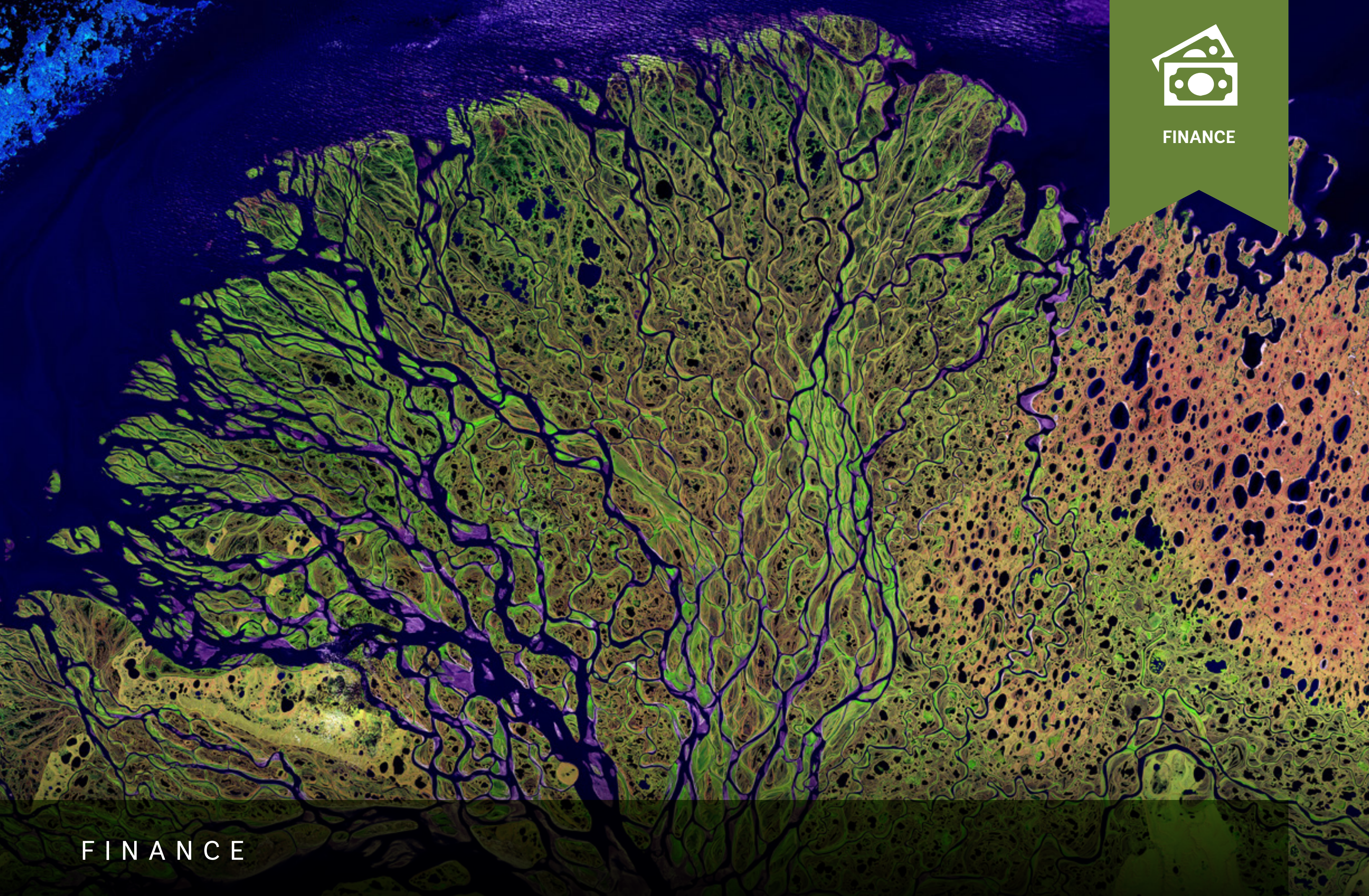

FINANCE

EQUITABLE GROWTH, FINANCE & INSTITUTIONS INSIGHT

Spatial Finance: Challenges and Opportunities in a Changing World

WWF

WORLD BANK GROUP

Graphic Designer: Diego Catto / www.diegocatto.com

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Foreword

In a short span of time we have changed the fabric of the land, air and sea. Today, the atmosphere has more carbon dioxide than at any time before in human history, three-quarters of land and about two-thirds of the marine environment have been altered by human activity. The results of our collective actions are pushing species to extinction and ourselves closer to breaching tipping points, such as runway ice loss. If crossed, we will face irreversibly a hotter and more unstable world. A world, in which it will be harder to protect both people and nature. The window in which we can determine our future is narrowing.

As an important part of the global system, the financial sector has taken on a more active role in our collective transition to a more sustainable future with better management of our natural resources. Sustainable finance has been making significant strides towards incorporating environmental considerations into investment and decision-making processes. This effort is aided by the adoption of Sustainable Development Goals (SDGs), the Paris Agreement in 2015 and a proliferation of organizations specialized in providing data, methodologies and analytical tools. Still, it is often not a lack of willingness of the financial sector to make the right climate and environmental decisions. More often it is a lack of clarity around what the right decisions are. The last decade has seen the development of corporate and sovereign ESG data in response to these questions. While the ESG field has contributed significantly to make environmental issues less opaque, recent World Bank studies illuminate that environmental considerations are still the most challenging to be incorporated by the financial sector. To address the nature and climate crisis in time we need to go further towards greater transparency and accountability.

This joint WWF-World Bank report tackles the E pillar of ESG - a critically underexplored issue for the financial industry. The report describes a potential solution within the emerging field of 'spatial finance', which complements existing ESG data streams, and outlines for the first time a robust taxonomy for the field. Along with insights from global thought leaders and practitioners, the report provides case studies from cutting-edge start-up technologies, such as methane detection from space, and perspectives of established financial data providers, such as Bloomberg and S&P Global. We conclude by outlining the role of the environmental non-profits, as key data holders, in supporting the field.

Securing a more stable world – a world enlivened and not degraded – will require action. To this end, the WWF together with other NGOs, businesses and financial institutions is advocating for a New Deal for Nature and People that aims to protect and begin to restore nature by the end of the current decade. **Together both WWF and the World Bank hope this report will serve as a foundation for a field that has significant potential in aiding improved transparency and accountability. Upon this foundation, stakeholders can accelerate their efforts to safeguard our natural world and strengthen the resilience of the global economy.**

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International

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Competitiveness at World Bank

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Summary

If financial markets are to realign towards truly sustainable development the financial sector needs to differentiate commercial actors more accurately on their climate and environmental performance. A potential breakthrough to help in this challenge is the emerging field of 'Spatial Finance', the independent assessment of the location of a company's or a country's assets and infrastructure using ground data, remote sensing observations and modelled insights, offers a potentially transformative means to gain improved quantitative ESG insights.

Rapid development is required if spatial finance is to deliver in the short term. In this report, we outline a possible taxonomy and hierarchy for spatial finance, showing how discrete forms of technology, approaches and data can be considered within a single consistent framework. Using this framework, spatial finance could provide insights at differing scales for different applications from the asset-scale for project finance, to company-scale for investment, to country-scale for sovereign debt.

Throughout the document we provide insights into current cutting-edge developments within the field, illustrated with case studies from practitioners and data providers, and explore potential future developments.

We identify three major data barriers in the mainstreaming of spatial finance:

- lack of reliable asset level data at required granularity and regularity,
- lack of supply chain data at required granularity,
- poor adaptation of observational climate and environmental data in financial applications.

In this report we argue there should be a strong dialogue between climate and environmental data experts and the financial sector to determine needs and iteratively develop data solutions. We argue that environmental non-profit players, as primary holders of climate and environmental data, have a responsibility to engage in this space to ensure the best data is available and is applied correctly to provide robust spatial finance insights. Finally, we argue that such a holistic climate and environmental data portfolio should become a global public good.

We conclude by outlining practical next steps in supporting the development of improved climate and biodiversity data for spatial finance.

Introduction

We are in the midst of a global biodiversity and climate crisis. If we are to overcome these challenges the financial sector will need to play a central role in their resolution. One critical question, which this paper explores, is what can the environmental non-profit community do now to aid the financial sector's awareness of the wider climate and environmental implications of their decisions and the risks to assets and the macroeconomy?

In recent years, the move towards sustainability has increased, yet there remains a shortfall on clear and consistent environmental, social and governance (ESG) data. This shortfall has hindered the realignment of markets towards true sustainable development. Fortunately, the emergence of a new field, 'Spatial Finance' offers hope of a potential solution by moving ESG away from dependence on voluntary company reporting, assessing companies at their word, to assessing companies by their actions, using a geospatial approach.

This report is in two parts and explores the following:

PART 1 – SETTING THE SCENE

1. What is Spatial Finance?
2. The Taxonomy of Spatial Finance
3. Why is Spatial Finance Relevant to ESG?
4. Existing Tools Relevant to Spatial Finance
5. Why is Spatial Finance Relevant to the Non-Profit Community?
6. Why should commercial actors encourage Non-Profit involvement?
7. Major Gaps to be Resolved and Possible Solutions

PART 2 – PROPOSED ACTIONS – WWF'S PERSPECTIVES

1. Improving Asset and Supply Chain Data
2. Improving Climate and Environmental Observational Data
3. Next Steps

PART 1

Setting the Scene


1.

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What is Spatial Finance?

Spatial finance is a geospatial-driven approach designed to provide ESG relevant insights into a specific commercial asset, a company, a parent company, a portfolio or national level scorings.

At its most basic level, spatial finance begins with the accurate location and definition of ownership of a commercial asset (i.e. factory, mine, field, ship, retail estate) known as '**asset data**'. using different data approaches in combination, such as Geographic Information Systems (GIS) and remote sensing it is possible to assess the asset against '**observational data**', such as environmental, climate, governance and social variables.[1] Sub-asset monitoring (e.g., power smart meters) or voluntary reporting (e.g. ESG company reports) can be integrated for even greater insights. Merging results of multiple assets at the subsidiary, parent company, portfolio or national, or sector level, provides insights at scales relevant to different financial applications, ranging from project finance to sovereign debt.

For a company whose environmental impact is primarily created through its supply chains, its footprint can be defined by running a spatial finance assessment that includes all the suppliers' assets as well as its own direct assets. For example, to understand the footprint of a major car manufacturer, run a spatial finance assessment of the car manufacturer's physical assets, their factories, headquarters etc., and a second assessment on their supply chain assets.

Data can be applied to in-house or open models to inform on impact, transition and physical climate change risks and biodiversity and natural capital risks within recognized frameworks.

1. Within this document, due to the authors expertise we focus discussion on climate and environmental data but social and governance observational datasets will also need to be included in spatial finance framework to provide well rounded ESG insights.


2.

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The Taxonomy of Spatial Finance

As an emerging field, there remains confusion over 'Spatial Finance' which has been exacerbated by a lack of clear terminology. Here we propose some new terminology and definitions, with a view to encouraging dialogue and the eventual setting of new standards and terminology.

Asset Data

Asset data is the ownership information (e.g. company name) and the geospatial information that defines the location of a commercial asset, i.e. real estate, a field, a mine, a factory, a powerline.

Asset data comes with additional information about each asset, called 'attributes'. Asset datasets vary significantly in information, some carry the minimum, ownership and geospatial coordinates (longitude, latitude). Others define 100s of attributes such as capacity, age, type, production, commodity, royalty holders, parent company, tickers, dates. While we might wish all asset datasets were as robust and extensive as possible, we must accept the practical limits of developing and maintaining such datasets.

Currently, some asset datasets are open and some closed, with closed data only accessible to approved users, often behind a paywall. Some industries have long-established commercial asset datasets, developed and maintained by commercial business intelligence providers in response to demand. Such global datasets exist for mining, oil and gas, shipping, fishing and power plants. Where no market exists for a global dataset, as for example with agriculture, large-scaled asset datasets remain undeveloped. Currently there are no systems in place that enable asset data exchanges between commercial actors.

Initiatives such as the Spatial Finance Initiative[1] are working to develop novel open source asset datasets on the steel and cement industry. World Resource Institute (WRI) and Google have worked previously to develop an open Global Power Plant Dataset[2]. Others provide additional asset insights such as The Global Tailings Portal[3], an open database with detailed information on more than 1,800 mine tailings dams around the world. However, the scale and long-term resources required to maintain a global asset dataset, which is only useful if up to date, means that commercial actors are likely to retain the competitive edge. For example, WRI and Google's open Power Plant dataset defines some 30,000 assets and was last updated in Jun 2019. Its commercial equivalent provides insights into over 120,000 assets and was last updated August 2020.

