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Sustainable Finance: AI Applications in Satellite Imagery and Data

Zhenjia Yang[1] | **Daniel Broby**[2†]

[1]Strathclyde Business School, Glasgow, Scotland

[2]Strathclyde Business School, Glasgow, Scotland

Correspondence
Daniel Broby (Director).
Strathclyde Business School, Stenhouse Wing, 199 Catherderal Street, Glasgow G4 0QU
Email: daniel.broby@strath.ac.uk; zhenjia.yang.2019@uni.strath.ac.uk

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This paper explores the applications of financial technology on the supervision of sustainable finance. It does this within the context of state level goals and how these can be monitored and enforced using AI applications, supported by satellite imagery and data. Its contribution is in showing how financial technology can aid and support sustainable goals. It finds that institutional investment monitoring variables are not aligned with the variables in either the literature or those that are mandated by legislation. It recommends a greater use of satellite imagery and data in the enforcement of Environmental, Social and Governance goals.

KEYWORDS
Air pollutant Emission, Water Pollution(Quality), Waste management, Natural resource management, Satellite imagery and data, Environmental indicators, Sustainable Finance, compliance

1 | INTRODUCTION

The supervision of sustainable finance goals lacks a robust framework and suffers from weak enforcement. In order to address this, we review both goals, benchmark targets and the literature that relates to environmental, social and corporate governance (ESG). Such benchmarks are increasingly used to understand sustainable investment at a national and at a company level. These are based on internal or external oversight, the focus of the paper being on the latter.

Sustainable development or sustainability was first introduced in the Brundtland Report in 1987. It was defined therein as "…development that meets the needs of the present without compromising the ability of future generations

† Director, Centre for Financial Regulation and Innovation

to meet their own needs."[1].

The legislative push for sustainability focuses on the impact of current transactions on future outcomes. This is explained by Ryszawska (2016) who emphasize the significance of sustainable transactions and how they facilitate an inclusive, sustainable and low-carbon economy. In a similar line of thought, Fatemi and Fooladi (2013) suggest using a sustainable value creation model based on empirical evidence. They conclude that businesses which fail to recognize sustainability related factors should be valued at a discount compared to their peers.

The literature on the use of satellite imagery and data is introduced alongside metrics on current compliance requirements. Greater usage of satellite data and imagery is proposed by way of extension to existing ESG oversight tools and techniques. The literature suggests unsustainable activity may harm investment return.[2] A notable example of profit loss caused by failing to include social and environmental impact during investment decision is Norwegian Government Pension Fund Global performance and BP's oil spill during 2010.[3]. The Pension fund holds 1.75% of BP's share, and have lost more than $1.4 billion following BP's scandal. Therefore, the literature concludes that it is crucial to recognize and understand sustainable finance for both investor and regulator, as it is closely associated with the return of investment and plays a vital role in the sustainable transition process.

Applications of Artificial Intelligence are not a feature of current sustainability initiatives. That said, its importance is exampled by John McCarthy famous statement that AI is "tomorrow's computer science", made in the early 1960s[4]. References to AI increased following the Association for the Advancement of Artificial Intelligence(AAAI) conference in 1987, which was the first dedicated to promote research and communication regards AIAAAI (2020). Binner et al. (2014) applications in finance and economics. It defined AI as a group of aggregated data-driven methodologies that involve artificial neural networks, genetic algorithms, fuzzy logic, probabilistic belief net-works and machine learning process. In the other words, these collective components together can be used to build a machine which is able to mimic "cognitive" functions, such as learning and problem solving.

