UN environment

White paper:
Digital earth: Building, financing and governing a digital ecosystem for planetary data

UN Science-Policy-Business Forum on the Environment
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1. A digital ecosystem for planetary data

a) Now is the time for action

Today, the ongoing digital revolution is generating more information than ever before on the state of the planet. A combination of satellites, drones, mobile phones, sensors, financial transaction technologies and devices connected to the internet of things (IoT) are collecting real time data that could transform the management of earth's natural resources and ecosystems. Furthermore, advancements in official statistical processes and related social and economic data sets enable census and survey data to be geolocated so that demand for natural resources can be more accurately modelled and predicted.

A range of new technologies are also democratizing access to environmental data, allowing academics, students and citizen scientists to be directly engaged in data collection, analysis and dissemination to the global community.

All of the major technology companies are planning to compete around spatial information services – helping to connect people to place and products. The major technology titans are effectively in a race to digitize the planet and commercialize access to a range of geospatial services. New data management technologies, artificial intelligence, block chain, cloud computing and cloud storage of information are making it possible to manage, share, process and analyze large volumes of data in near real time. They also offer the possibly to help "green consumption" by offering consumers more real-time data on the environmental footprints of different products and on the social and environmental performance of their supply chains.

In summary, governments, companies, academics, citizens and international organizations are all directly contributing to an explosion in the availability of planetary scale data and changing the way that the world thinks about and uses information. This wealth of data is being generated at multiple scales across time and space allowing for monitoring of environmental change across communities, countries and continents. The level of access to spatialized information will be unprecedented.

The opportunity to use this data to improve real time decision making on natural resources could also transform global environmental governance frameworks and agreements. There is tremendous hope that decisions can be made, monitored and enforced using real time spatial and statistical data, thereby closing the gap between action and impact.

Indeed, it is the convergence of big data and frontier technologies that is unleashing the 4th industrial revolution. This new era is characterized by "*a range of new technologies that are fusing the physical, digital and biological worlds, impacting all disciplines, economies and industries, and even challenging ideas about what it means to be human*".[1]

The 4th industrial revolution provides an opportunity to transform the way environmental data is collected and managed, how major environmental trends, patterns, risks and opportunities are analyzed, how market transactions for environmental goods are conducted.

A recent UN report by the UN Secretary General's Independent Expert Advisory Group on a Data Revolution for Sustainable Development highlights the importance of data, calling it "the lifeblood of decision making." Without high quality data that is collected in a spatial context, it is almost impossible to design, monitor, and evaluate effective policies that can achieve the Sustainable Development Goals (SDGs).

As *information is becoming the world's most valuable resource*, there is an urgent need for governments, companies and citizens to consider how the digital ecosystem for planetary data will be governed. Indeed, the time to act is now – before decisions are taken which concentrate the governance of this planetary data in private hands without sufficient public access, transparency, accountability and quality control. We are at an important crossroads where decisions that we take today will influence the scope and shape of the planetary data ecosystem for the coming decades. This paper sets out some of the key governance challenges that must be addressed in the coming year to ensure planetary data can remain within a public-private data commons and be accessed by all governments and citizens as a global public good.

b) What's at stake?

A common vision is clearly needed for building an *open digital ecosystem of planetary data* that can generate trustworthy insights in real time about the state of the environment and interactions between the economy, society and the environment. These insights need to be transformed into actionable evidence that can be easily understood by decision-makers, investors, consumers and citizens alike to maximize inclusion, transparency and accountability.

Progress toward the SDGs will not only require utilizing new sources of data, but also an enhanced ability to bring together these data on the environment with relevant economic and social data. The ability to analyze real time information, as well as long term trends, is essential for ensuring a balance between the social, environmental and economic pillars of sustainable

[1] https://www.weforum.org/about/the-fourth-industrial-revolution-by-klaus-schwab

development. Policy options and trade offs need to be modelled and future scenarios need to be visualized in a compelling manner.

Planetary data is a continuum that consists of a mix of commercial data requiring payment to access together with free and open public data that is maintained as part of a global public good. However, the portion of data that is private versus public warrants debate as do the incentives that are needed to push as much private data as possible into the public domain. Indeed, to move towards achieving the SDGs on a planetary scale with environmental, social and economic considerations in mind, this envisioned data ecosystem must truly be open and inclusive. This means that the ecosystem must represent data from diverse social and technological systems, including from academic, commercial and official government sources, and also traditional ecological knowledge and citizen science.

Investments are essential for closing the gap between the *potential* for planetary data to be used in the implementation of SDGs, and the *actual capacity* of countries and citizens to access and use data for effective decision making and monitoring. The most notable gaps are found between developed and developing countries, between private companies and public agencies, and between urban and rural settings.

The stakes are high as the potential exists for massive information asymmetries to be exploited in a manner which amplifies existing inequalities and social grievances linked to management of natural resources. In short – information is power and those who control it could influence the future sustainability trajectory of our common planet.

c) The Role of the UN Science-Policy-Business Forum on the Environment

At no time in recent history has leadership been so critical in the global application of planetary data and frontier technologies. The time is now to move forward on using data for the sustainable management of natural resources and the environment using public-private partnerships.

An ambitious vision and multi-stakeholder process is needed to ensure planetary data becomes a global public good that can inform planning, decision-making, investing and impact monitoring in real time. This vision should be built through a consultative process among private companies, member states, academia and civil society.

In this regard, the UN Science-Policy-Business Forum on the Environment may offer a perfect opportunity to anchor such a process. Established during the 3rd UN Environmental Assembly in December 2017, the forum leverages the expertise of its members to provide support to priority issues, initiatives and projects that are relevant to UN Environment's mandate and critical to the implementation of the SDGs.

During the first meeting of the UN Science-Policy-Business Forum on the Environment in New York in May 2018, a working group was established on Data, Analytics and Artificial Intelligence. The working group aims to address the issues related to establishing an open digital ecosystem of planetary data and to demonstrate the utility of new data sources for environmental monitoring through specific examples and demonstration projects.