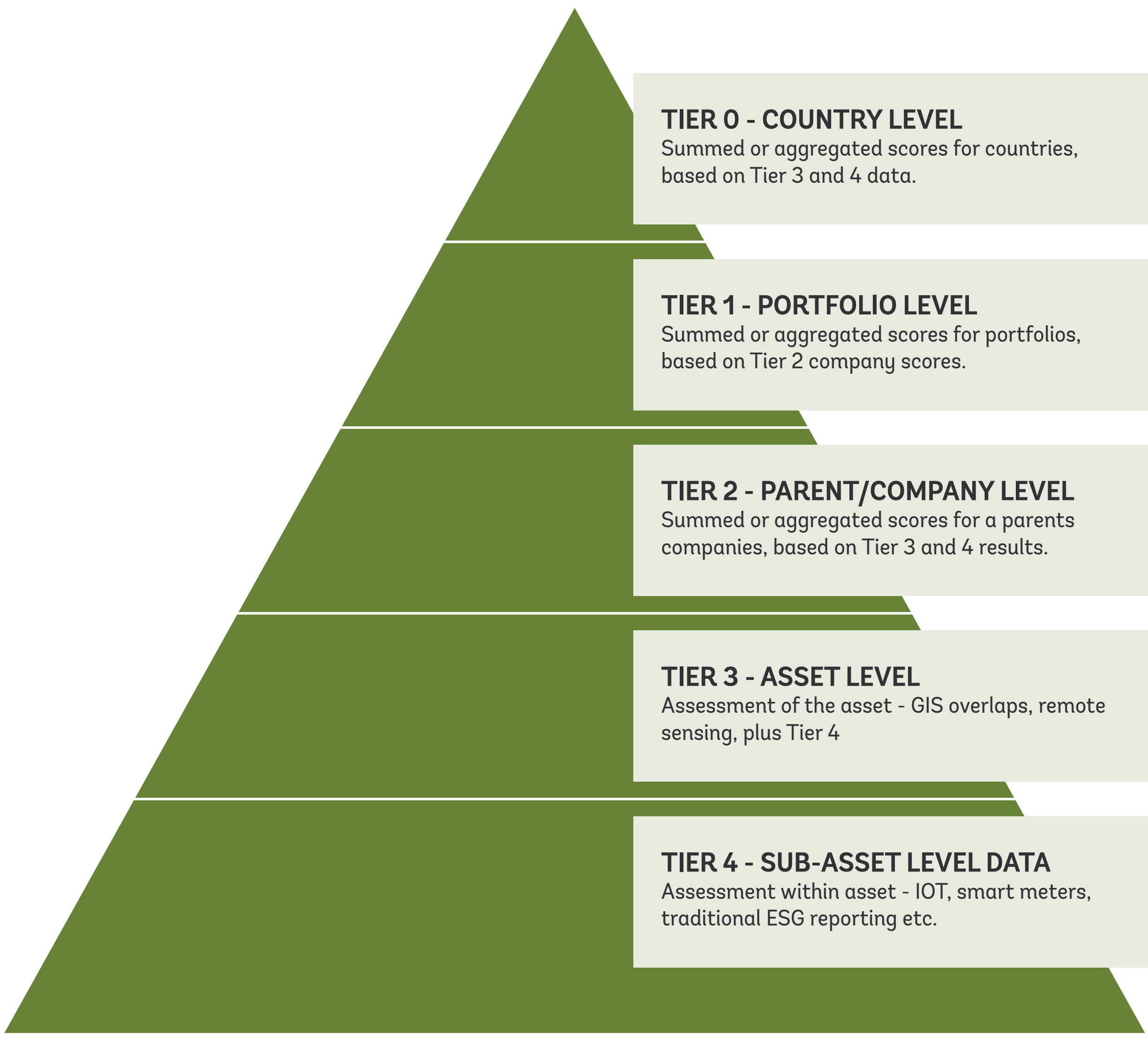
Observational Data

To gain useful insights into the ESG performance of an asset, we need observational data, such as deforestation or climate change information for comparison. **Observational data is classified as any data used to compare against asset data to provide insights.** Covering everything from freely available open datasets from the non-profit space to cutting-edge hyper-detailed results from niche commercial providers, observational data comes in a huge range and diversity. These comparisons can be run at different scales, depending on the user's application.

Here we introduce the concept of tiers for spatial finance[4]. We propose five tiers (Figure 1), running from Tier 0, large scale results (i.e. national scores for sovereign debt insights) to Tier 4, the hyper-detailed results within a specific asset (i.e. smart power meters for specific project finance insights).

> > >

FIGURE 1 - Diagram showing the five tiers of spatial finance, simplified here, not including supplementary supply chain assessments.



The same dataset should be used throughout the spatial finance tiers, where possible. For example, the risk of hurricane exposure of an asset (Tier 3), should be the same dataset summed at a national level (Tier 0). Below the tiers are described in more detail with real world examples.

Tier 4

Tier 4 is defined as ‘sub-asset measurements’, readings taken from nearby (≤100m) or within the asset itself, often at a high temporal frequency. Examples include air pollution monitors, smart power meters and industry specific measurements such as the genetic profile of timber logs or live cameras on the decks of fishing vessels recording by-catch. Potentially, established data sources of ESG insights such as internet-scraped data highlighting issues with a company (Tier 2) or its assets (Tier 3), or via Natural Language Processing (NLP) of a company’s published ESG reporting could be included in Tier 4 assessments.

Tier 4 is the most complex, varied, and high-resolution tier of data within spatial finance, often containing niche measurements specific to an industry. As a result, it has the potential to provide unprecedented insights. Many of its components, however, due to the complexity, sector specificity, frequent reliance of cooperation from operators and legal implications, are a long way from wide scale implementation within spatial finance.

While technological progress, such as 5G, will ease the technical difficulties for some Tier 4 datasets, it is likely the real world use of Tier 4 data within the wider spatial finance community will be determined on a case by case basis, primarily dependent on regulatory pressure, the sector’s resistance to disclosure, data sensitivities and wider legal constraints, rather than by technological constraints.

Yet despite the complexity, some useful Tier 4 insights are already possible with web scraping and traditional ESG reporting.

BOX. Tier 4 in the Real World

Author; Efrain Eduardo Tamayo Ruiz - Researcher, European R&D Centre – Hitachi

Accessing reliable evidence about the environmental merits of ‘green’ projects to inform decision making can be costly and time consuming. To help aid the accelerated transition to sustainability and the achievement of the SDGs. Hitachi has begun building and testing a Sustainable Finance Platform (SFP) to increase the transparency around the social, environmental, and economic values of green projects that are financed using instruments such as green loans, green bonds, or KPI-lending. The details of the value propositions and users are shown in Figure 2

> > >

FIGURE 2 - Details of the value propositions and users of a Sustainable Finance Platform

> > >

To fuel the SFP, the Internet of Things (IoT) is used to capture accurately the operational performance of single or distributed assets such as renewable energies, electric vehicles, power grids, etc. as shown in Figure 3. Depending on the project, the type and frequency of data can be adjusted to fulfil the calculation of KPIs and requirements of stakeholders. Energy generation or consumption data per minute or per 15 minutes is typically available, and for user interface purposes, hourly, monthly and yearly aggregated results are displayed. Sub-minute data is useful to extract and verify the evidence of environmental and social contributions from complex and distributed projects such as mobility and power grids. This high frequency Tier 4 data is then placed into a blockchain (Hyperledger) layer which stores the data to create an immutable, verifiable record of the monitored operational performance. Blockchain is also used to transform the data into KPIs and to keep a record about the data transformation, which is a much-needed feature in transparent reporting. Additionally, blockchain can be used to tailor the amount and type of data according to the audiences (e.g. investors, project owners, the public, auditors and regulators) solving privacy or competition concerns.

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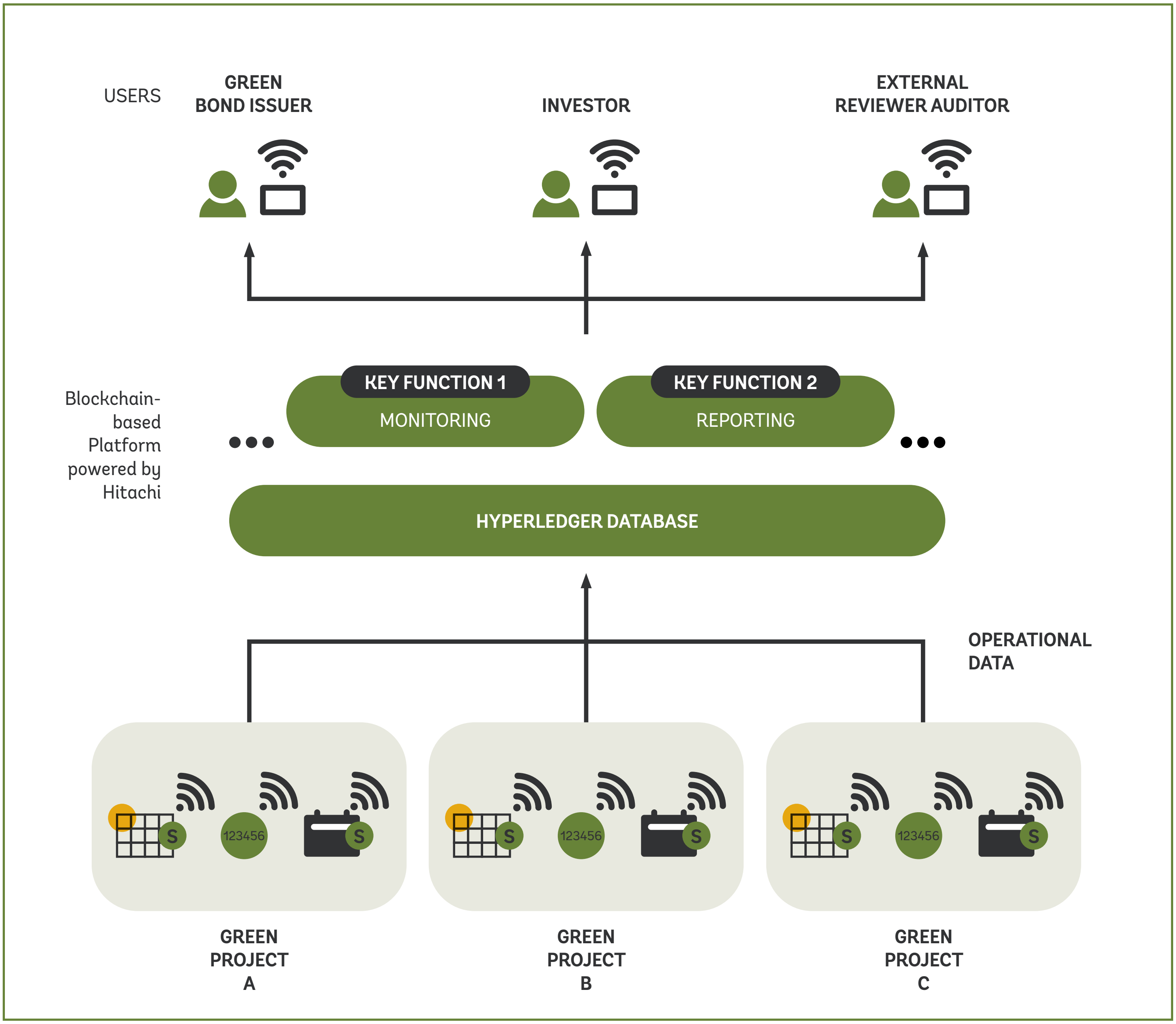
FIGURE 3 - Internet of Things and blockchain in a Sustainable Finance Platform



The system architecture and the flow of data are shown in Figure 4 where the data of individual assets of each project is aggregated by IoT modules. Then, each of the IoT modules is connected in the back-end, then pushed to the front-end so that the users can see the Monitoring, Reporting, and Verification information about each project.

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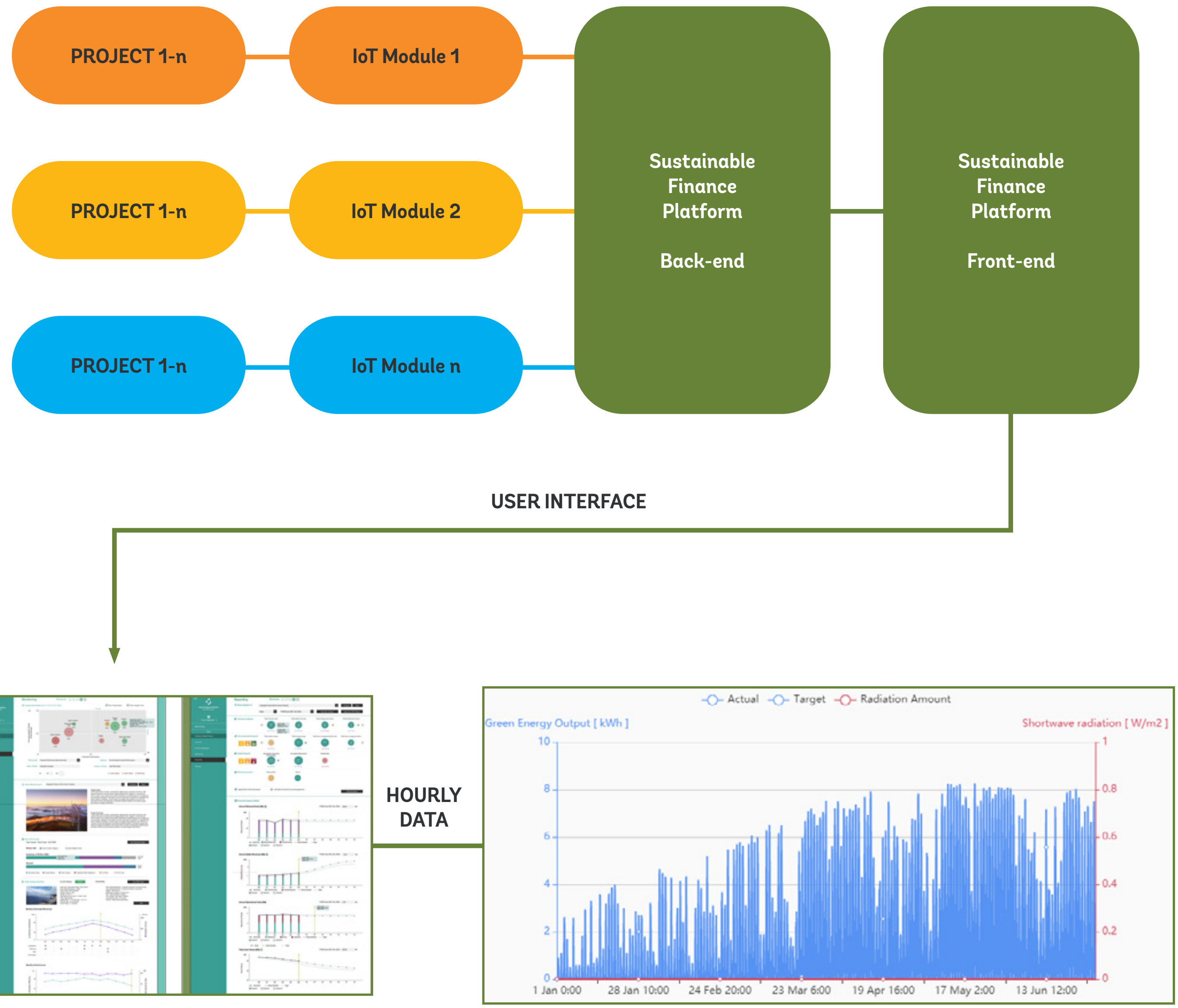
FIGURE 4 - System architecture showing the process from the connection of the projects' IoT devices to the visualization of the information by the users



A technical demonstration of the SFP has now been successfully carried out using the Smart Energy Islands project[5]. The next demonstration project will include financial institutions and the additional requirements of the finance industry. SFP has been accepted to participate in the Regulatory Sandbox by the UK' Financial Conduct Authority[6] and discussions are ongoing with partners to demonstrate the benefits of digitization in sustainable finance. Hitachi Europe is a committee member of ISO/TC 322 Sustainable Finance, with a view to introducing the above contents in standardization activities.