2 | BACKGROUND

The European Commission defines sustainable finance as the process of involving environmental, social and governance considerations when making investment decisions, and it could increase long-term investments and promote sustainable activities [5]. Generally, the environmental component involves mitigation and adaptation of climate change, as well as the environmental-related risks [5]. The environmental criteria includes energy usage, waste, pollution, and natural resource conservation. The Social component refers to the business relationship of the organization [5]., Social considerations may involve issues such as inequality, inclusiveness, human rights, product responsibilities to clients, investment in human capital and communities. The governance component mainly refers to the management structures, employee relations and executive remuneration [5]. More specifically, such as compliance level of government policy, monitoring and reporting. It enables the inclusion of environmental and social considerations in the decision-making

[1] World Commission on Environment and Development, 1987, p. 41

[2] This review used the search terms: *sustainable finance, Environmental Social and Governance(ESG), ESG indicators and criteria, air pollution estimation, water pollution estimation, waste generation or emission, Natural resource conservation, reforestation and deforestation, landscape conservation, compliance measurement, compliance monitoring, sustainable finance supervision, product responsibility, sustainable product, Satellite imagery, data, AI and Satellite data*. It excluded the literature on ESG value creation, ESG and investment performance, ESG indicators measurements which unable to processed by satellite imagery and data. The review includes 40 papers which are focused on six ESG indicators that the author found relevant to satellite applications, namely air pollutant emission, water quality, waste generation, natural resource conservation, product responsibility, compliance measurement and application of AI in satellite data and imagery.

[3] Fatemi & Fooladi(2013), p. 107

[4] Stewart Watson, 1985, p.1

[5] EU Commison,2020,https://ec.europa.eu/info/business-economy-euro/banking-and finance/sustainable-finance$_en$

process [5].

There are a considerable number of studies that have been conducted by international organizations regarding determining the ESG indicators. A well-known example of institutional research is the sustainability reporting guidance G3.1. This includes 84 sustainability performance indicators and lunched by The Global Reporting Initiative in 2011GRI (2011). The United Nation Global Impact proposed ten principles of cooperate social responsibility which relates to the indicators in social and environmentalUNGC (2008).Nonetheless, there are limited amount of literature focus particularly on ESG indicators identification.

Measurement and monitoring of ESG goals and targets is an important element in their compliance. Kocmanová and Šimberová (2014) examined quantitative and qualitative ESG indicators and demonstrated the importance of integrating these factors into sustainability performance metrics. It did this using the example of a Czech Republic manufacturer which complied with ISO 14001 standard. [6] To be awarded the standard, the company implemented social responsibility with 12 measurement areas with 28 performance indicators for ESG sustainability reporting. These were evaluated using principal component analysis. We suggest, AI can be used in the same way, based on and supported by satellite data.

The key performance measurement areas for the environment can be broken down into investment and non-investment expenditures for environmental protection, emissions, consumption and waste[7]. In a social dimension, the measurement areas are society, human rights, labour practices and work conditions and product responsibility[7]. In governance dimension, the extracted factors are monitoring and reporting, corporate governance effectiveness, corporate governance structure and compliance[7].

There is a clear frustration that ESG disclosure is voluntary and has a lack of standardization. Head of Research and Public Policy fat the World Federation of Exchanges(WFE), Siobhan Cleary, observed that “With more issuers engaging in ESG reporting, and more investors using this information, it is important to drive towards standardization of ESG reporting[8].”

There is some controversy over the extend of "green-washing". This includes activities to hide the true nature of corporate environmental performance indicators within a sustainability report Ly et al. (2015) and Delmas et al. (2013). We argue this shows the importance of consistent and standardised ESG reporting, and also oversight suing reliable data.

One of the critical guidance Task Force on Climate-related Financial Disclosure (TCFD) provided by the Financial Stability Board is based on the voluntary principleexpert group on sustainable finance (2020). The new announced reporting tool EU Taxonomy is aiming to improve the standardization and effectiveness of the private sector disclosureTCFD (2017). On the other hand, last year AI for good global summit suggested that the application of AI in Satellite imagery and data may provide support for the ESG supervision regards several specific indicators, such as air pollutant, water pollutant emission estimation.

A strand of the literature focuses on practical data applications of satellites. This supports our view that their use would enable higher level of sustainability supervision in several areas. We suggest that environmental indicator measurement might be interesting.Mazzanti and Zoboli (2008) support this, pointing out that by increasing satellite remote sensing capabilities, authorities could enhance surface air quality supervision. Additionally, Streets et al. (2013) found that geostationary satellite imagery and data provide accurate air pollution estimation.