This white paper has been drafted by the working group of the UN Science-Policy-Business Forum on the Environment[2]. It is based on the outcomes of the first meeting of the Forum held in New York in May 2018. This paper aims to advance the ongoing dialogue with stakeholders to establish a vision and strategy to harness and deploy the power of the information age to solve global environmental challenges. In short, combining data with people and planet to achieve prosperity and peace. It is also a response to the request of the UN Secretary General for "*realizing the data revolution*". In particular, building a vision for UN Environment to leverage planetary data and frontier technologies to achieve key environmental outcomes in support of the 2030 agenda, the Paris Agreement on Climate Change and the Sendai Framework for Disaster Risk Reduction.

Against this background, this white paper seeks to achieve *four main objectives*.

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[2] The initial draft of this paper was co-authored by David Jensen (Co-director of the MapX platform for spatial environmental data) and Jillian Campbell (Chief Statistician) of UN Environment. Additional inputs were provided by Saiful Ridwan, Ben Simmons, Barbara Hendrie and Shereen Zorba of UN Environment. The technical team at MapX also provided comments. It was mandated by the working group of the UN Science-Policy-Business Forum on the Environment and by the UN Environment Chief Scientist, Mr. Jian Liu and by the Director of the Division Policy and Planning, Mr. Gary Lewis.

A) **Digital ecosystem for planetary data:** To help the members consider different strategic questions and trade-offs on the basic elements of a digital ecosystem for planetary data. These are divided into three areas: data generation and analytics, infrastructure and frontier technologies, and financing. Each of these areas will also touch upon cross-cutting issues linked to governance, transparency, privacy, international standards and capacity building.

B) **Incentives for data sharing and integration:** To provide strategic guidance on establishing a public-private planetary data commons that incorporates and integrates data from official statistics, including census and surveys, monitoring stations and government administrative data with data arising from remote sensing, citizen science, internet recorded transactions, etc. This will also explore incentives for data sharing and integration of diverse data sets.

C) **Pilot applications:** To identify and share pilot cases, partnerships and resources that could be leveraged toward operationalizing a digital ecosystem for planetary data toward the achievement of the environmental dimension of the SDGs.

D) **Uptake and scaling:** To provide a strategic vision toward improving the global uptake and use of planetary data for environmental management at the local, national and global levels, including the requirements related to building capacity for uptake.

It is intended that this draft paper be reviewed, iterated and endorsed through a stakeholder consultation process. It will eventually be adopted by the UN Science-Policy-Business Forum on the Environment at the planned meeting in October 2018.

2. Key components of the digital ecosystem of planetary data

Data can arise from many different sources. It can stem from academic research, from administrative data maintained by Government ministries (for example, education registers or environmental permits), from surveys and censuses carried out by Governments and from a variety of technologies, including, for example, satellites, sensors, drones, mobile phones, financial transactions and other digital devices.[3]

Different types of data span different geographic scales and time periods from the site level to the global level. Data can either be structured in a traditional database or unstructured. It includes a high diversity of data quality. And it can be generated by multiple actors including international organizations, governments, companies, academics and citizens. Some of the statistics in Table 1 showcase the volume data currently being generated. All data sources that are relevant to tackle environmental issues and the management of natural resources are being referred to in this paper as planetary data (Table 1 is a non-exhaustive list).

[3] This combination of data is often referred to as "big data" meaning data sets that are so large and complex that traditional data-processing software are inadequate to deal with them.

Table 1. Data volume generated by different technologies

Data source	Statistics
Satellites	1,738 Satellites in orbit in 2017 5,700 generated scenes per day (open source) Landsat archive 32 years – over 5 million scenes
Internet of Things (IoT)	IoT creates 400 zettabytes of data per year (1 zettabyte is 1,000,000,000,000 Gigabytes Or 2 billion years of uninterrupted music on spotify).
Sensors	15.4 billion sensors in 2015 75 billion by 2025
Mobile phones	5 billion unique mobile phones offering opportunities for geocoded data collection as well as daily movements
Mobile apps	3 million unique apps
Internet access	Over 4 billion people, 54% of population
Censuses and surveys	More than 7 billion people are covered by censuses every 10 years. A variety of surveys are conducted by all Governments around the world at varied periodicity.
Citizen science	Apps like iNaturalist have 10 million unique records, of which 3 million are considered verified observations
Publications and documents	A wealth of data is available in academic publications, corporate reports reports and other documents which can be made discoverable using web scrapping algorithms
Administrative data	Governments, utility companies, and other services providers maintain data related to registration, transaction and record keeping.
Finance data	Virtually all non-cash financial transactions are recorded.

The potential to use this range of planetary data for global environmental monitoring and governance is unprecedented. However, access to data alone is insufficient. A robust digital ecosystem is needed to transform that data into information, insights, indicators, investment decisions and impacts. The transformation process is depicted in Figure 1.