Tier 3

Tier 3 is defined as high-level asset-level insights covering the full extent of the specific assets, resting primarily on the comparison of asset datasets (location of factories, farms, mines) against spatial datasets and remote sensing insights sourced independently. For example, insights generated by GIS define the proximity of commercial assets to other assets such as World Heritage Sites or Protected Areas, rivers, wetlands, endangered species, and indigenous areas. Combined with other modelled layers, or remote sensing products they can provide insights into risk and impact aspects of the commercial asset, such as water risk of the site, nearby deforestation, carbon emissions, methane emissions, and even insights into production and trade (although these remain resource-intensive). Metrics based on Tier 4 datasets, if available, can be aggregated to provide further insights into the status of the asset.

Tier 3 is arguably the most developed tier of spatial finance, with commercial operators already offering niche observational data services, or sector- wide Tier 3 insights to clients (see Box).

BOX. Tier 3 in the Real World

Already a few Tier 3- capable platforms have emerged for those sectors with already well-defined geo-located asset datasets such as mining, oil and gas, shipping, fishing, power, cement and steel industries.

WWF

In the non-commercial space WWF-SIGHT[7], developed in 2015 and now in its third iteration, provides WWF climate and environmental insights across 50+ variables into infrastructure, mining, oil and gas and power plant assets globally. Notably WWF-SIGHT has been used to define:

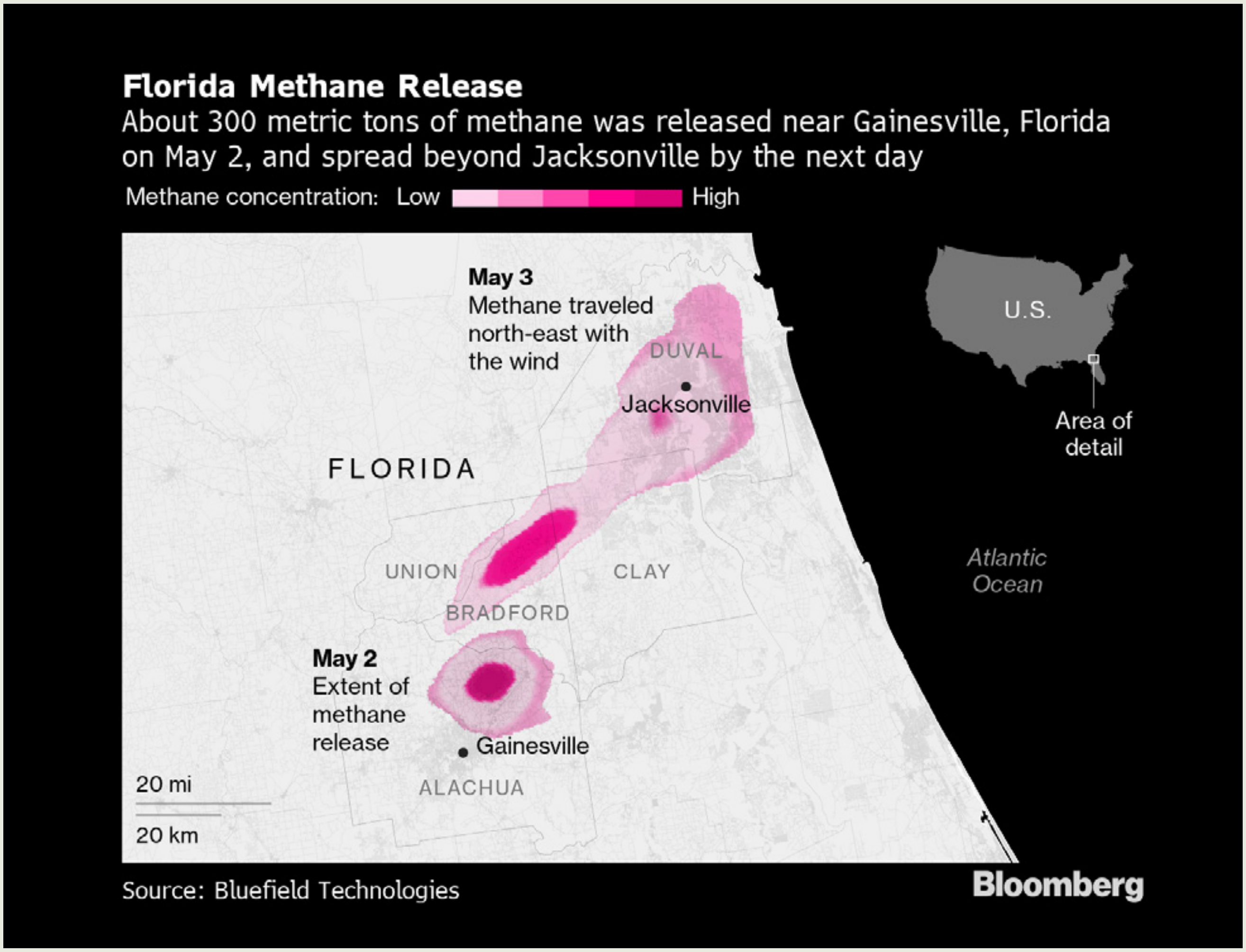
- Primary industry commercial assets (Tier 3) and companies (Tier 2) globally within natural and mixed World Heritage Sites and Protected Areas, every quarter since 2015.
- UK headquartered companies (Tier 2) with operations (Tier 3) within the Arctic.
- Tier 3 assessment of Chinese Belt and Road Project, defining the high-level environmental implications of 2,500 proposed projects and USD 3.3 trillion of investment

BOX. Tier 3 Observational Data - Detecting Methane Leakages

Author; Yotam Ariel - Founder & CEO - Bluefield Technologies

Bluefield has developed a satellite-based monitoring system that detects, pinpoints, and quantifies greenhouse gas emitters around the world, daily.

Bluefield was recently the first to detect a large (300 tons, ~1% of daily US emissions from natural gas systems), unreported methane release in Florida, USA. Without Bluefield's data, only a handful of people were aware of the methane release, but once detected by Bluefield, it was covered by Bloomberg[8], reaching tens of millions of people and triggering a federal investigation into violations by the emitting source.



Bluefield is detecting thousands more incidents similar to the Florida methane release, in many parts of the world where emissions data has so far been practically non-existent. The emitting sources being tracked include oil and gas operations, coal mines, refineries, heavy industries, etc.

The enabling algorithm

Bluefield's ability to monitor emitters around the world is achieved through an algorithm (called BFX-2) which analyzes worldwide data captured by specialized satellite-based sensors (such as the European Space Agency – Sentinel-5P/TROPOMI) within seconds. It then flags anomalies and runs an advanced automated assessment by fusing the emissions data with atmospheric data (wind, temperature, etc.) as well as topography information and details on key infrastructure in proximity to the emissions.

> > >

Temporal trends are calculated over territories, providing for example indicators of changes in commercial activity. Output is given via Bluefield's web data portal, and data is exportable in compatible formats and ready for integration into clients' GIS systems. Bluefield services also give insights to the financial and insurance sectors, increasing awareness of the wider climate and environmental implications of their decisions and the risks to assets and the macroeconomy.

The enabling hardware

Bluefield is also launching its own proprietary greenhouse gas tracking satellite in 2022. The space-grade sensor Bluefield developed is a compact NASA-proven technology allowing the identification of gases by visualizing their quantity distribution over terrains and detecting the gas concentration in two-dimensional images. It includes a methane gas capsule (for the detection of methane) and can locate and quantify specific emitters to an unprecedented sensitivity level and spatial resolution of 20 meters. That means it can attribute the emitting asset (for example an oil and gas well) to the company which operates it. This technology is unique in its ability to remove noise and eliminate false positives and scan large areas at speed. Bluefield's constellation of 8 satellites will provide measurements of every critical emitter, including emissions from melting permafrost, on the planet, every day.

Conclusion

Satellite-based emissions data is bringing unprecedented transparency and independent monitoring of emitters, anywhere on the planet. Satellite is the only platform capable of capturing data on each and every emitter as it requires no permission from the emitting source, or even the country it flies over. Bluefield fully owns the data and can distribute it multiple times (to the emitter, its competitors, regulators, investors, NGOs). This both makes the data affordable and completely changes the leverage and power associated with it, which once sat entirely within the emitting companies.

Tier 2

Tier 2 does not introduce any new data, rather it begins to aggregate Tier 3 and 4 data into useful metrics, to provide parent-company level analysis and highlight any red flags attached to any of the company's assets. This is particularly useful for investors, who tend not to be looking at project finance (Tier 3) but investing into an entire company which owns or co-owns these assets. A major challenge to aggregating asset-level data to a parent company for Tier 2 is the identification and/or untangling of ownership structures and linking those to physical assets on the ground.

At Tier 2 the inclusion of 'supply chain' assessments becomes vital. For primary industries (i.e. mining, forestry) impact is mostly contained within their operations. The wider environmental impact of secondary to quaternary industries is almost certainly defined, not by their physical assets (i.e. factories, headquarters), but by their supply chains. As a result, two asset level assessments are required to provide a company assessment (Tier 2). Firstly, a full Tier 4 – 3 assessment, summing the implications of the physical assets of the parent company and its subsidiaries. Secondly, an assessment of the assets contained within their supply chain assets, all the way to source. These two assessments can then be merged to give insights into the true implications of a company and its supply chains. However, the challenges in this approach are vast; for example, a car manufacturer is likely to have over 9,000 direct suppliers, and 40,000+ more required to supply those. And of course, there are significant data sensitivities around its suppliers.

Key Challenges

Tier 2 demonstrates the two most challenging aspects of spatial finance, the need for accurate geolocation of millions of commercial assets across the globe and the need for robust supply chain data. The first task of developing global asset datasets has already been achieved for some sectors by business intelligence providers. Additional work is already underway to create more asset databases. Unfortunately, the development of asset datasets for all sectors does not appear a scalable solution within the climate and environment crisis timeframe. The development of a single 10,000 asset database can take more than a year, and there are millions more assets requiring geolocation and constant active updates.

Whilst developing any asset dataset is a worthwhile endeavour, we argue finding high speed, low cost methods of normalizing asset and supply chain disclosure in some way will ultimately define the success of spatial finance. **Since companies themselves almost solely hold their supply chain data, the only practical approach in gaining this data appears to be in finding a way to encourage spatial disclosure by the companies themselves, perhaps as a mandatory requirement, via government regulation, certification, or industry bodies. It is important to note that public disclosure may not be necessary. Interoperable data exchanges based on existing technology, offer one potential solution for companies to share asset and supply chain data securely between themselves, as discussed later in this document.**

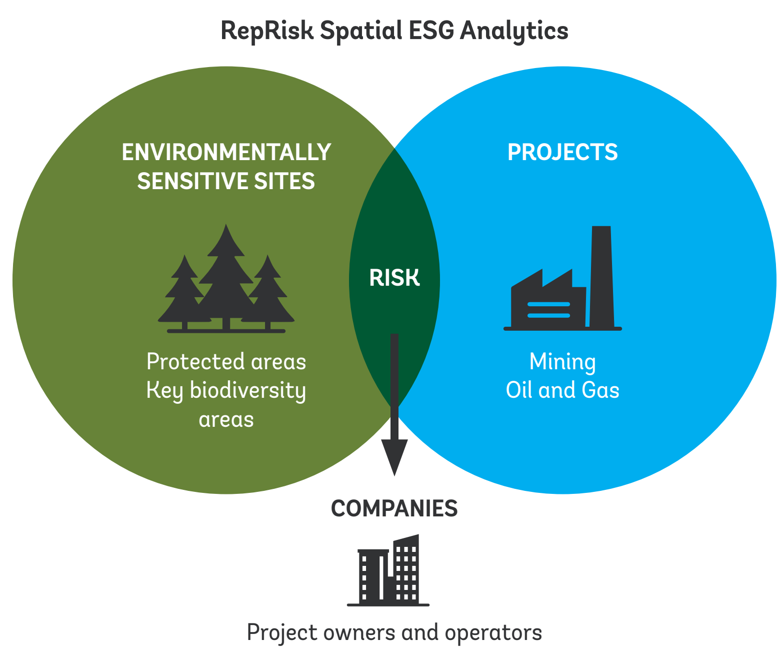
BOX: Tier 2 in the Real World

RepRisk

Author; Lioubov Protopopova - Executive Vice President, Products and Strategy - RepRisk

Since its founding in 1998, RepRisk has taken an outside-in approach to ESG risks - looking at what the world says about a company instead of what a company says about itself. Self-reported data can mask material ESG risks, from low-severity incidents to high-profile scandals. RepRisk leverages a combination of AI and machine learning with human intelligence to systematically analyze public information and identify material ESG risks – screening documents from more than 100,000 public sources a day in 20 languages to produce qualitative research, quantitative risk analytics, and proprietary metrics.

Spatial data offers a novel, scalable way to uncover risks before they are even reported. It is therefore a natural extension of RepRisk's solutions for clients, particularly in the finance sector, as it furthers RepRisk's goal of serving as a reality check for how companies conduct business around the world.



