodiversity importance in 1km increments
InVEST (Integrated Valuation of Ecosystem Services and Trade-offs)	No - global	N/A	Yes	Yes	Yes	Local/site Regional National International Global	Varies with dataset
i-Tree Eco	Yes	Pre-processed data available for Canada, Australia, UK, Mexico, US	Yes	No	No	Local/site Regional	Individual tree to regional forests
LUCI (Land Utilisation Capability Indicator)	No - global	Applied most extensively to date in the United Kingdom and New Zealand	Yes	Yes	No	Local/site Regional National	5x5m to 10x10m data recommended
Moabi	No - global (but currently only applied in Democratic Republic of the Congo)	Currently applied in Democratic Republic of the Congo	Yes	Yes	Yes	Varies with dataset	Varies with dataset
Natural Capital Asset Map and Decision Support Tool	Yes	Colorado, South Platte River Watershed	Yes	Yes	No	Regional	Acre pixels
NCPT (Natural Capital Planning Tool)	Yes	England	Yes	Yes	No	Local/site	Varies with dataset
NEVO (Natural Capital Valuation Online) Tool	Yes	England and Wales	Yes	Yes	Unknown	Unknown	Unknown
OPAL (Offset Portfolio Analyzer and Locator)	No - global	N/A	Yes	No	No	Local/site	Varies with dataset
ORVal (Outdoor Recreation valuation tool)	Yes	England and Wales	Yes	Yes	No	Local/site Regional National	Site level information
Resource Watch	No - global	N/A	Yes	Yes	Yes	Varies with dataset	Varies with dataset
SENCE (Spatial Evidence for Natural Capital Evaluation)	Yes	Wales, Scotland and England	Yes	Yes	No	Local/site Regional	Unknown

Name	Spatial information						
	Specific locations	Location	Terres-trial	Freshwa-ter	Marine	Scale	Resolution
SolVES (Social Values for Ecosystem Services)	No - global	N/A	Yes	Yes	Yes	Dependent on user input data	Varies with dataset
Trends Earth	No - global	N/A	Yes	No	No	Dependent on user input data	Varies with dataset
UN Biodiversity Lab	No - global	N/A	Yes	Yes	Yes	National	Varies with dataset
UNdata	No - global	N/A	Yes	Yes	Yes	Varies with dataset	Varies with dataset, typically country-level information
United Nations Global SDG Database	No - global	N/A	Yes	Yes	Yes	National	Varies with dataset, typically country-level information
Viridian	Yes	UK	Yes	Yes	No	Local/site Regional	5m

A.7 TEMPORAL INFORMATION

Name	Temporal information			
	Set time point	Change over time	Backward-looking	Forward-looking
ARIES (Artificial Intelligence for Ecosystem Services)	Varies with dataset	Varies with dataset	Varies with dataset	Varies with dataset
Benefit Transfer Toolkit	Yes	No	N/A	N/A
Co$ting Nature	Yes	Yes	No	Yes
Coastal Resilience Decision Support Tools	Yes	Yes	Yes	Yes
Collect Earth	Yes	Yes	Yes	No
Earth Online	Yes	Yes	Yes	No
Ecosystem Valuation Toolkit (EVT)	Yes	Unknown	Unknown	Unknown
ENCORE (Exploring Natural Capital Opportunities, Risks and Exposure)	Yes	No	N/A	N/A
Environmental Value Look-Up (EVL) Tool	Yes	No	N/A	N/A
ENVISION	Yes	Yes	No	Yes
IBAT (Integrated Biodiversity Assessment Tool)	Yes	No	N/A	N/A
InVEST (Integrated Valuation of Ecosystem Services and Trade-offs)	Yes	No	N/A	N/A
i-Tree Eco	Yes	Yes	No	Yes
LUCI (Land Utilisation Capability Indicator)	Yes	Yes	No	Yes
Moabi	Varies with dataset	Varies with dataset	Varies with dataset	Varies with dataset
Natural Capital Asset Map and Decision Support Tool	Yes	No	N/A	N/A
NCPT (Natural Capital Planning Tool)	Yes	Yes	No	Yes
NEVO (Natural Capital Valuation Online) Tool	Yes	No	N/A	N/A

Name	Temporal information			
	Set time point	Change over time	Backward-looking	Forward-looking
OPAL (Offset Portfolio Analyzer and Locator)	Yes	No	N/A	N/A
ORVal (Outdoor Recreation valuation tool)	Yes	Yes	No	Yes
Resource Watch	Varies with dataset	Varies with dataset	Varies with dataset	Varies with dataset
SENCE (Spatial Evidence for Natural Capital Evaluation)	Yes	No	N/A	N/A
SolVES (Social Values for Ecosystem Services)	Varies with dataset	Varies with dataset	Varies with dataset	Varies with dataset
Trends Earth	Yes	Yes	Yes	No
UN Biodiversity Lab	Yes	Yes	Yes	Yes
UNdata	Yes	Yes	Yes	No
United Nations Global SDG Database	Yes	Yes	Yes	No
Viridian	Yes	Yes	No	Yes

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