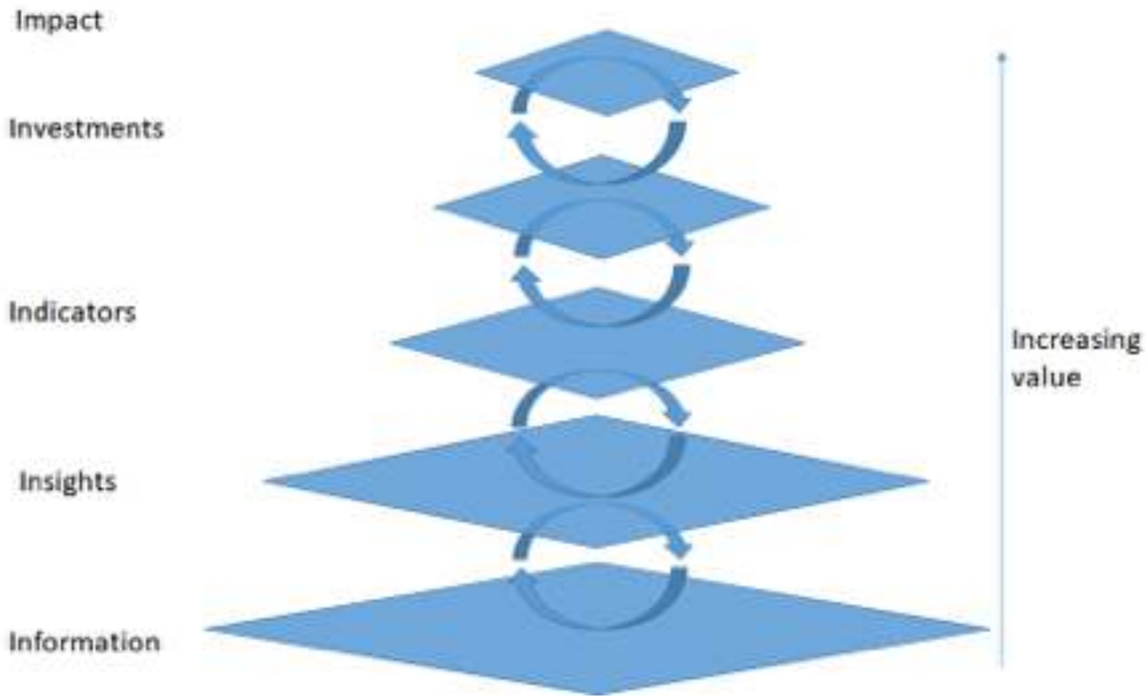

Figure 1: Transforming information into insights, indicators, investments and impact (Modified from Source: Andrew Zolli, Planet Labs presentation to the UN Science-Policy-Business Forum on the Environment, May 2018)

The digital ecosystem that is required for this transformation process can be understood as having an interlocking series of key building blocks that work together to produce a 'Flywheel Effect' (see Figure 2 below). The basic idea is that once an organization has all of the core technology pieces in place, they have an energy of their own that drives other positive changes and innovations.

While planetary data is the foundation of the digital ecosystem, it requires both processing infrastructure together with algorithms and analytics to extract relevant insights and business intelligence. Indeed, it is only when big data is coupled with analytical methods involving artificial intelligence and machine learning that it can be used to detect patterns, identify trends, determine interactions, optimize variables and make predictions. The question of who pays to build and maintain this data processing and analytical infrastructure is critical to consider.

Ideally, the analytical data is then made available through application programming interfaces (APIs) and web services for aggregation into higher level indicators. Alternatively, the data can be consumed directly by specific user applications to inform investment decisions and monitor impact.

The final applications and websites which consume data feeds and curates the data into specific user products are incredibly dynamic. These applications receive, remix and reshape multiple data streams in a manner where the data can "flow". Indeed, one of the goals is to give users the power to freely innovate, analyze and recombine data in ways that cannot be predicted.

Figure 2: Emerging ecosystem for planetary data and analytics consists of 5 flywheels (Modified from Source: Dr Lucas Joppa of Microsoft Research, Presentation at Eye on Earth Webinar, May 2018).

In understanding the ecosystem of planetary data, it is important to keep in mind that technology is only a means to an outcome - not the outcome itself. We need to keep at the forefront of the debate the sustainable development goals and understand how technology can enable their achievement. In this regard, the UN Science-Policy-Business Forum on the Environment needs to ask three major groups of questions on the potential benefits, risks and governance challenges linked to a new digital ecosystem for planetary data. These are covered in the next section.

3. Potential benefits, risks and governance challenges linked to planetary data

The emerging ecosystem of planetary data could potentially transform the way that environmental data is collected and managed, how major environmental trends, patterns, risks and opportunities are analyzed, and how market transactions for environmental goods are conducted. As with any technology, there are trade-offs to make in terms of addressing potential benefits, risks and governance challenges. The following section outlines some of the most important considerations.

a) What are the potential benefits?

The first question relates to the potential benefits that could flow to environmental stakeholders from increased access to a digital ecosystem for planetary data and related technologies. What are the main benefits and opportunities offered by the 4th industrial revolution for the environment? In no particular order, eight major benefits are worth exploring:

1. **More efficient and lower cost data processing technologies:** the processing of large global data sets can now happen at a fraction of the cost and time compared to a decade ago. For example, the Global Surface Water Explorer which uses a timelapse sequence of the Earth using Landsat satellite images takes around 2 million hours of computation time. This would have taken a single computer around 228 years to process - but today takes a parallel series of 66,000 computers in the cloud only 1.5 days to crunch. Today we have the ability to process data on a global scale to monitor the vital signs of the planet.

2. **Automated monitoring with near real time spatial data:** one of the largest potential benefits involves the ability to set up automated artificial intelligence algorithms that are applied to a combination of data feeds to monitor specific environmental issues and to automatically detect certain landuse changes or movements. For example, both Global Forest Watch and Global Fishing Watch offer regular global monitoring of deforestation and tracking of the global commercial fishing fleet respectively. Importantly, frontier technologies are generating huge amounts of spatial data that can be triangulated to monitor a range of different environmental trends across multiple scales. This offers the potential for earlier identification of risks and focused action.

3. **Improved transparency, data quality and data integration:** ensuring that methodologies, metadata and information about data integrity are publicly available and discoverable will provide assurance to users that they are using the best available data. Additionally, this will inform which data can be pulled together to create integrated

analysis across multiple datasets from multiple sources. For example, a highly useful analysis of potential risks to water security could arise from integrating environmental data on ecosystem cover with water quality data and geospatial population data and data on the location of industry.

4. **Accelerating transformation of science into policymaking and impact monitoring:** planetary data and analytics can provide an improved evidence-base for policy makers, in particular through modeling different policy options and developing forwarding looking scenarios. As the sources of data grow richer and more diverse, there are many ways to use the resulting insights to make decisions faster, more accurate, more consistent, and more transparent. For example, smart cities with full IoT capabilities can monitor air quality or hyper-local weather conditions.

5. **Increasing citizen engagement and co-creation of knowledge:** it is becoming apparent that professional science alone cannot provide information at the scales and resolutions necessary to understand environmental change. The new planetary data ecosystem offers tremendous opportunity for citizen science, local engagement and public participation in decision-making and compliance monitoring. Importantly, there can be a multidirectional exchange of data between scientists, citizens, governments and companies. The Blue Sky map app is a good example whereby real-time air quality data for 380 cities in China and pollution data from 9,000 companies can be accessed and then shared on social media to name and shame companies. The iNaturalist app is a crowd-sourced species identification system and occurrence recording tool, driven by citizen science with 10 million records.