RepRisk's Spatial ESG Analytics offering first had to be enabled by adding physical asset location data to their pre-existing global dataset of infrastructure projects, particularly in high-impact sectors (mining, oil and gas). Jointly with data partners, RepRisk is now focusing on deriving ESG risk data from the proximity of these 65,000+ assets to environmentally and socially sensitive sites. Future plans include extending analyses to other sectors, as well as adding remotely sensed data on issues such as GHG emissions. RepRisk's Spatial ESG Analytics first attributes detected ESG risks to Tier 3 (assets) and then aggregates them to operators and/or owners, enabling data users to quickly and conveniently assess risks at Tier 2 - 0 levels.

BOX: Tier 2 in the Real World

Asset Resolution

Authors; Noémie Klein - Chief Executive Officer - Asset Resolution and Vincent Jerosch-Herold – Analyst – Asset Resolution

Asset Resolution (AR) provides a forward-looking database of over 350,000 physical assets covering key energy-related sectors: oil and gas extraction (upstream), coal mining, power generation, automotive manufacturing, aviation and shipping transport, and cement and steel manufacturing. AR links these assets to over 80,000 companies and financial instruments — helping financial institutions look under the hood of their portfolios.

AR works with leading data providers across the eight sectors AR covers, bringing various data sources and indicators into a robust and consistent framework. Starting from Tier 3, AR matches physical assets through ownership chains (Tier 2) to ultimately financial securities (Tier 1). This framework allows the aggregation of asset-level data at the company and portfolio-level with key sector-specific indicators (see figure below).

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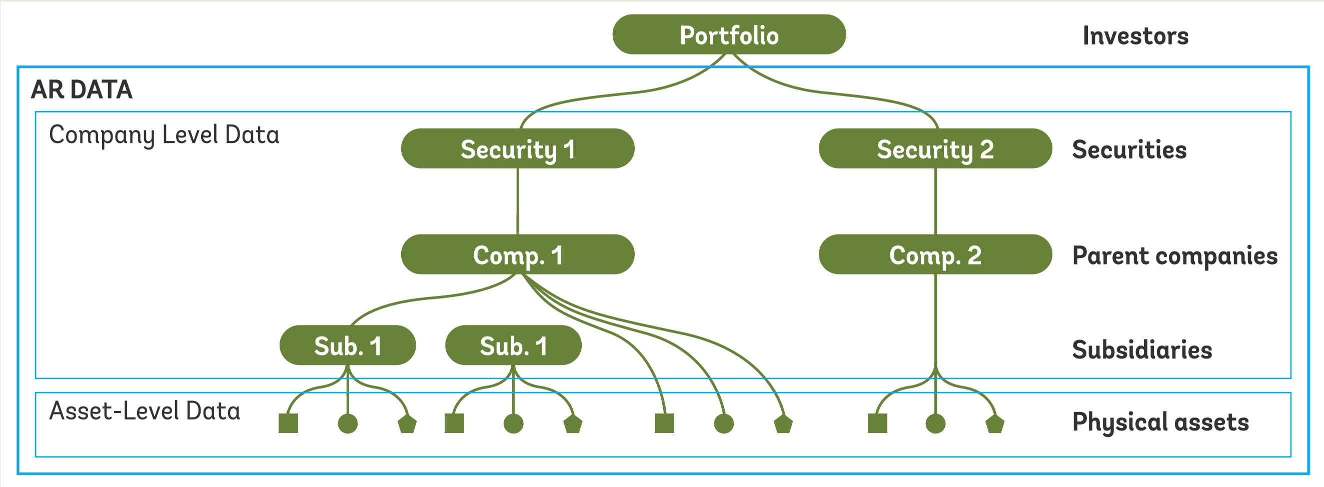
FIGURE 5 - How AR data works



Each asset holds a wealth of technical and physical characteristics. At the asset-level, AR works in partnership with providers of physical asset-level data to aggregate, calculate and homogenize indicators such as production, capacity, technology types, and emission factors. Other asset details, such as coordinates, can be linked to maps of physical risks and other geospatial datasets.

AR consolidates these asset indicators at the level of companies and financial securities. While each asset offers a wide range of potential insights, aggregating these insights over hundreds of thousands of assets, companies, and securities remains essential to discover meaningful trends. For this purpose, AR's aggregation methodology provides a transparent and consistent backbone. This backbone lends insights into the energy transitions happening within and across sectors, such as a company's shift away from upstream oil and gas extraction and towards renewable power generation.

AR's database is used in various high-profile tools such as the Paris Agreement Capital Transition Assessment (PACTA) tool developed by 2° Investing Initiative with support from the UN-backed Principles for Responsible Investment (PRI). An ever-growing number of regulators, supervisors, and financial institutions (+1,500) apply PACTA to their portfolios. With a standardized methodology across all sectors, AR enables comparability of the data, supporting coordination and decision making within and across initiatives and organizations.

AR was born out of research as a spin-off of the 2º Investing Initiative, which works to align financial markets and regulations with the Paris Agreement goals. AR seeks to continue working with researchers as clients, partners, and advisors to develop tools and indicators across existing and new sectors.

Tier 1

This tier simplifies the data further to provide results at a portfolio level, allowing users to filter for 'red flags', such as do any parent companies within the portfolio hold assets with negative social news stories, links to deforestation, or operations within World Heritage Sites? Users can dig down into the sub tiers to better understand exactly where and what these red flags are and use a visual mapping system to view the asset in question, if of interest.

Currently only partial Tier 1 systems exist. This is because at best we are only able to provide partial portfolio assessments, giving scorings for those companies which already have geo-located assets (i.e. power plants, mining, oil and gas, transport). This is exemplified in products like those of Asset Resolution[9] which are incorporating asset data and spatial finance methods, but are still limited to those sectors with near comprehensive global asset data. Since most portfolios include large volumes of companies from secondary or higher industries whose impact is mostly embedded within their supply chains, complete Tier 1 assessment will remain unfeasible until supply chains are unraveled for large sections of the global economy.

Tier 0

Tier 0 provides geospatially aggregated level insights, frequently cut to national areas. By cutting Tier 3 climate and environmental observational data to a defined geographic area, i.e. all data within countries boundaries and their associated exclusive economic zone (EEZ), additional novel climate, environmental, social or economic indicators can be developed for nations, or indeed any geographic area, state, municipality, water basin. For example, indicators could include;

- Probability of weather risk on economic outputs, at several scales.
- Probability of climate risks on economic outputs, at several scales.
- Regional, national impact on key habitats, biodiversity, (development, habitat loss, etc)
- Extent of national (and in some specific cases or international) illegal environmental activity (for specific sectors), illegal fishing, oil spills, deforestation, land degradation with protected areas etc.
- Quantification of atmospheric carbon and methane pollution events at several scales.

Interestingly, already it is possible with existing commercial asset datasets and Tier 3 comparison datasets to generate useful sub-national and national insights. These outputs can be used to fill Tier 2 data gaps. For example, the national proportion of fossil fuel power generation could be used to help estimate the carbon footprint of a factory if fuel consumption were unknown. However, the primary application for Tier 0 is to provide consistent, high frequency (ESG) indicators for every nation on Earth, to better inform sovereign debt investors.

Various datasets are already applied to provide national climate or environmental indicators. Frequently these datasets have been aggregated to give new national scale insights. Examples include the Environmental Performance Index[10] and commercially driven insights such as WWF and Ninety One's Climate and Nature Sovereign Index[11] or Swiss Re's Biodiversity and Ecosystem Services (BES) Index[12]. Others such as the UN Global Assessment Report on Disaster Risk Reduction (GAR) provide publicly available national-level hazard, exposure, and vulnerability data.

BOX: Tier 0 in the Real World - World Bank

Authors; Ekaterina M. Gratcheva - Lead Financial Officer, World Bank, Long-Term Finance and Dieter Wang - Consultant, World Bank, Long-Term Finance

The World Bank (WB) has been a leading provider for sovereign ESG data[13], covering 239 countries along 67 dimensions, and growing. WB sovereign ESG data portal[14] was launched in October 2019 in response to the increasing demand from the financial industry and policymakers for transparent, high quality sovereign ESG data comparable across countries and E, S and G dimensions. This data is being used extensively by market participants to assess and manage their ESG risks and, since relatively recently, on the financial sectors' contribution to the country's sustainability, such as for example, in their achievement of SDGs. Maintaining the breadth of coverage and comparability between countries are key properties of this dataset, especially in low income and/or developing countries where such data sets are not produced by private sector data providers. The WB continuously takes stock of how the data is used, to keep track with growing and changing demands on the practitioner side. A recent study[15] by WB on sovereign ESG data gaps evaluates underlying data production and management issues that affect availability and provide recommendations for improving the accessibility, quality and coverage of sovereign ESG indicators. Among the key shortcomings of the largest available sovereign ESG data - curated by WB and made publicly available through its sovereign ESG data portal[16] - is the low data frequency and long durations between data points, especially for environmental metrics.

To continue to improve sovereign ESG data availability and quality, the WB is working on leveraging earth observation data. Based on extensive ongoing consultations with the market participants and policy makers, WB's objective is to continue improving the existing data and to expand it to new indicators that are currently underrepresented, such as related to biodiversity loss, marine life, etc. **Reaping the benefits of GIS data is, however, not straightforward: Processing the vast imagery data to extract ecologically and environmentally meaningful data requires technical expertise and raw computational power. Furthermore, the processed data needs to undergo additional scrutiny and guidance on how to translate these indicators into decision-ready metrics for economic agents and financial market participants.**

Earlier this year, the WB deepened its collaboration on sovereign ESG data with the European Space Agency (ESA), which has already been working with the World Bank in monitoring development projects and disaster- risk financing programs for several years. The first project under the leadership of the WB's Long-Term Finance team[17] has explored the value-added of remote-sensing data in 15 countries in Southeast Asia, Latin America and the Caribbean, and Europe. Together with established statistical methods and flexible machine learning methods, the high frequency weather and agronomic data serve as the foundation to improve related ESG indicators. Furthermore, the team is exploring the informational content with an explicit focus on sovereign debt pricing.

Through this effort, the WB is beginning to answer the call made in several parts of this report – sustainability data as a public good - for non-profit organizations to take the lead in the propagation of spatial finance and data sources. Sharing this data and associated knowledge pieces is in full alignment with the WB's Open Data Initiative. In line with the Global Program for Sustainability[18], it promotes the use of high quality data and analysis of sustainability to better inform decisions made by governments, the private sector and financial institutions. Among its key objectives is to develop and disseminate policy recommendations and practical guides on sovereign ESG integration for institutional investors, emerging market bond issuers, credit rating agencies, ESG data and ratings providers. Geospatial data serves an indispensable role to realize this agenda.

Bloomberg

Author; Bobby Shackelton – Head of Geospatial - Bloomberg LP

At Bloomberg and across finance, the adoption of geographical data and applications is growing. More firms are using this data and hiring specialists to build, manage, and analyze it. In 2018 Bloomberg collaborated with the UN Environment Programme Finance Initiative (UNEP FI) and 16 of the largest banks in the world. This pilot group came together to work on implementing the recommendations of the TCFD - the Task Force on Climate-related Financial Disclosures. The working group published guidance and methodology for banks to report climate-related risks — such as transition and physical risks — much like companies report annual financials.

Bloomberg's Head of Geospatial, Bobby Shackelton, was invited to this working group because they thought maps and visual climate data would be useful for their reporting. But looking beyond the reporting visual, Shackelton led them to use geospatial technology to connect climate-related attributes to power plant locations, which gave them the quantification they needed at the plant, company, and portfolio level. The work accomplished here was ultimately published in a UNEP FI white paper[19] on physical risk assessment methodologies.

Since that time, the group of companies supporting TCFD has grown to over 1,500 of the biggest firms in the world, and continues to grow. The power of spatial finance is helping drive this.

S&P Global

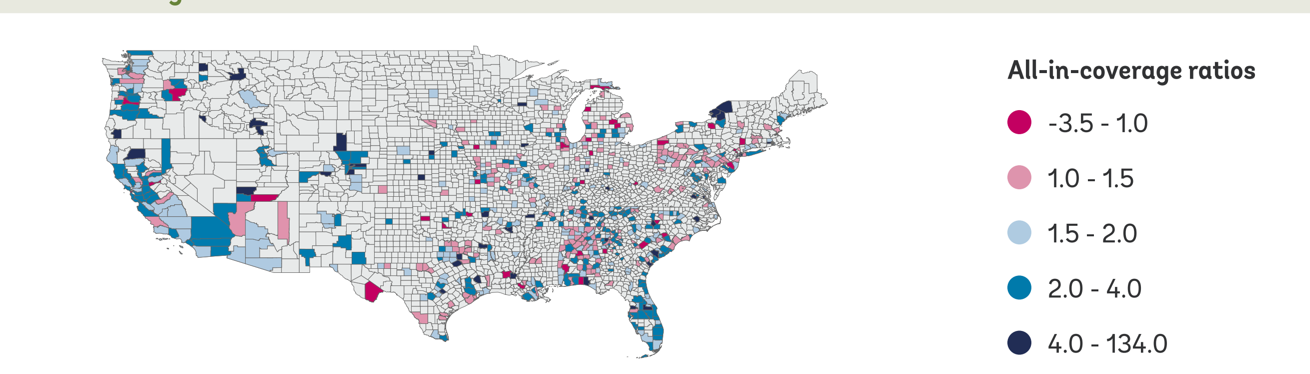
Author; Beth Burks - Director of Sustainable Finance, S&P Global Ratings

At S&P Global Ratings, we believe spatial finance could be the future of ESG risk analysis. Within the financial sector, it can provide investors and analysts with data before government statistical accounts are made available, and to monitor assets and infrastructure almost in real time.

Importantly, widespread uptake is plausible. Earth observation costs are steadily declining and Euroconsult forecasts 52 countries will have at least one satellite in orbit by 2028. Thus, spatial finance is within reach even for emerging markets, where information is scarcer. By bridging this data gap, spatial finance could enable more sustainable investment in those regions that struggle to secure it – and those that need it most.

We carried out our own unique spatial finance study, "Space, The Next Frontier: Spatial Finance And Environmental Sustainability"[20], to establish a link between the locations of U.S. public water utilities and their financial performance. It demonstrated that utilities located in regions with evergreen forests and perennial ice and snow had better all-in-coverage ratios (the ratio of freely available cash to debt service, recognizing fixed costs as debt-like in nature) than utilities located elsewhere. In other words, ecosystems that maintain good water quality and natural water storage also appear to support the debt metrics of the analyzed utilities.