We further suggest that the applications of satellite data are extensive. For example, (1) Mohamed (2015) found

[6] ISO 14001:2015 specifies the requirements for an environmental management system that an organization can use to enhance its environmental performance

[7] Kocmanová Šimberová,2014), p. 1023-1024

[8] GRI,2018, https://www.globalreporting.org/information/news-and-press-center/Pages/Driving-standardization-of-ESG-reporting-WFE-Guidance-and-Metrics-mapped-to-GRI-Standards.aspx

that the Medium-Spectral Resolution Imaging Spectrometer (MERIS) satellite imagery enables real-time water quality supervision; (2) Elias et al. (2014) found that satellite data could improve groundwater quality and pollution estimation based on the Evros River case study; and (3) Lanorte et al. (2017) found that Landsat satellite imagery with Support Vector Machines can support plastic waste management in Agriculture activities (providing a more accurate waste estimation).

The literature shows satellite data and imagery can be as beneficial for natural resource conservation supervision as it is for agricultural yield management. Filonchyk and Yan (2020) used satellite data to monitor the natural and traditional reforestation of Northern China and suggested that satellite monitoring would support the development of reforestation techniques. In a similar vein, Svancara et al. (2009) used satellite data to assess the landscape context and conversion in the United States. This indices that using satellite data to monitor such factors would enable a consistent national land conservation assessment.

Satellite derived indicators are also correlated with some social and governance criteria, such as product responsibility and compliance level. For the product responsibility, the promise of a green product involves the concern regards the environmental damage during the produce and delivery process. The compliance of environmental requirement is an essential component of governance. As the motioned above, the satellite imagery and data have particular advantages within some specific area relates to ESG. These include six indicators, namely air pollutant emissions, water pollutant emissions, waste generation, natural resource conservation, product responsibility and compliance level data.

We believe satellite data and imagery provide a massive amount of information and suggest that advance machine learning process could enhance the analysis of this data with minimum human intervention. At the 2019 AI for Good Global Summit, the International Telecommunication Union (ITU) supported our view by claiming the application of artificial intelligence in satellite imagery and data would enable real-time information analysis and support the movement to predictive modelling **?**

Academics have used satellite data in ESG related areas. For example, Hemanth researched AI techniques for satellite imagery analysis. They found that it would significantly contribute to object identification, vegetation land identification, maritime traffic supervision, crop nutrition detection, deforestation detection and water body extraction. For sustainable finance supervision, this means the regulators would be able to access more accurate and efficient data analysis regards the relevant indicators and even predict the feature trends of the related environmental issues, such as deforestation and reforestation. This can be further strengthened by employing artificial neural networks (ANN's) Victor Nobre Carrijo et al.) pioneered this, applying ANN's and satellite data to conservation in the Savanna. This shows that with ANN's. it would be possible to generate accurate energy capacity estimation in shorter time and at lower cost.

The authors believes that AI suggests a successful predictive model can support the regulators to perfect the relevant requirements and setting appropriate ESG benchmarks. That said, there exists a research gap in respect of the application of AI in Satellite imagery and data for sustainable finance supervision.

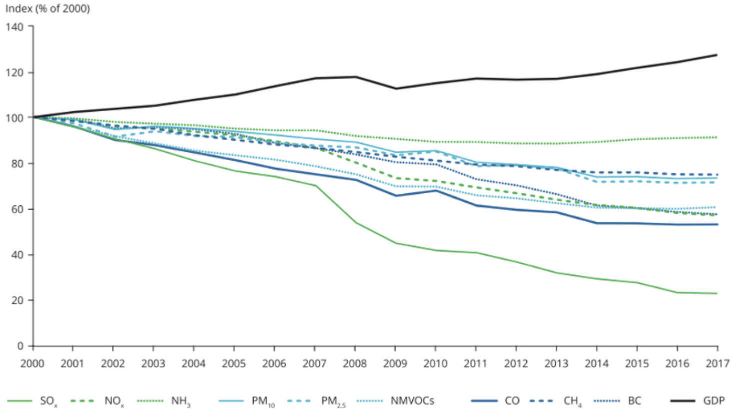
3 | SATELLITE DATA APPLICATIONS

Satellite data can complement current information sources used for the oversight of sustainable finance. Images produced by satellite offer a non-invasive information. This is often superior to self-reported information. Data allows for standardised analysis on air, water and waste pollution.