6. **Engagement of the business community:** companies are becoming increasingly engaged in the evaluation of the sustainability and environmental soundness of their business processes, including through a dedicated SDG target on Corporate Sustainability Reporting (SDG target 12.6.1). Additionally, there is a growing recognition of the value of Corporate Sustainability Reporting for not only large multi-national companies but also small and medium size enterprises. The data and information contained in such reports can provide a wealth of information relevant for targeting policy interventions while helping to create incentives and awareness towards greener consumption.

7. **Enhancing investor and consumer awareness and transparency:** real time data on the environmental performance and the supply chains of different commodities and raw materials has the potential to dramatically influence investor and consumer awareness and behavior. There is huge potential to use data and artificial intelligence algorithms to help consumers make more informed product choices while also naming and shaming companies with poor environmental performance across their supply chains. For example, the Earth Accounting app enables consumers to access product information around the specific issues they are interested. Google and Facebook could also potentially use a combination of big data and AI to help consumers compare and select more sustainable products or offer "opt in" filters for advertising that is targeted towards

more environmentally friendly products. Thomson-Reuters are using big data to inform their Environmental, Social and Governance (ESG) Index to help mitigate and assess the risk of companies to help inform sustainable investment decisions.

8. **Decentralized and trusted environmental transactions:** the environmental crisis is growing partly because of a lack of trust — the increasing distance between multiple actors who are unknown to each other, from companies and governments to individual consumers, creates many opportunities for fraud, failed policies and a lack of direct responsibility. The time may be ripe for 'crypto governance'[4], in which trust, rule of law and enforcement are supported by frontier technologies such as blockchain and smart contracts. For sustainability, blockchain technology could be a game-changer by enabling decentralized transactions and contracting linked to natural resources. Smart contracts with environmental performance conditions can be connected directly into IoT sensors and environmental oracles (trusted databases) to verify compliance against certain performance criteria. Datasets could also be managed using blockchain technology in order to track usage and establish mechanisms for micropayments.

b) What are the potential risks?

Moving beyond these potential opportunities, there is also a need to consider a series of questions linked to potential risks from planetary data and related frontier technologies. If information is power, then those who control access to information and processing capacity hold more power than other stakeholders. We need to carefully understand the implications of potential power imbalances and how these can be mitigated.

One of the most important considerations going forward is that the infrastructure needed to process planetary data and the algorithms needed to extract insights are currently held by a handful of technology companies. While public institutions are increasingly deploying these technologies, their capacities and access to financial resources often lags behind private sector actors. Public sector actors simply cannot keep up with the pace of innovation together with the engineering capacity that private sector companies can deploy. As a result, public-private partnerships will likely be needed at various points across the planetary data ecosystem if it is to be used in a manner where it can tackle global environmental problems and contribute to positive public outcomes. New frontier technologies with public good environmental applications may also need help to accelerate and scale through blended public and private financing. Against this background, potential risks to consider include:

1. **Platform monopolies and predatory pricing:** by having a near monopoly on the ability to process big environmental data, tech firms will face a temptation. While their initial intentions to build big planetary data platforms might be noble, once these platforms begin to scale, there may well be a shift to a winner take all mentality. "Free" is often transformed into "pay to play" once the revenue potential becomes clear. If fundamental

[4] https://www.nature.com/news/the-environment-needs-cryptogovernance-1.22023

dependences are created between companies and public sector partners, what safeguards are needed to reduce the potential for progressive price hikes and prevent predatory pricing?

2. **Privacy violations:** much of the data collected from individual transactions is maintained in the private sector and many countries do not have strong legal frameworks which regulate the sharing and anonymization of such data where it may have important environmental applications. There is a need to strike a balance between ensuring the privacy of individuals while at the same time utilizing the full potential of the data available.

3. **Lack of understanding of data quality:** more and more data is being generated by different sources, including data which employs high-quality data standards and data which is created without a standard or created with a particular bias in mind. This creates a challenge for governments, communities and individuals in determining which data can be trusted. There is also a need to distinguish between official government sources of data and non-official sources that may be the best available.

4. **Information asymmetries and inequities:** data are owned and generated in particular nodes of data intensity, which creates a potential for massive information asymmetries among companies, governments and local communities. If only the largest commercial firms can afford to pay for AI-powered monitoring of planetary data, what negotiating advantage does this bring for exploration and contracting of high value natural resources? How can governments and local communities possibly negotiate a fair deal when they lack access to such high-quality analysis and insights? This kind of monopoly of knowledge could create a massive imbalance of power in transactions linked to natural resources – a worst case market failure and catastrophe for sustainable development if it leads to lopsided and investment deals and unfair benefit sharing outcomes. Such an asymmetry of data may additionally lead to speculative investment from the entities with the greatest access to information, which could lead to disrupting global markets, stocks and currencies as well as lead to major speculative investments in land, water and other commodities that could lead to local shortages and price spikes.

5. **Conflict of interest between profit making, public goods and green-washing:** to avoid regulation and public scrutiny, many technology companies have jumped on the "big data for social good" bandwagon and often frame their mission as making the world a better place. It is important to understand how such firms can resolve potential conflicts of interest that might arise between their public mission of doing good together with the private mission of making money. In many cases, the global public good of protecting a certain natural resource could be in direct contradiction with a commercial interest to sell the same data to exploit it. How will this conflict be managed? How can their neutrality as a data broker be maintained if it affects their bottom line? While many companies have adopted ethics policies that requires disclosure of potential conflicts of interest – how this will play out in practice remains to be seen.

6. **Blended financing and public subsidies:** if public funds and subsidies are made available to commercial firms to scale frontier technologies though blended financing, how can the underlying intellectual property, data and algorithms be open sourced and released into the public domain? How can blended financing be used as an incentive to on-board companies in the use of new technologies to cover the public good cost of engagement rather than simply subsidize the underlying business model. Additionally, how can private sector funds and in-kind technology support be leveraged to support global data products which have no immediate commercial value and are only useful for public good?

c) What are the governance challenges?