All-In-Coverage Ratios of U.S. Counties' Water Utilities



Source: S&P Global Ratings. |

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Why is Spatial Finance relevant to ESG?

Established ESG insights have been provided by a diverse and proliferating group of rating agencies, such as MSCI. Historically the main source of company-level ESG data has been the companies themselves, either from publicly disclosed information or via providers directly engaging with companies to source private information, often by questionnaires.

Sourcing data from companies themselves has created a range of issues around accuracy, coverage, comparability, timeliness, and granularity. Self-reporting, for example, can lead to positivity biases, with companies omitting critical negative details, such as fines. Worsening the situation is that different data and methods are applied by companies within self-reporting, making comparisons between companies problematic. But arguably the greatest issue is timeliness, with most companies only publishing an ESG report once a year and often with a large lag time. Privately sourced data also faces the same issue with most rating agencies running a single annual survey, limited by companies' willingness to complete surveys at a higher frequency.

To help resolve these issues ESG providers have turned to other data sources such as regulatory datasets or machine learning to analyze vast volumes of text data from public sources (media, NGOs etc.) to provide greater insights. But these too have their challenges, where for example data sourced from media is often biased towards dramatic issues concerning well-known companies, with smaller climate and environmental impacts such as a minor pollution events, not seen as newsworthy and as a result not captured. Further complications shadow the machine learning approach, with their black box nature making methodological assessment difficult, giving rise to uncertainty surrounding the accuracy of the results highlighted.

A lack of robust ESG data is found across financial use cases. For example, a recent World Bank report[21] found issues in the coverage and frequency of their sovereign ESG indicators. It found 50% of ESG indicators assessed (115) had no value for the most recent study year and 13% had no values for the most recent four years or more.

Spatial finance, by drawing on previously uncaptured data and approaches - as outlined above - offers a novel data source to gain additional ESG relevant insights and as such is highly complementary to existing ESG approaches. Arguably spatial finance is currently best positioned to provide insights focused on the 'E' in ESG simply due to data availability within the environmental space, although this is likely to change soon with an increasing number of data studies attempting to qualify social concerns. Specifically, spatial finance offers the potential of:

- High frequency data on the climate and environmental performance of assets, week on week, month on month;
- Qualitative data, factual numbers driven by remote sensing or other means;
- Comparability of assets and company by applying globally consistent observational data against assets;
- Consistency across multiple scales, from assessing project finance issues to sovereign debt.

As we shall see in the next section, while there are significant challenges in geo-locating commercial assets and unravelling supply chains, spatial finance is already delivering valuable insights.

4.

Existing Tools Relevant to Spatial Finance

Despite the difficulties, operational spatial finance systems, both commercial and non-profit, are already online today, offering useful insights. Here we attempt to describe some of the differences in current approaches.

Within the emerging world of spatial finance tools, it is useful to make a distinction between those which provide pre-packaged asset data and those which do not.

Systems that require the user to upload their own asset data are common, with a growing ecosystem of these platforms. Many are global, others designed specifically for a single region and even sector. Global generalists commonly offer tens or even hundreds of observational data layers to compare assets against, i.e. Ecometrica[22]. Others are more niche offering specific insights on specific dimensions, such as environmental risk (IBAT[23]) or deforestation (Global Forest Watch Pro[24], Maphubs[25]), water risk (Aqueduct[26], Water Risk Filter[27]) or carbon (FlintPro[28]). They tend to be Tier 3 styled systems, designed to provide users insights for project finance, often limited by on-the-fly online processing, limiting users to assessing less than a thousand assets at a time.

Spatial finance platforms which hold asset data and supply chains data have the means to provide pre-processed asset (Tier 3), company (Tier 2) and in theory even (Tier 1) results. Such platforms are rarer, due to challenges around sourcing robust global asset databases. Despite this, already a few sector- specific Tier 3 and 2 spatial finance systems have emerged.

WWF-SIGHT[29] an internal tool of WWF, has run global assessments of the oil and gas, power, mining and shipping sectors every quarter since its launch in 2015 against 50+ ESG variables, allowing WWF greater systematic insights into which parent companies (Tier 2) are operating in critical conservation areas, and the impact of entire sectors and outliers within those sectors. In the commercial world the first offering was produced by Verisk Maplecroft Corporate Exposure Tool (CET)[30] in 2018, which provides ESG insights across 150+ variables into oil and gas assets (Tier 3), subsidiaries and parents (Tier 2) as defined by their sister company, Wood Mackenzie's, asset data.

Shortly we can expect a wider industry roll out of spatial finance methods. With many of the major traditional ESG providers now moving to add spatial finance components to their product portfolios. For example, RepRisk[31] has taken the move to integrate asset geolocations and enable users to uncover spatial ESG risks for such assets, while Bloomberg (Bloomberg MAPS<GO>) which uses real-time weather data to inform the dynamic and changing risk to millions of global assets, has recently added fires and corona virus into its mapping system.


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Why is Spatial Finance Relevant to the Non-Profit Community?

The common aim of WWF, other environmental NGOs (eNGOs) and the wider climate and environmental community is to avert the biodiversity and climate crisis and alleviate the ensuing social issues.

A key step in achieving this will be to limit the negative climate and environmental impacts of commercial actors. To have any hope of positively changing their operations, those impacts must be accurately measured and assigned to correctly, so the actor responsible can be held to account. Yet despite significant efforts across multiple approaches, accountability remains elusive, with commercial actors frequently getting away without having to record or assign the impacts of their operations, which are hidden within supply chains and distant subsidiaries.

Spatial finance offers a novel opportunity to increase the transparency and accountability around the impact of a company's operations. Bluefield's methane detection, for example offers the means to assign previously hidden emissions to an actor. Better still, spatial finance is data agnostic and can adapt and grow as better data is created, through advances in modelling, or improved satellite technology. But most importantly of all, it has direct commercial application, with the potential to deliver at scale. Spatial finance then offers the non-profit world the hope, through increased transparency, of changing how companies can operate, to help address climate, social and environmental issues. It requires no new technology or unachievable developments. Indeed, spatial finance in some forms is already operational.


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Why should commercial actors encourage Non-Profit involvement?

Commercial actors incorporating spatial finance approaches will seek to include environmental, climate and social observational datasets, to provide insight. This data is increasingly essential to aid financial institutions' insights in a large number of policy initiatives vital for testing areas such as: financial regulatory frameworks, environmental alignment of fiscal and monetary policy, bank and insurance risk management and regulation, debt sustainability analysis etc.

Recently, the International Financial Reporting Standards Foundation[32] found that all stakeholders across investor and corporate communities, central banks, regulators, public policy makers, auditing firms and other service providers, faced an urgent need to improve the consistency and comparability in sustainability reporting. It noted that large institutional investors require better climate risks and sustainability indicators as asset managers are faced with ever increasing expectations on ESG issues from customers, clients and beneficiaries, yet hold underdeveloped ESG relevant data and analytics. Central banks are also increasingly focused on climate-related risks and sustainability as a key driver in their financial stability. All of this points to the need for robust climate and data and standards to build trust.

In WWF's engagement with FIs over the past five years, the same message has been repeatedly voiced: a need for robust climate and environmental data and clear standards. Although needs vary depending on role, size and motivation of the FI, commonly FIs have expressed the need to have access to raw data, as well as more real-time and high frequency data to gain a more accurate picture of investment risk and opportunity. Interest has also been strongly expressed in future- looking models, such as WWF Water Risk Filter scenarios, based on climate and socio-economic changes[33] (Optimistic, Current Trend and Pessimistic) for 2030 and 2050. Beyond current data needs, future developments such as the newly forming Task Force for Nature-related Financial Disclosure (TNFD) are expected to put greater focus on being able to assess the impact and dependencies of investment on biodiversity.

Despite the growing pressure and need for data, commercial actors are almost entirely dependent on the non-profit space for the provision of high frequency, accurate global climate and environmental observational data layers. It is not feasible for commercial actors to recreate global biodiversity records, climate change models, or obtain the vast volumes of expertise the non-profit space holds. Furthermore, beyond data access is the need for correct data selection, interpretation, and application.

What is needed then, is a much closer interaction between the financial community and the data experts who understand the non-trivial complexities and implications of various environmental and climate datasets. Through an ongoing dialogue the FIs need to advise on specific needs, while the data experts need to advise on the best current possible data solutions, and what might be done to further refine future products to better meet needs. This continuing iteration is particularly vital, because to date no environmental or climate data has been generated specifically for application within spatial finance. To help illustrate the importance of this dialogue we provide a climate data example in the box below.

BOX: The Right Climate Data for the Right Task

Author; Donald J. Wuebbles, Professor of Atmospheric Science - University of Illinois & Senior Advisor to Earth Knowledge

Although different analyses of climate impacts may have different national, regional, and sectoral focuses, most begin with the same premise: that future climate conditions under a set of consistent assumptions regarding human choices, as reflected in future greenhouse gas emissions, can be simulated by global climate models.

Modeling of climate processes, that is, the physics, chemistry, and biology defining the Earth's climate, are usually done at the global scale. There are now over 30 global climate models around the world that are used in the international comparisons of these models (called CMIP) that occur for each major international assessment of climate change. They also vary in quality and there is no perfect model. These models are extremely complex and computationally expensive, so the resolution of these models currently is roughly 1 degree or about 100 km in latitude and longitude. This resolution is generally far too coarse for most applications to study the potential impacts of climate change. As a result, downscaling techniques, both regional climate models and statistical techniques, have been developed to get to higher resolution, towards being able to better define local and regional impacts.

Which set of global models, what downscaling approach, what climate variables are needed, and what spatial resolution to use for climate impacts analyses, will depend on the specific sector of interest, and often on the specific location of concern. How can businesses, communities, or countries plan for adaptation in a changing climate? The answer isn't just a matter of spatial and/or temporal scale: often, climate model outputs must be translated into the variables or indicators already used as input for planning – return period, threshold exceedances, degree-days, streamflow, or more. This requires that a non-trivial amount of time and effort be invested in communication and collaboration between experts in climate information and experts in quantifying the impacts on a given system.

For some systems or sectors, only average changes in temperature and precipitation may be needed, but for many others, the changes in climate extremes are necessary to determining risk and vulnerabilities. In other words, for some applications statistical downscaling using a simple delta approach may be perfectly adequate, but in most cases, that technique is likely to be deficient because it does not adequately treat temperature and precipitation extremes. For this reason, much effort has gone into statistical techniques that can much more accurately consider extreme events. Also, if more parameters are required than temperature and precipitation changes, regional climate model results for that specific region at appropriate resolutions can provide many more climate variables (e.g., cloudiness, winds) for impacts and resiliency analyses.

In addition to climate datasets, other scientific tools may also be needed to fully understand the impacts of climate and other forms of global change on a landscape. For example, very high-resolution models developed by Earth Knowledge for Northern California and other parts of the western United States use statistical downscaled projections of temperature and precipitation as inputs to detailed energy and water balance models that account for the local landscape structure and surface and near-surface hydrology to determine risks resulting from extreme heat, droughts, floods, and other climate extremes and variability affecting local and regional utilities, manufacturing, real estate, agriculture, forestry, and other sectors.

Earth Knowledge's high-resolution models have successfully forecasted the likely location and extent of catastrophic wildfires in the 2017, 2018, and 2020 fires seasons in the North Bay area of California. The 270 m spatial and monthly temporal resolution of these models allows for a clearer representation of dramatic shifts in hydrologic conditions on the landscape and the high degree of water stress. Likewise, because of the monthly statistical downscaled climate data these models accurately show the dramatic change in very wet conditions to very dry conditions in a short period of time indicating the potential for a high volume of vegetative matter that has a high vulnerability for extreme wildfire conditions. In 2020, a brief period of high-intensity lightning storms ignited wildfires throughout Northern California contributing to the most destructive wildfire season in California State history.