3.1 | Air Pollutant Emission

The United States Environmental Protection Agency (EPA) describes air pollutant emissions as detrimental gasses which are discharged into the air. They can be generated through various sources such as manufacturing process, transportation[9]. European Environment Agency (2019)), classified the main Air Pollutant Emissions in Europe into sulphur oxides: SO2, nitrogen oxides: NOx, ammonia: NH3; non-methane volatile organic compounds: NMVOCs and fine particulate matter: PM2.5. Figure 1 presents the trends in total emissions of the main air pollutant and gross domestic product in the EU 28 countries from 2000 to 2017. Almost all types of air pollutant emissions shows a prominent decreasing trend except the NH3, which seems to have a relatively small change across the year. Satellites can be used to monitor such data.

FIGURE 1 Air pollutant emissions and gross domestic product



The figure shows trends in total air pollutant emissions and gross domestic product EU-28 EEA (2019b)

Based on the amended Gothenburg Protocol and the requirements set by new EU National Emission Ceilings Directive, EU regions need to reduce 59 % of SO2; 42 % of NOX, 6 % of NH3; 28 % of NMVOCs and 22% of PM2.5 emissions compared with the 2005 levels by 2020 European Environment Agency (2019). Although the annual statistics for 2020 air pollutant emission is not released yet, the lockdown and other related policies for stopping the spread of COVID-19 have led to decreasing in economic activities which have an obvious impact on air pollutant concentration. The latest data posted by EEA indicate that there are a significant reduction of the nitrogen dioxide(NO2) emissions which correlated with PM2.5 in almost all the cities in the EU region. [10]. Take Italian as an example. The average concentrations of NO2 for the week of 16-22 March in Milan and Bergamo was 21 %, 47% lower than the same week in 2019 [10]. Hans Bruyninckx, EEA Executive Director, claimed that this significant drop in air pollution is especially caused by reducing traffic in cities, and solving air quality problems requires ambitious policies and forward-looking investments.

Another important air pollutant mitigation commitment for EU members is the 2030 target. This can also benefit from statelite monitoring. This requires compliance with 40% of NOx, 15% of NMVOCs and NH3, and more than 30% of SO2 as well as PM2.5 reduction compared with 2017 emissions level(EEA, 2019). However, some researchers

[9] EPA,2020,https://www3.epa.gov/airquality/emissns.html

[10] EEA,2020,https://www.eea.europa.eu/highlights/air-pollution-goes-down-as

suggest that the EU region need additional effort to achieve the 2030 target EEA (2019c) and Amann et al. (2018). Amann et al. (2018) Used the Greenhouse gas - Air pollution Interactions and Synergies model(GAINS) to define the cost-effective way for achieving 2030 requirement based on the EU Reference 2016 Scenario and 2017 legislation baseline. The results indicated that along with quantifying the necessary emission reduction volumes, the regulators also need an additional measurement for the sector emission distribution to identify the least-cost approach. We suggest satellite data can be used to do this.

The literature on the shape, size and toxicity of particles is also relevant. Oberdörster et al. showed that these were related to adverse health outcomes, and found that nanoparticles, agglomerates of nanoparticles, and particles of nanostructured material are most risky could nanomaterials for human health. Kampa and Castanas (2008) also indicated that air pollution could lead to both acute and chronic results on human health, including minor upper respiratory irritation to chronic respiratory and heart disease.

Aside from overall air pollutant emissions goals set by the regulator, many institutional investors has also included air emission criteria into there ESG scores evaluation. Bloomberg has collected ESG data annually since 2007 with around 13000 unique companies, and used these data to generate ESG scores both separate and aggregate [11]. In the environment domain, Bloomberg includes 33 air pollutant emission indicator which based on two aspects, Greenhouse gas(GHG) emission management and Air Quality. Figure 2 presents the details of these indicators.