Finally, given the above combination of potential opportunities and risks, it is essential to ask how the entire digital ecosystem can be governed in a manner where governments and citizens have a voice in decision-making and where the lines of accountability are clear. Going forward, the main question for public officials is to agree on the scope and shape of the governance framework for planetary data. In particular, how to ensure that it becomes a key component of the global environmental governance framework and maintained as a global public good? In this regard, a number of key governance questions need to be addressed:

1. **Standards and transparency:** a series of international standards will be essential to underpin the convergence of frontier technologies. Interoperability standards are necessary ensure data can be seamlessly shared or streamed on different platforms and integrated into a global data commons for analysis. Similar standards regarding metadata, data taxonomies and classification, and data integrity should follow. Full transparency is needed on who generated the data, how it was analyzed, how quality was controlled and who takes final responsibility for the content. The SDG indicator framework provides a starting point for ensuring the use of standards for a set of 241 indicators, but does not apply more broadly to other data and indicators.

2. **Data sharing laws and incentives:** as companies begin to deploy sensors and IoT applications across their supply chains and operations, they will start to collect huge qualities of useful environmental data that could populate a planetary data commons. How much of this data should companies be required to share as part of their legal or social licence to operate ? How can the privacy of individuals be ensured within the legal framework? What incentives are needed to share non-commercial planetary data to maximize the amount of data in the public domain? How will governments and other public sector actors who are deploying sensors in IoT applications such as smart cities manage and publish this data ?

3. **Open and accessible data and algorithms:** open data is data that can be freely used, re-used and redistributed by anyone and is essential for improving data governance. Currently, APIs (Application Programme Interface) are the best way of sharing data which can be re-used and redistributed. We are now faced with the challenge of data

spread across multiple formats such as excel tables, pdf documents and unconnected databases which are difficult for users to access. A planetary data ecosystem should consist of a mix of open and public data, combined with private data with use restrictions in place to ensure privacy and confidentiality is maintained. This ecosystem should include a basic set of georeferenced and open planetary data for which international standards exist and which has been agreed in an existing international framework (such as the SDGs or multilateral environment agreements). This data should be coupled with relevant environmental data for assessing the state of the environment and other social and economic data which are needed for analyzing the interactions between society, the economy and the environment. These open data standards apply to data which is generated at any level (national, sub-national, regional or global). As artificial intelligence algorithms needed to process open data begin to proliferate, it will be equally important to publish them in an open format to avoid potential "black box" applications.

4. **Quality control / quality assurance:** as private sector actors occupy an increasing role in the delivery of public environmental monitoring services using planetary data and their related algorithms, a minimum level of quality control/quality assurance is also needed to build public trust in the results. All methodologies and metadata should be publicly available in order for data users to ensure that the data is not only of high quality and unbiased but also are fit for purpose. Importantly, guidance is needed on the data layers that can be mixed in a scientifically sound manner that takes into account spatial and temporal resolution, spatial autocorrelation and the modifiable areal unit problem (MAUP) (a source of statistical bias that occurs in the aggregation of spatial data that can significantly influence the results of hypothesis tests). New verification and certification standards will be needed to indicate the quality of the underlying analytical process.

5. **Privacy and data security safeguards:** guidance will be needed on the set of organizational policies, procedures and maintenance of security measures that are designed to protect private information, data and access within the planetary data ecosystem. Strong legal frameworks are essential for protecting the privacy of individuals, particularly due the fact that much data is privately owned and the intrinsic value of this data.

6. **Intellectual property and revenue sharing:** new intellectual property laws need to be developed that can account for derived data products that are based on a mix of underlying data sources, including commercial and non-commercial data. In other words, how can intellectual property protections take into account different commercial use restrictions of input data layers within a final composite data product. Ideally, data sets should be given a unique digital fingerprint so that users can have absolute assurance on the history of the data set, the most recent version, the ownership and the end user license agreement (EULA). This would also allow the custodians of data sets to track how their data is being used in planetary data applications and participate in and micro-payment systems.

7. **Transparency:** One of the core outcomes of the information age should be to increase real time and long term environmental transparency on compliance with international and national laws and environmental performance commitments. In the same spirit, full transparency is also needed in data sources, collection methods, analytics and algorithms used in the planetary data ecosystem.

The interplay among these three groups of questions means that the UN Science-Policy-Business Forum on the Environment cannot focus its attention on only one aspect of this planetary data ecosystem. The forum needs to work with a series of strategic partners across the full spectrum of technologies and building blocks to capitalize on opportunities, mitigate risks and contribute to the global environmental governance framework.

4. Entry Points and Opportunities for Engagement

Clearly, planet earth desperately needs the best data and processing power humanity has to offer. As international organizations and countries move forward in partnership with the private sector, a vision is needed on how different components of the planetary data ecosystem need to be built, financed and governed. The questions outlined in section three of this white paper need to be answered before the system moves in a proprietary direction, or past critical tipping points which restrict the public data commons and voice of stakeholders its governance.

In this regard, the UN Science-Policy-Business Forum on the Environment needs to systematically review and expand on the following list of entry points and opportunities for engagement.

a) Planetary data ecosystem

Data Infrastructure

- **Data standards:** work with partners and existing processes to ensure a process for validation that planetary data is based on global standards.
- **Data management**: provide guidance on how to store, process, share and integrate different types of data into the planetary data ecosystem including: qualitative and quantitative, structured and unstructured, as well as geospatial, statistical and time series. Data will be generated by a range of sources including countries, companies and citizens requiring different levels of quality control and distinctions between official and non-official sources.
- **Data collation:** support the development of a global data ecosystem that consists of planetary data which is relevant for analyzing the environment.

- **Data dissemination:** Work collaboratively to bring together data from multiple sources in an ecosystem which ensures compliance with end user licence agreements for the use of private and public data, including recommendations to data providers on licencing. This should encourage a rethinking of the notion of non-commercial use restrictions for environmental data that are used by companies for avoiding harm or prioritizing investments and monitoring impact.

- **Promote open data:** invest in processes that are working to maximize the openness and standardization of APIs for planetary data, including data derived from citizen science. This also includes promoting existing data sharing standards, including the Statistical Data and Metadata eXchange (SDMX) which is endorsed by the UN for sharing data between national and international partners; the Open Geospatial Consortium (OGC) which is adopting web map services (WMS), web feature services (WFS), web coverage service (WCS) and web processing services (WPS); and the GEO DAB which is brokering a framework that interconnects hundreds of heterogeneous and autonomous supply systems (the enterprise systems constituting the GEO metasystem) by providing mediation, harmonization, transformation, and Quality of Service (QoS) capabilities.