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Major Gaps to be Resolved and Possible Solutions

We are perhaps five years away from a robust commercial global set of Tier 4 to Tier 0 system. First, many challenges will need to be overcome, most of which are not technological, but data related. We will need to find ways to improve observational datasets and develop methods which encourage and/or require actors to disclose their ownership structure, asset data and supply chains. Here we consider some of the larger gaps to be resolved;

1. Lack of Asset Data
2. Improving Tier 3 Climate and Environmental Observational Data
3. Tracking Parent Company and Company Trees
4. Benchmarking Scoring Methodologies
5. Supply Chain Asset Assessment
6. Complexities of Tier 4 Data

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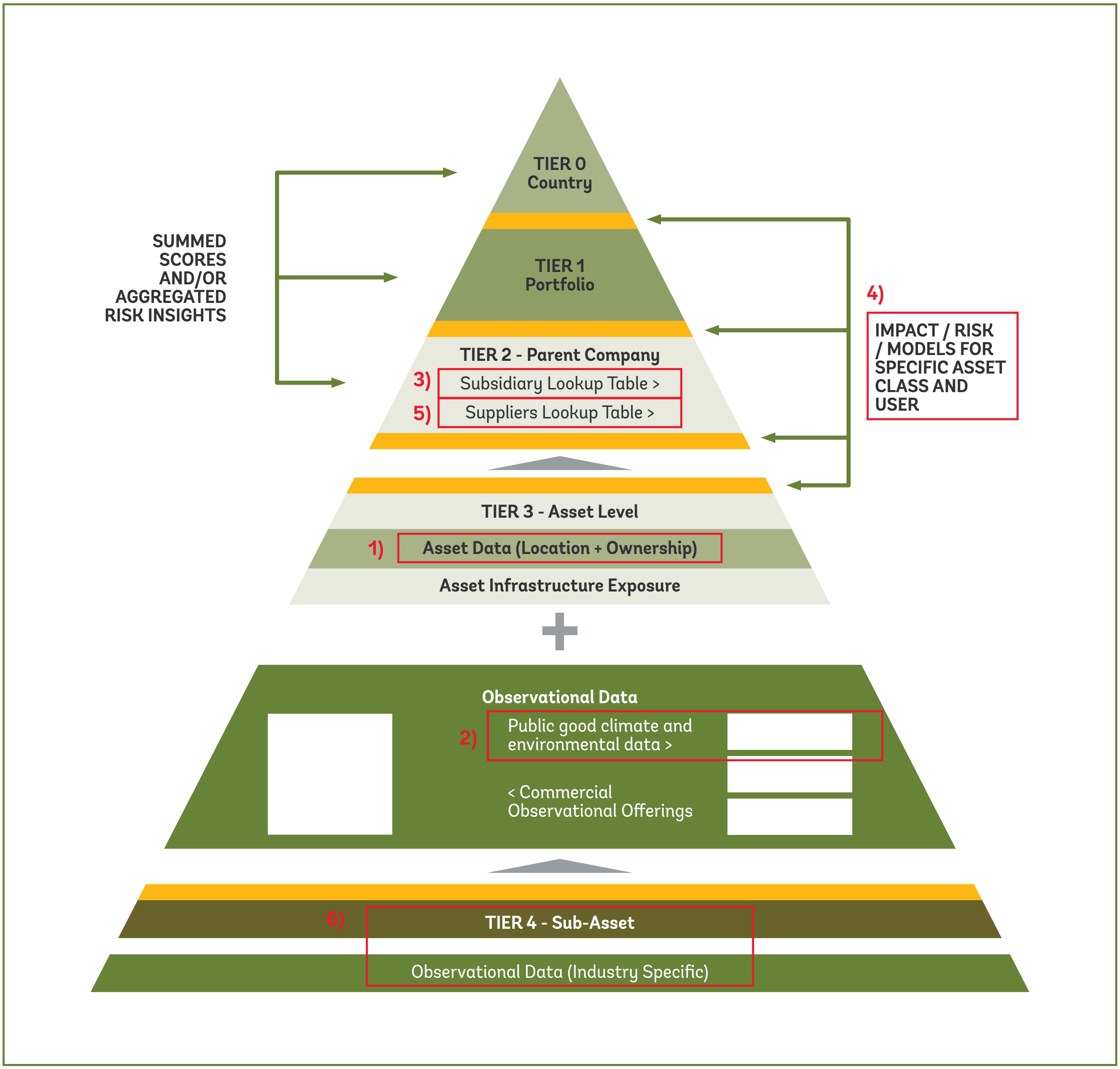
FIGURE 6 - Diagram showing the major issues in spatial finance within the five tiers.



1. Lack of Asset Data

Issue: A lack of asset data, openly or commercially available, to enable spatial finance assessment of assets, companies and portfolios.

Currently asset data, the location and ownership information and other attributes of specific assets is commercially available for a few primary industries, a small subset of which is openly available. To generate insights with sufficiently wide coverage to meet most use cases, asset data and the supporting information on company trees needs to be dramatically improved.

The model of users providing their own asset data may be viable for specific project level applications but is an impractical solution for wider spatial finance assessments with users simply lacking the necessary in-house asset data. Alternatively, siloed commercial or open asset datasets are of course valuable, but commercial datasets still need large amounts of development to widen their coverage across all sectors. Due to their resource intensive nature to build and maintain, scaling them to define all assets globally and update constantly appears problematic. Efforts are already underway that use machine learning and remote sensing to identify the location of assets more efficiently, and these offer potential aid in the future development of open or commercial datasets.

Other options for increasing asset datasets come via the establishment of new regulation to enforce spatial disclosure of commercial activity. This could be achieved either through government regulation, within certification standards, or as a requirement by the FIs, or some other mechanism. However, whilst regulation offers hope, any form is likely to require time to become established and enforced.

One potential solution to avoid necessitating the development of ever-increasing asset datasets or the requirement of new legal frameworks is the use of data exchanges. In an exchange, an interested party (i.e. insurer, bank, regulator) can request privately and securely asset data directly from the companies themselves or other nominated third-party data holders. With no centralized database, commercial actors retain control of their sensitive data. Insurers, banks and other financial institutions could incentivize companies to adopt the use of the data exchange. The gain for the financial institutions is better risk management for the client, providing means to check compliance, identify opportunities and in doing so lower physical (material), transition, litigation and systemic risks.

ACTORS CREATING SOLUTIONS: *Already the business intelligence providers, ESG providers and open data actors are using differing approaches and technology to develop improved asset databases. It is likely all will continue to make gains in this space, with various voluntary and regulatory initiatives later supporting developments. In this document we explore the viability of a non-profit data exchange as one potential solution.*

2. Improving Environmental and Climate Observational Data

Issue: Lack of robust climate and environmental data to use as observational datasets within spatial finance.

In order to gain better environmental and climate spatial financial insights, there is a need for up-to-date, high resolution environmental or climate observational datasets covering metrics across a wide portfolio to analyze asset data against. Some datasets, contingent on application, will need to be produced at a high temporal frequency, others at a lower frequency. All will need to ideally remain methodologically consistent both over time and with other observational datasets used, drawing from the same base datasets.

Of central importance is an integrated approach, vital to get the best out of the limited high temporal frequency data, using updated datasets to update others, perhaps using daily high frequency data to update values within other datasets by spatial location. Generally, issues surrounding global environmental and climate observational layers for use in spatial finance could be grouped as follow;

- **FORMAT** - Data comes in inconsistent formats, projections, or formats unable to be easily integrated within spatial finance systems.
- **FREQUENCY** - Many key environmental and climate datasets update infrequently (6 months+), some are never updated. Conversely, some core variables such as temperature and rainfall update at very high frequency. Overarching this is uncertainty over what time frames might be adequate within spatial finance approaches to consider specific risks.
- **RELEVANCE**- Data is frequently not provided in adequate proxies ready to use within spatial finance, so it needs to be reprocessed to be applicable.
- **ACCURACY** - Many global climate models (100 km^2), and a few environmental layers commonly used within spatial finance are of low resolution (10 km^2). These layers need to be refined to improve resolution to sub 100 m^2 for some spatial finance needs.
- **COMPARABILITY** - Data ideally needs to be global in coverage, or as wide as possible, to enable consistent direct like-for-like comparison around the world.
- **TOPIC COVERAGE** - There is a lack of any meaningful data products designed for spatial finance applications across some critical topics, such as biodiversity. Opportunities present themselves to create more tailored products to aid understanding of issues around complex topics like biodiversity, which do not readily fit within current financial sectors operations.
- **ACCESSIBILITY** - Data can often be restricted within academia, mired in complexity or blocked by non-commercial license constraints resulting in barriers to entry for many financial institutions.
- **SATURATION** - Across climate and environmental measures, there is a huge volume of data, and differing definitions for indicators, i.e. water stress, heat stress etc, so identifying which data to use, which values to include in risk models, can be complex.

ACTORS CREATING SOLUTIONS: *Climate and environmental data experts, often within academia or the eNGOs, already hold large volumes of data. To date much of this data and expertise has not yet been adapted and applied to spatial finance. This document outlines a potential solution in this space, calling for dialogue between the financial sector and data experts and the need for a data clearing house.*

3. Tracking Parent Company Unique IDs and Company Trees

Issue: Difficulty in accurately assigning subsidiaries to parent companies, and consistently matching parent companies across different systems.

Unique identifiers for parent companies should be achieved by using existing open systems, such as Open PermID by Refinitiv or the Legal Entity Identifier (LEI), easing collaboration between teams. Other identifiers, such as exchange tickers, face the increased potential for error, as often large companies are listed on multiple exchanges. However, it seems prudent to design systems around multiple data points to aid identification.

Commercial assets, subsidiaries, and even parent companies, frequently change ownership; as a result, commercial asset datasets and company trees will need to be updated regularly to remain effective. Whilst there are detailed commercial business intelligence datasets on company subsidiary trees, and large volumes of data available on companies via systems such as Open Corporates, to date there is no single globally reliable open system. In addition, to enable the matching of discrete data sources to holders, some actors have built AI algorithms aiding the matching of data from any source correctly to a unique parent's company id.

Due to the scale of the challenge in developing and maintaining company trees and asset datasets, one option over the longer term would be to place responsibility onto commercial actors themselves to regularly publicly disclose their company trees and assets, either via new regulation or through data exchanges.

ACTORS CREATING SOLUTIONS: *Actors such as GLEIF (LEI) and Refinitiv already offer effective solutions for universal parent company ID. Business intelligence providers already have significant company trees-databases. The open space is less developed, with products like Open Corporate limited in accuracy. Regulators may in time have significant impact in this space through mandating the public release of such data.*

4. Establishing Benchmarked Scoring Methodologies

Issue: Complexity around the establishment of benchmarked methods to define climate and environmental impact and risk across different industries

Spatial finance considers all types of commercial assets, from mines to retail shops. Within each sector there is the opportunity to create finer scale differentiations, by type of activity. For example, there are tens of thousands of mines globally, some mines are open pit mines, others underground, some are gold mines, some lithium. These subcategories have different social, environmental and climate implications and could be used to model additional insights.

It seems likely in the initial development of spatial finance there will be the temptation as with current ESG to focus on data availability, to use what is at hand. A challenge moving forward will be to ensure the development of asset datasets and observational datasets that support in-depth sector specific insights. Development of methodologies will take time, requiring detailed expert input and iteration.

ACTORS CREATING SOLUTIONS: *Actors both within the non-profit space and commercial arena have long modeled climate and environmental impacts and risks of specific asset classes for various sectors. The challenge moving forward will be the translation and incorporation of this complex and varied field into spatial finance. However, because their integration rests first on the uptake of more basic spatial finance components, we do not expect significant developments in the open space in the short term.*

5. Supply Chain Asset Assessment

Issue: Lack of robust supply chain data to use within spatial finance and high data sensitivities around the use of such data.

Supply chains are essential to the global economy. Equally, they are universally acknowledged as important to sustainability, social and environmental impact, pollution, and human welfare discussions. And yet, whilst there is strong demand for greater information on environmental and climate impact from businesses and consumers to inform their financial decisions, supply chains remain opaque, lacking detail and coverage. Within spatial finance understanding, true implications of secondary industries and above will require accurate supply chain data.

To date, global supply chain databases provide results at a national or sector scale, unable to link specific actors to specific on-site activity. Many have called for a spatial approach to create fine scale inventories of supply-chain steps by modelling available subnational economic data with spatial observations or models of supply chain activity to gain greater specificity and from that spatial insights into environmental impact. Indeed, some actors have already made gains within this space, such as TRASE, FINEPRINT, and IElab.

The next step towards spatially explicit supply-chain data, will require supply chain data with high resolution geolocation i.e. to specific assets. This data could be generated by the companies themselves or via some form of regulation. Indeed, some retailers already offer supply-chain tracking. Inevitably the culture change towards greater supply chain transparency – necessary to enable any detailed assessment – will require multiple strategies, simultaneously lobbying consumers, retailers, governments to change the culture and legal requirements around supply chain disclosure. In this model, public pressure placed on household names will lead to their demanding their wholesalers record their supply chains and so on. The whole arsenal of national and international legal reforms, sector best practice, regulation and data coupling should be called on to support supply chain disclosure.

In the meantime, open spatial finance systems could use subnational economic datasets as a stopgap to provide rough probabilities of risk of environmental impact for specific sectors, i.e. if company x sources aluminum from region y in Brazil the probability of deforestation, water risk, biodiversity, etc, is value 1,2,3. This means merging all results for a region together, so if a municipality has a high rate of deforestation, all relevant suppliers (those which could cause deforestation) within that municipality, regardless of their specific deforestation impact, would have a high deforestation score. An undesirable result, but one which might remain in favor simply because no other solution is present.

The goal of transparent open supply chain data required for all sorts of applications including spatial finance insights is likely to take some time, and indeed may never emerge, because of data sensitivity. One alternative is secure interoperable data exchanges, which enable commercials to privately share such data. This is discussed in the 'Future of Spatial Finance' section.

ACTORS CREATING SOLUTIONS: *Many actors within the profit and non-profit space are working on increased supply chain transparency. However, if supply chain information is to become more widely accessible, radical change will be required, perhaps through regulation or some other means. In this document we consider the approach of data exchanges as a possible solution.*

6. Challenges of Super Fine Resolution Data (Tier 4)

Issue: Legal issues and data challenges in the application and use of Tier 4 data in spatial finance in the future.

Although Tier 4 will come online slowly, particularly in the open space, it should be considered. Tier 4 will generate huge volumes of data, from web scraping millions of documents, to minute-by-minute measurements of power use or noise pollution by smart meters. As a result, it will be necessary to aggregate data and create key measures. How should this data be summed? Who is responsible? How do we ensure data security? Even deciding on what key measurements should be could potentially be controversial.

As with many components of spatial finance, Tier 4 demonstrates the need for clear transparent methodologies on how data has been gathered and summarized and clear pathways of ownership. The legal complications in developing Tier 4 datasets, in particular, should not be underestimated, with each state frequently having its own data compliance laws and each sector its own specific data variables and sensitivities which potentially may need to be addressed case by case.

Any spatial finance system creates the potential for data biasing, geographic biasing (where data may not be available for some regions), subjectivity on importance or significance of data points, and potential biasing when aggregating results. The way data is collected and presented will have implications that define the perceived impact of companies and even nations, with potentially large financial implications, efforts must be taken to minimize biasing and provide transparency on methods used.

PART 2

Proposed Actions
WWF's PERSPECTIVES

Spatial finance is an emerging field, with significant potential to provide greater factual insights on the climate, environmental and social impact and risks of companies. We have outlined a new taxonomy for the field, showing how asset data can be assessed against observational data at multiple scales. From sub-asset measurements (Tier 4), i.e. smart power meters, air pollution monitors, to summed data at a national level (Tier 0) for sovereign debt insights. Already a range of partial spatial finance tools is commercially available, with most major ESG providers and business intelligence providers developing capabilities within the space.