FIGURE 2 Air pollutant emissions indicators

GHG Emissions Management	GHG Emissions	F0947	Scope 1 GHG CO2 Emissions*
		ES027	Gas Flaring (Th Tonnes)
		SA055	Percent Methane of Scope 1 Emissions*
		SA058	Process Emissions
		SA059	Emissions from Other Combustion
		SA060	Vented Emissions
		SA061	Fugitive Emissions
	GHG Emissions Policies	SA161	GHG Emissions Reduction Policy
		ES036	Emissions Reduction Initiatives
	GHG Regulation	ES222	Carbon Dioxide Allowances Million MT Under EU ETS
		ES221	CO2 Emissions Less Allowances Mil MT Under EU ETS*
		ES228	Carbon Dioxide Emissions Million MT under EU ETS
		SA001	GHG Covered Reg Other EU ETS
		SA002	Total GHG Emissions Covered under Regulatory Prog*
		SA003	Pct GHG Emissions Covered under Regulatory Prog*
	GHG Target	SA004	Baseline Year for GHG Emissions Target
		SA005	Target Year for GHG Emissions Target
		SA006	GHG Emissions Intensity Reduction Target
		SA129	GHG Emissions Reduction Target Absolute
		SA130	GHG Emissions Absolute Reduction Target
		SA199	Percent GHG Emissions Reduct Achieved Aga Target
		SA232	Scope 1 GHG Target - Baseline Year
		SA233	Scope 1 GHG Target - Target Year
		SA234	Scope 1 Emissions Reduction Target - Intensity
		SA235	Scope 1 Emissions Reduction Target - Absolute
		SA236	Scope 1 Emissions Absolute Reduction Target
		SA237	Percent Reduction Achieved for Scope 1 Emissions Reduction Target
Air Quality	Air Emissions	ES007	Nitrogen Oxide Emissions (Th Tonnes)
		ES009	VOC Emissions (Th Tonnes)
		F0949	Sulphur Dioxide / Sulphur Oxide Emissions*
		SA089	PM 10 Emissions
		ES013	Particulate Emissions (Th Tonnes)
	Air Emissions Policies	SA162	Air Pollution Reduction Policy

The figure shows Bloomberg air pollutant emission indicators.(Bloomberg,2020)

Satellites can also help with the biggest climate change issues. The Intergovernmental Panel on Climate Change(IPCC) defines greenhouse gasses as the natural and anthropogenic gaseous which constitute the atmosphere, it will absorb and emit radiation at specific wavelengths [12]. As these are in the atmosphere, the best place to monitor them is from

[11] Bloomberg, 2019, https://www.bloomberg.com/professional/solution/esg/?bbgsum-page=DG-WS-PROF-SOLU-ESGmpam-page=23555

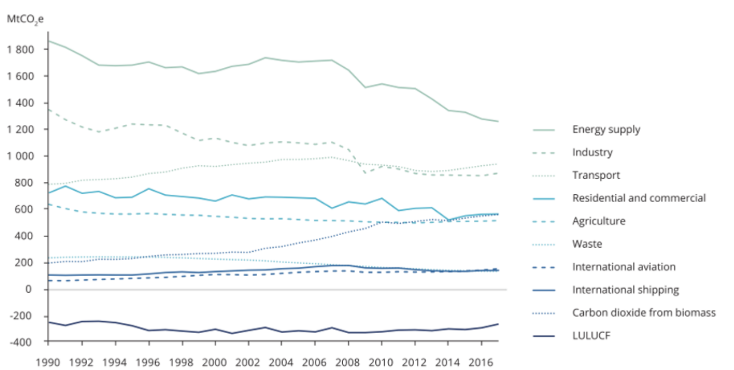
[12] IPCC,http://www.ipcc-data.org/guidelines/pages/glossary/glossary_fg.html

near earth orbit. The EPA listed four main types of GHG emission, which are Carbon dioxide (CO2), Methane (CH4), Nitrous oxide (N2O) and Fluorinated gases [13]. Figure 2 presents the total GHG emissions of 28 EU countries by the main sector from 1990 to 2017, excluding land use, land use change and forestry(LULUCF). It shows a decrease of GHG emission in the majority of sectors during that time, with the notable exception of transport and international aviation. The emissions of energy supply and industry have the most significant decrease, and the agriculture, residential, commercial and waste sectors have also contributed to the emission reduction since 1990. The figure shows a substantial increase in carbon dioxide (CO2) emissions from biomass.