Analytics and algorithms

- **Data analytics and algorithms:** bring transparency and quality control to the analytics and algorithms that are used to extract insights from planetary data. Ensure the release of algorithms into the public domain when they are financed by public sector resources.

- **Verify analytical methods and algorithms:** build on existing processes whereby UN "custodian agencies" help to design and verify methods that will be used to generate global environmental monitoring data for the 96 SDG indicators with environmental dimensions (see annex 1 for list of layers where UNEP is the custodian agency). Consider how to market a "verified" method using the UN Environment logo or some kind of alternative certification.

- **Promoting national validation of algorithms and analytics with in situ data:** ground-truthing or testing of globally generated data products could not only improve the quality of the algorithms but also provide a mechanism for increased national and community level engagement through citizen science.

- **Citizen science:** identify opportunities for leveraging citizen science data for developing verified data products. This would enhance the use of citizen science data for environmental monitoring and for formal assessment of progress toward the SDGs and other agreed environmental goals.

- **Data integration:** promote the concept of an open data cube or similar data integration techniques which would provide a framework for integrating multiple types of data for analytical use.

Applications

- **Applications:** focus on the transformation of planetary data to customized user facing applications that inform specific decision-making processes and needs. To the extent possible, applications should try to curate data to solve a specific problem and set of user needs. These can include government policies, academic research, financial investments and citizen action.

- **Open source software:** work to identify open source software solutions that can navigate the full planetary data ecosystem and that can be integrated into a technology stack. MapX is a good example of a spatial data infrastructure built exclusively on open source software by UN Environment.

- **Citizen awareness:** help build applications that enable citizens to access localized and global planetary data in real time to monitor compliance of national and international commitments as well as more practical applications such as pollution risks, water quality, air quality, disaster risk and unregulated activities.

- **Informing consumer awareness and choice through planetary data**: there is a tremendous opportunity to use planetary data about the environmental footprint of products and their supply chains to inform consumer choices using mobile apps and e-commerce suites. Using blockchain technology for supply chain management would permit companies to offer consumers assured information on the Environment, Social and Governance (ESG) performance of products. The consumer would have absolutely certainty on the supply chain and authenticity of the product by accessing the blockchain history.

Capacity

- **Capacity building:** it is essential that the needs of users of planetary data are placed at the center of all efforts. Training and capacity building programmes will be needed to reduce the potential for massive information asymmetries to be created between different stakeholders.

- **Leveraging private sector capacities and infrastructure:** consider how to structure public private partnerships that will be required to process planetary data and apply AI algorithms using the infrastructure and capacities of major technology firms.

- **Trust building:** Many data users lack the capacity to analyze the utility of new data technology and artificial intelligence applications. As a result, the uptake of globally derived data products is low. There is a need to form partnerships which allow users to increase their engagement and trust while at the same time being able to leverage new planetary data and AI algorithms which are being generated by others, including the private sector.

b) Institutions, laws and policies

- **Innovation culture:** help identify and create institutional incentives for sharing planetary data, developing innovative applications and building internal capacity for uptake.
- **Institutions, laws and policies:** provide technical guidance on legal frameworks related to planetary data governance, accessibility, privacy, cost sharing.
- **Disclosure and due diligence:** promote the disclosure of companies on the use of planetary data sets and AI algorithms that were used for investment decisions, environmental impact assessments and due diligence. A global mechanism is needed to report and redress the negative unintended consequences of planetary data and artificial intelligence or if countries feel that planetary data is being used in a non-competitive and monopolistic manner, or if sensitive planetary data is being collected without consent.
- **Environmental requirements in smart contracts:** looking even further into the future, one cannot help but notice the huge potential for blockchain technology and "smart contracts" to revolutionize the management of natural resources and the environment. Indeed, the moment that investment contracts, green bonds or resource concessions move into smart contracting there will be a massive opportunity to include social and environmental performance requirements directly in the blockchain. Smart contracts would automatically execute once a set of agreed conditions are met, such as emission standards, water quality, or energy production. They would run exactly as programmed without any possibility of censorship, fraud or third-party interference. A smart contract could be informed by traditional monitoring data from a public sector actor or automated to rely on data from an environmental sensor, a satellite image and an artificial intelligence algorithm.
- **Information sharing and public verification of smart contracts:** One of the most interesting dimensions of the smart contract is the potential to support information sharing among all stakeholders. Everyone involved in the contract can be informed in real time of each execution or addition to the blockchain thereby maximizing transparency and trust. Smart contracts could even offer the possibility for a benefit verification mechanism among stakeholders. Each stakeholder could digitally report on the achievement of the contractual requirement in each block, and once all conditions are met, the contract block would execute forward. This could enhance participatory environment monitoring and give local communities a direct voice in the verification of agreed jobs, revenues and other benefits.

c) Markets and finance

- **Incubators and accelerators:** must be identified to speed the uptake of relevant frontier technologies for the environment through public and private financing (grants, guarantees or loans). The objective is to stimulate and leverage private sector capital for global public goods and to use planetary data to measure the positive environmental impacts at scale.

- **Environmental performance monitoring:** establish standards, blockchain smart contract protocols and quality control protocols for the use of environmental data for informing environmental performance conditions and environmental financing flows.

- **Corporate Sustainability reporting:** promote global sustainability reporting of companies with differing level of ambition depending on the company size. There should be a mechanism for small and medium companies to demonstrate the efforts that they are making to achieve sustainability. For larger companies and multinational companies, a more stringent set of information will continue to be required through legal obligations.

- **Blended finance and green bonds**: for projects which disclose relevant non-commercial environmental performance data, blended finance and green bonds could automatically stream into the global data trust with the option for anonymization. Blended finance is the strategic use of development finance for the mobilization of additional commercial finance towards the Sustainable Development Goals (SDGs). Green bonds have been created to fund projects that have positive environmental and/or climate benefits.

- **Environmental, social and governance (ESG) factors:** there is growing evidence that suggests that ESG factors, when integrated into investment analysis and portfolio construction, may offer investors potential long-term performance advantages. As a result, there is a need to understand how ESG metrics can benefit from improved access to planetary data together with quality control requirements. In particular, how can the ESG performance of a company be calculated as robustly and transparently as possible.