Due to direct application of data within the financial sector it has the potential for real world positive impact, making it highly relevant to eNGOs and the non-profit space. Because of the need for highly accurate and robust climate and environmental datasets, the non-profit space as holders and experts of this data will be an essential part of the field's development. This will require an ongoing dialogue between the financial sector and non-profit world to iteratively develop climate and environmental observational datasets for application.

Various data challenges now stand in the way of the field's development, such as a lack of asset data, inconsistent observational data and barriers around access to supply chain data. We propose that gains in spatial finance, increased transparency, and accountability, will aid the non-profit world in attempting to limit environmental degradation, social issues and worsening of the climate crisis. In this section, **we look specifically at what the environmental non-profit sector might do to resolve some of the challenges the field faces within the short term.**

1.

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Improving Asset data and Supply Chain Data

Although not within the remit of the WWF, a specialized non-profit might be able to provide a bridging function to enable the sharing of sensitive asset and supply chain data between commercial actors.

One of the major challenges with an individualistic approach to asset data will be the struggle to get to scale. This is because any single actor, or small group, will have to constantly deploy resources to track and maintain global geo-located assets, company trees and supply chains for many companies. Even with significant resources it is highly unlikely data would ever be near the breadth of coverage required by the FIs, due to difficulties in obtaining sensitive supply chain data.

An alternative approach might be a more open system, with no centralized database, which allows any actor to fairly (with compensation on unfair exchanges) exchange asset data securely between themselves on request, using APIs and existing technology. It seems unlikely even in the medium term, due to the length of time regulation may take, that companies will have an incentive to openly release their asset data, company trees or detailed supply chains necessary for full spatial finance insights. They might however be willing to do so within a secure data environment, to a specific insurer, or bank for improved rates or for best practice compliance. Arguably there is an incentive for the banks, investors, and insurers to use such an exchange to obtain asset data as a means to lower material and reputational risk and a means to identify potential commercial opportunities in a changing climate world.

A distributed data exchange has several advantages: users would be able to confidently source accurate asset data and company trees and supply chains from the company themselves, or other FIs. They are highly adaptive, flexible to provide the user with the best data sources as they come on and offline. The disadvantages are significant, requiring standards to be set across a diverse set of industries and nations with differing data laws and regulations. However, the Open Banking Standard which defines how banks share data in the UK, and now copied in Australia, Europe, Hong Kong, India, Japan, Mexico, Malaysia, New Zealand, Rwanda, Singapore and the USA provides an example, showing how such systems are possible. The Open Banking Standard does not just mandate interoperability around data, but defines rules around liability, rights, security, redress, etc, and it is changing behaviors across the financial market. The success of spatial finance may then rest in part on the speed of an ‘Open Spatial Finance Standard’, enabling interoperable data exchanges for asset data linked to a dynamic marketplace for observational data in the near long term.

It seems likely one way or another asset data, via exchange or by increased open asset datasets and commercial operations will develop over time to resolve the asset data side of the equation. However, the other side of the equation, climate and environmental observational data, remains to be resolved. In the next section we explore potential solutions.

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Improving Climate and Environmental Observational Data

As outlined throughout this document climate and environmental observational datasets can be applied against asset data, using GIS approaches, to provide asset level insights (Tier 3). Results can be captured to give insights at company level (Tier 2) and the high tiers or cut to provide geographical insights (Tier 0).

These datasets are vital to enable high level risk assessments directly on both the impact and dependency of commercial operations (asset data) in topic areas such as biodiversity impact, operations within environmentally sensitive areas, coastal flooding risk, risk of extreme temperatures, weather, fire risk etc. This is a particularly valuable approach to rapidly screen assets at multiple scales. The applications for this data are broad and can also be applied to inform models, develop indices or applied across any other application in finance and beyond, as useful scientific outputs, for other areas of finance, regulatory performance, or applied within frameworks such as TFCD, the newly emerging TNFD, or the EU Taxonomy. **It's vital however, the work is in the first instance decoupled from any specific data framework, as the best data should be generated and then later refined to match a regulatory framework, if required.**

Why can't the financial sector be left to it?

The non-profit space holds much of the useful 'climate and environmental spatial data'. Unfortunately to date, business intelligence providers and FIs are not able to effectively utilize much of this data. Data is frequently obscured in complexity. Environmental data are frequently restricted in access behind licensing constraints. As a result, the most useful data is not consistently applied. Even that data which is applied can be applied incorrectly, a common issue with complex climate model data. Worse still, much of the data is not designed for spatial finance, with low temporal and spatial resolution. The data is generated in the non-profit space for different applications and as such may not align to the FIs needs.

Despite these problems, such is the desire for such insights, some commercial actors have invested in new in-house geospatial and made significant progress. For example, Lombard Odier, an independent Swiss bank, has recently established an in-house ten-person geospatial-driven team to help make sense of the exposure and resilience of companies to climate change. Whilst some FIs and business intelligence providers may have made progress, they will remain reliant on the environmental non-profits data and expertise and cannot resolve the data issues alone.

As climate and environmental observational data is increasingly used within the financial sector to inform decision making, the quality of the data and how it is applied has increasing real world implications. As such we argue the non-profit space has a significant vested interest in ensuring access, quality, and correct application. We propose it makes far more sense for one dedicated centralized team of experts to work to resolve issues and provide a cleaned, ready to go, tailored portfolio of climate and environmental datasets, as a public good than for the financial sector to have fractured conversations with the non-profit community, resulting in unequal access, application and insight across the sector. A centralized hub would provide a natural contact point for dialogue (see below), a venue to establish standards, and help ensure outputs are robust and methodologically aligned.

Establishing a Dialogue

An ongoing dialogue between the financial sector, cutting across different financial groups (e.g. insurers, sovereign debt investors), and experts in environmental and climate data needs to be established. This is necessary to ensure the best climate and environmental data is being applied correctly within each specific application. It is also vital to gain feedback from the FIs to guide the iterative development of future climate and environmental data that can be tailored to meet FIs needs.

This need is already reflected in several emerging initiatives, such as the European Commission which recently announced a new Knowledge Centre for Biodiversity data. It will provide a one-stop shop for science-based evidence for the EU region to protect the natural ecosystems. In addition, the need for something akin to an 'international data comission' is being voiced in the early discussion of the Technical Expert Group of the TNFD.

Generating Tier 3 Climate and Environmental Observational Data for Spatial Finance

The environmental non-profit sector, as primary data holders, have an obligation to ensure the best climate and environmental data is easily available, to help ensure financial decision making is not restricted by a lack of timely and accurate information.

The provision of data has several advantages, it removes uncertainty for commercial operators around data selection. It reduces FIs' workload by providing data cleaned, consistent and ready to use with the right legal licensing. For the non-profit sector it helps to ensure quality control and that the financial sector has the data it needs within this space.

Currently the climate and environmental data portfolio is disorganized and frequently lacking temporal and spatial resolution for use in spatial finance. To resolve these issues, in combination with ongoing dialogue to guide the work, we propose to develop a climate and environmental 'data clearing house' of sorts. Importantly, by approaching the data as a related 'set' rather than as discrete layers with no relationship to one another, we will be able to gain greater temporal and spatial resolution within the portfolio, whilst supporting methodological consistency across all outputs.

Underlying Platform

A centralized database could be used to generate outputs. To do this a new server could be established for this specific application. Alongside this, it seems sensible to make use of existing resources, if available, which can help meet the progressing requirements, such as Google's Earth Engine or Microsoft's Planetary Computer. The disadvantage of this is that some non-profit actors may not wish to put data into these systems or may not wish to share code or methods within these systems.

The alternative is to share data between non-profits via API and use existing in-house systems and capability. The logistics of organization, however, will create an additional burden upon data teams who are likely already stretched. In addition, they may lack the human and computing resources required. Consequently, the simpler solution appears to be a centralized database that still would have the flexibility to pull data via APIs if required.

Approach

Dialogue with various actors across the FI industry will inform a shortlist of observational climate and environmental data layers to prioritize for output. The specifications of these can then be debated, considering needs vs feasibility. Data will be placed into one of three groups 1) clean and standardized 2) backfill and/or produce at high frequency or 3) generated from scratch.

Firstly, we recommend the following steps;

- Build and publish a data directory listing all robust and potentially useful climate and environmental spatial layers, their location, and limitations, pertinent to the financial sector.
- Define as widely as possible which non-profit actors are developing new data, models, methods and solutions relevant to spatial finance by topic.

To standardize data to enable an integrated data approach we propose:

- Agree and establish standards after consultation with data experts and the financial community.
- Clean and standardize data using proven GIS approaches.

To improve the resolution of datasets, we propose:

- Backfill data to convert coarse resolution datasets into high resolution using the other datasets i.e. geophysical datasets to improve insight.

To improve temporal frequency of those datasets which are required month on month, or higher we propose:

- Use datasets with high frequency updates to continuously update other datasets, by cascading values. For example, if an-area has lost its forest cover, what does that mean for the other data layers, such as biodiversity, water, climate layers, etc.? The new data inputted can be used by inference to update other layers.

To improve insights in areas not currently met with existing methods or data, we propose:

- To work in collaboration across the climate and environmental community to apply modeling and or machine learning methods to generate new data layers.

Multiple approaches, focusing on specific tasks, will need to be explored; however, all ideally would be methodologically consistent. For example, if global elevation is used to backfill one dataset, the same Digital Elevation Models (DEM) must be used to inform other datasets. Of course, within this and indeed across all the work complexities arise, so the advantages and disadvantages of including differing DEM of higher regional resolution must be considered against needs, practicality, and methodological consistency.

BOX: Data Case Studies

While an in-depth discussion with a wider group of FIs and actors is required to determine exact needs, some are inevitable. Here we explore two topics, biodiversity, and climate change, looking at the generation of new data and backfilling.

Biodiversity - New Models

The greatest challenge with creating global biodiversity layers is data collection, verification, and management. Current biodiversity products primarily use species observations to define biodiversity for a given area. This means they are often focused on the need to continually improve species observation records to give more accurate insights. Due to the infeasibility of global sampling on the ground, the resulting products they create are biased to areas of easy sampling and developed over long time frames often over five years. Furthermore, they often fail to differentiate uniqueness within areas of high biodiversity, providing instead saturated high scores i.e. the entire Amazon is listed within a narrow band of high scores. Moreover, no easily accessible biodiversity layer for the financial community to date uses dynamic updates, where for example a forest loss input can be used to update a specific site's likely biodiversity.

Spatial finance applications, however, need to be able to distinguish between sites, to flag issues such as damage to areas of uniqueness, and have up-to-date insights. It's not useful to flag a project site as high forest biodiversity if it was converted to farmland five years ago or conversely a low priority site subsequently found to have highly endangered species present. To address these issues, we propose to focus first on developing a machine learning approach based on the theory of energy-stability alongside species observations verified by observations on the ground to train a model to determine a site's biodiversity. By uniting data as outlined above, we propose to cascade discrete dataset updates into the biodiversity layer, where for example new fires, roads, mines, forest loss can be used to update biodiversity insights, week on week.

The theory of energy-stability suggests that the more solar energy and the greater the stability in climate month to month and the greater the area, the greater the biodiversity. Applying the same datasets as used for backfilling climate insights, we can define geophysical inputs, solar energy intensity, precipitation rates/flux, elevation, surface water, create a high res global map of geophysical stability/variability and any points of localized uniqueness within it. Against the geophysical map, we apply the energy-stability to give an approximate biodiversity score. We can then apply multiple tiers of on the ground-verifiable species observation data to refine those scores.

BOX: Climate - Downscaling Data

There are over thirty IPCC-standard climate models in development across the world. However, many of these models share the same sub-models (e.g., the ocean sub-model), or are derived from similar/parent codebases, meaning that these climate models are not independent from one another. This makes it challenging when trying to decide which climate model output to use for a given case study, or how to optimally combine the various model outputs for use in impact assessment. AI tools are now being applied to intelligently and optimally aggregate across these climate model ensembles, with the aim to provide a single and statistically robust global layer of climate change metrics and/or sector specific associated climate risks (e.g., number of days in the growing season where temperatures exceed levels detrimental to the health of a specific crop).

While climate models do a reasonable job at what they were originally designed for, to understand changes in large-scale climate phenomena under specified climate forcing conditions, they are increasingly being used to make predictions at the regional and local-level. However, global climate models typically have a spatial resolution of 1 degree (about 100 km) so they are too coarse to be really useful for such analyses (meteorological patterns in the data over complex terrain [e.g., localized rainfall or cooling over mountains, or increased temperature over urban environments] are often smoothed out or missing entirely), and these models are too expensive computationally to be run effectively at finer resolutions. Climate models include varying levels of regional biases (e.g., too warm, too dry), and also some systematic biases (e.g., the Southern Ocean warm bias) often resulting from lack of robust localized in situ measurements and/or limited understanding of the climate physics processes. It is commonplace for these biases to be corrected during post-processing (by remapping distributions in climate variables, e.g., temperature). To automate this process, machine learning tools are now being applied to correct model output, making them more suitable for impact assessment.

Another area of climate model refinement is known as 'climate downscaling' in which the irregularly sampled and/or coarse resolution climate data is adapted to increase the spatial granularity to the resolution required. Using these downscaling techniques, both regional climate models and statistical techniques have been developed to get to higher resolution, towards being able to better define local and regional impacts.

Regional climate models (RCMs) can account for the relevant physics to dynamically downscale to finer grid-spacing over a limited region. However, these RCMs are still computationally expensive and more time-consuming to derive than statistical downscaling. Not only do these models derive many more climate relevant quantities but they are also not dependent on local observational data. Interpretation of results from RCMs need to also account for their limited number of downscaled products - they typically consider a few future scenarios and only a few global models as boundary conditions for their studies.

Machine learning can help to combine these various available high-resolution datasets together (surface topography maps, surface types and the extent of urban sprawl) with coarser resolution climate model output to create global layers with increased and location specific granularity.

Feasibility

The establishment of a hub to centralize conversations between the FIs and the climate and environmental data experts is highly feasible, requiring fairly insignificant resources. It makes practical sense that any dialogue is connected to the same body responsible for the production of climate and environmental observation data layers. This body would take more resources to establish. Arguably it is only viable as a non-profit entity, designed around providing a clear open-source public good, as data holders and experts are unlikely to provide their resources to a commercial operation. The feasibility then, mostly rests around the ability to source funds to establish such an outfit. This body does not necessarily need to be a new organization, it could for example be an offshoot of a non-profit with a related function like CDP. A clean sheet however might be favourable to ensure the organization has a specific spatial data focus and retains independence in its mission.

Actors Required

Firstly, the selection and production of data needs to be guided by the needs of financial institutions, requiring detailed and structured dialogue with a large array of actors, such sovereign debt investors, private equity, ESG rating agencies, business intelligence providers, government bodies etc.

Most climate data is openly available, so arguably no permission is required to source data. However, understanding the data, the methods and the cutting edge of the field demands significant expert input from climate scientists. This would need input to be sourced from academia, international bodies to provide guidance on how climate models and data should be applied within specific spatial finance needs.

Environmental data covers a wide and diverse landscape of actors and licensing issues. Some such as remote sensing products, such as NASA's and ESA satellite imagery archives, or WRI's and University of Maryland forest loss insights are openly available. Others such as the World Database on Protected Areas, or IUCN Red List Species data are not open for commercial redistribution. Other datasets are not available at all. The holders of these data - eNGOs, academia, government bodies, international bodies - will need to be engaged with on a case by case basis. Expert input on the selection and application of data would, due to the diversity of data, need to be sourced from each topic's area of expertise, mostly likely from eNGOs and international bodies. Key actors include the IBAT Alliance, GBIF, GEO, larger NGOs, academia, space agencies.

To clean, update, backfill and generate new data products will require data scientists, machine learning expertise, GIS experts, programmers, etc. It also may require substantial compute resources, requiring donation or support from big tech such as Google EE or Microsoft AI of Earth. This expertise will in part be supported via the aforementioned actors involved but additional resources may be sourced from AI think tanks, private sector or academia.

Finally, from a practical standpoint, a dedicated project team would be required to coordinate and push the work forward. This would require a high level of specialization and would need to be sourced from across a diverse range of actors.


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Next Steps

With the pressure of the climate and biodiversity crisis looming, there is an urgent need to catalyze the application of spatial finance to support improved ESG insights. While many challenges need to be overcome and will require many new developments across sectors from regulators, business intelligence providers, and the commercial actors, here we outline the next steps for two specific developments related to the environmental non-profit space.

Improved Asset Data via Distributed Data Exchanges;

Although beyond the remit of eNGOs like WWF, the development of an 'Open Spatial Finance Standard' is likely to be central and critical to the mainstreaming of spatial finance and the use of climate and environmental data in Tier 4 - 1 assessments. Therefore, we propose to support where possible a standard to:

- Support and liaise with actors developing open spatial finance standards.
- Engage with regulators, standard bodies i.e. TNFD and other relevant bodies, to explore and push for wider spatial disclosure via data exchanges.
- Work on a case study with the reinsurance sector to explore the concept of an asset data exchange within their sector and for their needs, publishing the results.
- Work to ensure climate and environmental data developments (below) align with real world needs.

Improved Climate and Environmental data via an Integrated Data Approach:

Within the observational data space, we propose to;

- Unite key data and technical partners together in online meetings in 2021 to discuss the concept of a public good environmental and climate data clearing house for spatial finance application and to serve the needs of the developing frameworks and existing and evolving climate and environment related disclosure and regulatory requirements.
- Support the development of proposals to secure funding necessary to establish a body responsible for coordinating dialogue and data production.

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Glossary of Key Terms

ASSET DATA - data defining an asset's ownership (e.g. company name) and location, i.e. a field, a mine, a factory, a powerline. Often asset data provides additional information.

OBSERVATIONAL DATA - any data used to provide insights against asset data. Data is highly diverse, from specific ground-level data to global data layers. Data is commonly applied to provide insights into the climate or environmental implications of specific assets. Observational data is tiered within this document as follows:

OBSERVATIONAL DATA TIER 0 - provides insights at a defined geographic area, often at a national level. Aggregating Tier 3 climate and environmental observational data to a defined geographic area, i.e. countries boundaries and associated exclusive economic zones (EEZ).

OBSERVATIONAL DATA TIER 1 - provides insights at a portfolio level. An aggregation of Tier 2 data to provide portfolio overviews, allowing users to filter for 'red flags', such as any companies within the portfolio with links to deforestation.

OBSERVATIONAL DATA TIER 2 - provides insights at a parent company level. An aggregation of Tier 3 and 4 data of the parent company assets and their suppliers assets providing a parent company level analysis and highlighting any red flags attached to any of the company's assets nd operations.

OBSERVATIONAL DATA TIER 3 - provides insights at the asset level. Defined as high-level insights covering the full extent of specific assets, such as an overlap with Protected Areas, species, indigenous areas or insights into the water risk of the site, deforestation, carbon emissions, methane emissions, etc. Tier 4 datasets can be aggregated to provide further insights.

OBSERVATIONAL DATA TIER 4 - provides insights at the sub-asset level. Defined as 'sub-asset measurements', readings taken from nearby (≤100m) or within the asset itself, often at a high temporal frequency. Examples include air pollution monitors, power smart meters and industry specific measurements such as the genetic profile of timber logs.

SPATIAL FINANCE - an emerging field, which works by defining the location of a company's physical assets and their suppliers' assets, and then comparing those assets against other datasets (observational data) to providing independent insights (often climate and environmental) into the performance of assets, companies, and even regions or states for use within the financial sector.

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About WWF

WWF is one of the world's largest independent conservation organisations, active in nearly 100 countries. Our supporters – more than five million of them – are helping us to restore nature and to tackle the main causes of nature's decline, particularly the food system and climate change. We're fighting to ensure a world with thriving habitats and species, and to change hearts and minds so it becomes unacceptable to overuse our planet's resources.

WWF. For your world.

For wildlife, for people, for nature.

Find out more about our work, past and present at

wwf.org.uk

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Endnotes

1. Established in 2019 the Spatial Finance Initiative is working towards the mainstreaming of geospatial capabilities within financial decision making, leveraging space technology and data science. spatialfinanceinitiative.com/
2. The Global Power Plant Database is an open source global database of power plants. The database covers approximately 30,000 power plants from 164 countries. It includes thermal plants and renewables. Attributes include information on plant capacity, generation, ownership, and fuel type. datasets.wri.org/dataset/globalpowerplantdatabase
3. The Global Tailings Portal, launched in January 2020, is an open database on more than 1,800 mine tailings dams globally. It provides attributes on location, company, dam type, height, volume, and risk, among other factors. Developed by the Investor Mining and Tailings Safety Initiative, which surveyed 300+ publicly listed mining companies for detailed disclosures on their tailings storage facilities (TSFs). Previously there was very little information about mine tailings dams publicly available. tailing.grida.no/
4. As defined by D.J. Patterson - SFI network event on the 5th of March 2020.
5. Smart Energy Islands aims to use technology, including Hitachi's Internet of Things (IoT) platform and Artificial Intelligence (AI), to reduce the carbon footprint of the Isles of Scilly whilst optimizing locally-produced, renewable energy. social-innovation.hitachi/en-eu/case_studies/smart-energy-islands-isles-of-scilly
6. Financial Conduct Authority, Regulatory sandbox - cohort fca.org.uk/firms/regulatory-sandbox/regulatory-sandbox-cohort-6
7. WWF-SIGHT is the WWF internal mapping tool, developed and run by WWF's Conservation Intelligence Team. The data and results mentioned in this document are only accessible internally. wwf-sight.org
8. News report into significant methane leaked identified by Bluefield 31, July 2020 bloomberg.com/news/articles/2020-08-20/epa-launches-investigation-into-massive-florida-methane-leak
9. Asset Resolution is a spatial finance provider, offering insights into over 350,000 physical assets covering key energy-related sectors: oil and gas extraction (upstream), coal mining, power generation, automotive manufacturing, aviation and shipping transport, and cement and steel manufacturing. asset-resolution.com/
10. The Environmental Performance Index (EPI) is a joint project of the Yale Center for Environmental Law & Policy and The Center for International Earth Science Information Network (CIESIN) at Columbia University's Earth Institute. The index provides a data-driven summary of the state of sustainability around the world. Using 32 performance indicators across 11 issue categories, the EPI ranks 180 countries on environmental health and ecosystem vitality. epi.yale.edu/
11. WWF / Ninety One (2020) Climate & Nature Sovereign Index ninetyone.com/-/media/documents/brochure/91-climate-nature-sovereign-index-white-paper-en.pdf
12. Swiss Re Institute (2020) Biodiversity and Ecosystem Services - A business case for re/insurance. swissre.com/institute/research/topics-and-risk-dialogues/climate-and-natural-catastrophe-risk/expertise-publication-biodiversity-and-ecosystems-services

13. World Bank Sovereign ESG Data Framework. datatopics.worldbank.org/esg/framework.html
14. World Bank Sovereign ESG Data Portal. datatopics.worldbank.org/esg/
15. World Bank (2020), An analysis of coverage gaps in ESG data. worldbank.github.io/ESG_gaps_research/ESG_gaps_research.pdf
16. World Bank Sovereign ESG Data Portal. datatopics.worldbank.org/esg/
17. World Bank Long Term Finance. worldbank.org/en/topic/longtermfinance
18. World Bank Global Program on Sustainability worldbank.org/en/programs/global-program-on-sustainability
19. UNEP FI Navigating a New Climate unepfi.org/wordpress/wp-content/uploads/2018/07/NAVIGATING-A-NEW-CLIMATE.pdf
20. S&P Global, Space, The Next Frontier: Spatial Finance And Environmental Sustainability. spglobal.com/ratings/en/research/articles/200122-space-the-next-frontier-spatial-finance-and-environmental-sustainability-11317146
21. World Bank (2020), An analysis of coverage gaps in ESG data. worldbank.github.io/ESG_gaps_research/ESG_gaps_research.pdf
22. Ecometrica provides spatial finance observational data insights based on a diverse range of satellite-derived products. From forest protection to disaster response, sustainability reporting software to full global supply chain intelligence, Ecometrica's technology uses machine learning to provide users with a complete view at local, national, regional or supranational scales. ecometrica.com/
23. Integrated Biodiversity Assessment Tool (IBAT): IBAT provides authoritative geographic information about global biodiversity. The users can access the World Database on Protected Areas, IUCN Red List of Threatened Species, and the World Database of Key Biodiversity Areas through the tool's data download services. ibat-alliance.org/
24. Global Forest Watch Pro (GFW Pro) is an online tool to help support reducing deforestation in commodity supply chains. GFW Pro delivers forest loss analysis at the property, supply shed and portfolio levels. GFW Pro is built upon best-in-class, timely data from the Global Forest Watch Partnership and World Resources Institute's scientific research.pro.globalforestwatch.org/
25. Maphubs Forest Report is an automated deforestation and fire hotspot monitoring system that analyzes thousands of locations in near real-time. maphubs.com/forest
26. Aqueduct is an online platform which helps users identify and evaluate water risks around the world. Aqueduct's tools map water risks such as floods, droughts, and stress, using open-source, peer reviewed data. wri.org/aqueduct/
27. Water Risk Filter is an online tool, launched in 2012, that helps companies and investors assess and respond to water-related risks facing their operations and investments across the globe. Developed by WWF and the German finance institution DEG. waterriskfilter.panda.org/
28. FLINTpro is an online platform, designed to aid organizations' ability to manage their land-sector GHG emissions. flintpro.com/
29. WWF-SIGHT is the WWF internal mapping tool, developed and run by WWF's Conservation Intelligence Team. The data and results mentioned in this document are only accessible internally. wwf-sight.org

30. Verisk Maplecroft: Corporate Exposure Tool - Measures asset-level oil & gas company and peer group industry exposure to ESG, climate and political risks, allowing users to compare and benchmark the exposure of almost 3,000 companies and 10,000+ assets to over 150+ issues. maplecroft.com/solutions/above-ground-risk/corporate-exposure-tool/
31. RepRisk is an ESG data provider. RepRisk identifies and assesses ESG and sustainability risks associated with over 30,000 projects and 120,000 companies in more than 180 countries. The data and metrics are updated daily and can be fed into the underwriting, risk, compliance and investment. reprisk.com/
32. IFRS Foundation Consultation Paper on Sustainability Reporting (2020) cdn.ifrs.org/-/media/project/sustainability-reporting/consultation-paper-on-sustainability-reporting.pdf?la=en
33. Added recently, the WWF Water Risk Filter scenarios, based on climate and socio-economic changes (Optimistic, Current Trend and Pessimistic) for 2030 and 2050 are designed to better help companies better understand future water risks and drive more effective corporate action on climate and water resilience. wwf.panda.org/wwf_news/?933366/New-Water-Risk-Filter-Scenarios-will-help-companies-and-investors-turn-risk-into-resilience
34. Refinitiv Permanent Identifier (PermID) is an open identifier that provides a unique reference for a data item. PermID provides comprehensive identification across a wide variety of entity types including organizations, instruments, funds, issuers and people. PermID never changes and is unambiguous, making it ideal as a reference identifier and is intended to enable interoperability. permid.org/
35. The Legal Entity Identifier (LEI) is a 20-character, alpha-numeric code based on the ISO 17442 standard. It connects to key reference information that enables clear and unique identification of legal entities participating in financial transactions. Each LEI contains information about an entity’s ownership structure. gleif.org/en/about/open-data
36. Open Corporates is the world’s largest open database of companies in the world. opencorporates.com/
37. TRASE is an open online platform which provides insights into how commodity exports are linked to agricultural conditions, including specific environmental and social risks. trase.earth/
38. FINEPRINT is working to develop footprint models, taking a geospatial approach for assessing global material flows looking at the worldwide raw material flows embodied in products and services and assessing the associated environmental and social impacts. fineprint.global/
39. The Industrial Ecology Virtual Laboratory (IELab) is a collaborative platform for multi-region input-output modelling and research. IELab is designed to process and analyze economic, environmental and social data from any sector, country or region. ielab.info/
40. Open Banking Standard standards.openbanking.org.uk/

WORLD BANK GROUP

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