- **Supply chain risk management:** there is a tremendous opportunity to use blockchain technology for supply chain management in a manner that would permit companies to offer consumers assured information on the Environment, Social and Governance (ESG) performance of products. The consumer would have absolutely certainty on the supply chain and authenticity of the product by accessing the blockchain history. In addition, there is high potential for the non-commercial aspects of this data to be potentially shared.

- **Micropayments for data inputs**: as blockchain technology continues to develop, public data sets could be registered in a global blockchain database and given a unique digital fingerprint so that users can have absolute assurance on the history of the data set, the most recent version, the ownership and the end user license agreement (EULA). This would also allow the custodians of public data sets to track how their data is being used by the public and private sectors and potentially benefit from revenue sharing agreements. For example, where public data is helping to generate commercial revenue, either as an input to business intelligence that is being sold, or by driving traffic to a particular site selling ads or apps, a portion of the revenue could be channeled to the data custodian.

5. Building on existing initiatives

While it is important to have a conceptual solution oriented framework in mind, it is equally essential to ground all discussions in practical applications and pilot testing within existing efforts and processes. In this regard, the UN Science-Policy-Business Forum on the Environment could focus on engaging with 3-4 core thematic areas where significant efforts and partnerships already exist. The following selection criteria could be used to identify potential partnerships:

a) Selection criteria

- **Combination of planetary data sources:** partnership already uses a combination of data sources, including earth observation and other frontier technologies, as well as other sources of data (sensors, surveys, citizen science, etc.) where interoperability and data governance are key challenges.
- **Multi stakeholder approach:** partnership has a multi stakeholder membership structure including a minimum of three different stakeholder groups (e.g. government, academia, private sector, civil society, international organizations). Consideration should also be given to balancing geographic diversity and representation.
- **Connection to international environmental agreements:** partnership should have an explicit connection to monitoring progress against a multilateral environmental agreement (e.g. Paris Agreement or Aichi Biodiversity targets) or to the implementation of a specific Sustainable Development Goal (SGD) and target. Priority will be given to the 26 indicators for which UN Environment acts as the data custodian (see Annex 1).
- **Deliverables during 2019 and 2020:** a series of global deliverables are already planned by the partnership for 2019 and 2020 that offer entry points for pilot testing solutions to challenges identified in this white paper.
- **Scalability**: all pilot projects should have the potential to scale to a planetary level by other partners, developers, and users. The potential for scalability on the basis of organic growth and network effects should be the driving question for every engagement and funding allocation.
- **Sustainability**: all pilot projects have long term relevance and be able to demonstrate the project has the potential to be continued over time.
- **Data for planet and people:** potential pilot projects need to explicitly connect data providers and respective analysis with end users and decision-makers. Projects should be

fit-for-purpose and responsive to the needs of end users ranging from governments to civil society.

- **Open data and open source technologies:** Partnerships should support open data and open source software solutions that are interoperable with commercial platforms.

- **High data quality and transparency of methodologies:** potential pilot projects should commit to making all methodological information on the data product openly available and have a data validation process in place which ensures the product is of high quality.

b) Existing projects and partnerships involving planetary data

On the basis of the criteria presented in the previous section, the UN Science-Policy-Business Forum working group on Data, Analytics and AI will identify pilot projects. A few relevant initiatives to consider that comply with the above selection criteria include:

- **Space Climate Observatory:** The world's leading space agencies have proposed the creation of a Space Climate Observatory (SCO) to pool acquired data and share it with scientists throughout the world, as per the Paris declaration adopted by the One Planet Summit in December 2017.

- **UN Biodiversity Lab:** a multi-stakeholder partnership convened by UNDP and UN Environment that focuses on offering to the parties of the Convention on Biological Diversity the best available spatial data on biodiversity for their 6th national report.

- **Planetary dashboard for global surface water monitoring:** a partnership by UN Environment, Google Earth Engine, the EU Joint Research Centre, NASA, ESA and the GEO Secretariat to map the location and temporal distribution of water surfaces at the global scale over the past 32 years and provide statistics on the extent and change of those water surfaces.

- **Optical methods for Marine Litter detection (OPTIMAL):** is initially focused on detecting microplastics on or near the surface of the ocean as well as larger pieces of plastic along shorelines.

- **Land cover and use.** The Land Degradation Neutrality Fund (LDN Fund) was launched during UNCCD COP13 to achieve the target of a land degradation neutral world (SDG target 15.3).

c) Key questions for each partnership

Once the partnerships have been selected, they should each be surveyed to gain a better understanding of the unique challenges they face in terms of accessing, using and financing planetary data. In particular:

- What kind of governance model has the partnership adopted for the generation, analysis and publication of planetary data ?

- Does the partnership have a strategy to achieve organic growth, global scale and long term sustainability ?
- How is the data released by the partnership quality controlled and made inter-operable ?
- How is the generation, publication and long term management of the data set being financed ?
- How is the partnership dealing with a mix of data with commercial and non-commercial use restrictions and how are the final derived data product being licensed ?
- How is the partnership integrating spatial and statistical data into a single user interface ?
- How is the partnership addressing data licensing, meta data and data integrity?
- What are the largest technical and governance challenges the partnership has overcome ? What successes offer models of best practice ?
- How is the partnership building national & local capacity to use data products?
- How is the impact of the data generated by the partnership being measured ? What formal indicators have been adopted ?
- What is the financial and business model for the partnership ? What is the greatest financing challenge ?
- What are the key legislative barriers or gaps towards contributing data to a planetary data ecosystem ?

6. Other policy processes

All work of the UN Global Science-Policy-Business Forum on the Environment will need to connect to and inform a number of existing high-level processes, including:

- **UN General Assembly:** Seventy-third session will start on 18 September with the opening debate starting 25 September 2018.

- **UN World Data Forum (UN WDF):** will be held from 22 to 24 October 2018 and hosted by Federal Competitiveness and Statistics Authority, of United Arab Emirates and the United Nations Statistics Division.

- **UN Environmental Assembly:** The fourth session will take place from 11-15 March 2019. The theme is innovation and technology for sustainable consumption and production.

- **Inter-Agency and Expert Group on the SDG Indicators (IAEG):** The IAEG is mandated by the General Assembly to define the monitoring framework for the SDGs. This working group meets twice a year.

- **United Nations Global Geospatial Information Management (UN-GGIM):** UN-GGIM aims to address global challenges regarding the use of geospatial information, including in the development agendas, and to serve as a body for global policymaking in the field of geospatial information management. The next UNGGIM Congress will take place from 19 – 21 November 2018 in Deqing, China.

- **Group on Earth Observation (GEO):** coordinates international efforts to build a Global Earth Observation System of Systems (GEOSS). It links existing and planned Earth observation systems and supports the development of new ones in cases of perceived gaps in the supply of environment-related information. It aims to construct a global public infrastructure for Earth observations consisting of a flexible and distributed network of systems and content providers.

7. Conclusion

As the United Nations is one of a very short list of trustworthy global institutions that can neither be purchased nor dominated by any single country or company, there is an urgent need to ensure it can play a constructive role in the governance of planetary data before the chance to influence the shape of this emerging digital ecosystem is lost. We are at a critical crossroads in the evolution of the 4th industrial revolution. Decisions that are taken in the next 12 months will have important ramifications for the coming decades. As this paper has demonstrated, the stakes couldn't be higher.

On the one hand, humanity now has the potential to leverage a range of technical innovations that could monitor and protect the health of the planet as well as promote the sustainable use of natural resources. On the other hand, the same technology could be used to drive hyper consumption and rampant consumerism that amplify resource consumption, and potentially drive a larger wedge between developed and developing nations. Companies could effectively control the infrastructure needed to gather and use planetary data – thereby further amplifying information asymmetries between the private and public sectors that could potentially undermine the sustainable use and fair contracting of natural resources.

As the governance challenges for planetary data are complex and involve numerous stakeholders, only an entity like the UN can leverage its convening power to help forge a common path forward that respects the ideals of the UN charter and the SDGs: a vision that unites people, planet, prosperity and peace.

Technology leaders and private corporations are looking for global leadership to govern the potential applications of disruptive technologies such as big data and artificial intelligence. Entrepreneurs such as Elon Musk[5] are calling for proactive regulation of emerging applications of AI. However, they ask for a clear process, a results-based orientation and a single UN entry point. Given that some of these same firms are members of the UN Science-Policy-Business Form for the Environment, it is now our collective responsibly to outline a vision and governance framework for planetary data that offers the right mix of incentives, standards and financial models that can continue to support innovation and profit making while also generating global public goods. A future that leverages the 4th industrial revolution for the environment is ours to imagine and create.

[5] https://www.theguardian.com/technology/2017/jul/17/elon-musk-regulation-ai-combat-existential-threat-tesla-spacex-ceo

Annex 1. UN Environment is the custodian agency for 26 SDG indicators

6.3.2 Proportion of bodies of water with good ambient water quality
6.5.1 Degree of integrated water resources management implementation (0-100)
6.6.1 Change in the extent of water-related ecosystems over time
8.4.1 Material footprint, material footprint per capita, and material footprint per GDP
8.4.2 Domestic material consumption, domestic material consumption per capita, and domestic material consumption per GDP
12.1.1 Number of countries with sustainable consumption and production (SCP) national action plans or SCP mainstreamed as a priority or a target into national policies
12.2.1 Material footprint, material footprint per capita, and material footprint per GDP
12.2.2 Domestic material consumption, domestic material consumption per capita, and domestic material consumption per GDP
12.3.1 Global food loss index - proposal for FOOD Waste
12.4.1 Number of parties to international multilateral environmental agreements on hazardous waste, and other chemicals that meet their commitments and obligations in transmitting information as required by each relevant agreement
12.4.2 Hazardous waste generated per capita and proportion of hazardous waste treated by type of treatment
12.5.1 National recycling rate, tons of material recycled
12.6.1 Number of companies publishing sustainability reports
12.7.1 Number of countries implementing sustainable public procurement policies and action plans
12.a.1 Amount of support to developing countries on research and development for sustainable consumption and production and environmentally sound technologies
12.c.1 Amount of fossil-fuel subsidies per unit of GDP (production and consumption) and as a proportion of total national expenditure on fossil fuels
14.1.1 Index of coastal eutrophication and floating plastic debris density
14.2.1 Proportion of national exclusive economic zones managed using ecosystem-based approaches
14.5.1 Coverage of protected areas in relation to marine areas
15.1.2 Proportion of important sites for terrestrial and freshwater biodiversity that are covered by protected areas, by ecosystem type
15.4.1 Coverage by protected areas of important sites for mountain biodiversity
15.9.1 Progress towards national targets established in accordance with Aichi Biodiversity Target 2 of the Strategic Plan for Biodiversity 2011-2020
15.a.1 Official development assistance and public expenditure on conservation and sustainable use of biodiversity and ecosystems
15.b.1 Official development assistance and public expenditure on conservation and sustainable use of biodiversity and ecosystems
17.7.1 Total amount of approved funding for developing countries to promote the development, transfer, dissemination and diffusion of environmentally sound technologies
17.14.1 Number of countries with mechanisms in place to enhance policy coherence of sustainable development

Annex 2. The potential role of UN Environment

To successfully harness the power of planetary data and analytics for the environment, the UN Science-Policy-Business Forum on the Environment could consider recommending the following missions for UN Environment to adopt during 2018-2020.

Table 2. Vision and four proposed missions for UN Environment to achieve by 2019

Vision Statement:	
An open digital ecosystem of planetary data that can generate trusted insights in real time about the state of the environment at any scale to inform government policies, academic research, financial investments, and citizen action	
Mission 1: Data infrastructure	**Mission 2: Integrating within UN family**
Build a shared digital ecosystem which can host environmentally-relevant data and statistics, including geospatial data, including project and programme data. A data infrastructure for hosting planetary data is already being developed through the Environment Situation Room powered by MapX.	Collaborate with the UN system to build a common information platform where all environmental data generated by UN actors can be shared to inform planning, programming, impact monitoring and communications by all UN country teams.
Mission 3: Envisioning a planetary data ecosystem	**Mission 4: Building capacity for impact**
Convene countries, companies, civil society and international actors to agree on a global vision for an open digital ecosystem of planetary data that can generate trusted insights in real time about the state of the environment at any scale.	Democratize access to the planetary data ecosystem and build capacities to generate and use data to support government policies, academic research, financial investments and citizen action.