3.2 | Water Pollution

Water covers 71% of the earth's surface and is vital to sustaining human life. The monitoring and control of water pollutants is therefore an important academic and practical endeavor. Due to the size of the planet covered by water, it is best observed from space. Water pollution refers to any contamination of water caused by chemicals or other foreign substances that could damage water quality and detrimental to human, animal, or plant [14].The Water Framework Directive (WFD) which implemented in 2020, is one of the critical primary frameworks for EU water quality assessment, management and protection [15]. Figure3 presents a rough structure regards how WFD classifies and assess the EU water quality status. As the figure shows, the scope of water quality assessment involves two types of water, groundwater and surface water.

FIGURE 3 WFD Assessment of status of surface waters and groundwater



The figure shows the WFD Assessment process of status of surface waters and groundwater Kristensen (2018)

Satellite monitoring of surface water is assessed by its ecological status and its chemical status. The ecological status is based on several biological quality elements: phytoplankton, phytobenthos, macrophytes, benthic invertebrate fauna and fish. These biological quality elements are associated with several hydromorphological and physico-chemical indicators, such as nutrients, oxygen condition, temperature and transparency. Priority substances are the most significant indicators for the chemical status of surface water. The environmental quality standards (EQS) defines the good surface water chemical status based on the concentrations of all priority substances compare to its

[13] EPA,https://www.epa.gov/ghgemissions/overview-greenhouse-gases

[14] NIEHS, https://www.niehs.nih.gov/health/topics/agents/water-poll/index.cfm

[15] EU commission,https://ec.europa.eu/environment/water/water-framework/index$_en.html$

established standard [16]. The Environmental Quality Standards Directive 2008/105/EC identified 33 substances(see Figure4) or group of substances, and 13 of these have been identified as priority hazardous substances [16]. The WFD aims to reduce the hazardous substances in water bodies to 0 in the next 20 years, as these have been recognized as extremely harmful to the water statuesKristensen (2018). However, there are criticisms regarding the listed hazardous substance and its strict restriction. Taylor (2020), suggested that WFD should exclude any substance that has currently authorized by other legitimate parties such as Plant Protection Products, Biocides Regulations and follow the socioeconomic assessment results. Which means some of the listed priority hazardous substance may bring excess social and economic benefits compared to its environmental cause. This project would not be able to research the conflicts within these indicators. However, it seems to be necessary to include these priority substance pollutants in the ESG evaluation, as the companies should consider both the benefits and environmental damage of these substances.

FIGURE 4 EQS priority substances

Number	CAS numberi	EU numberii	Name of priority substanceiii	Identified as priority hazardous substance
(1)	15972-60-8	240-110-8	Alachlor	
(2)	120-12-7	204-371-1	Anthracene	X
(3)	1912-24-9	217-617-8	Atrazine	
(4)	71-43-2	200-753-7	Benzene	
(5)	not applicable	not applicable	Brominated diphenyletheriv	X
	32534-81-9	not applicable	Pentabromodiphenylether (congener numbers 28, 47, 99, 100, 153 and 154)	
(6)	7440-43-9	231-152-8	Cadmium and its compounds	X
(7)	85535-84-8	287-476-5	Chloroalkanes, C10-13 iv	X
(8)	470-90-6	207-432-0	Chlorfenvinphos	
(9)	2921-88-2	220-864-4	Chlorpyrifos (Chlorpyrifos-ethyl)	
(10)	107-06-2	203-458-1	1,2-Dichloroethane	
(11)	75-09-2	200-838-9	Dichloromethane	
(12)	117-81-7	204-211-0	Di(2-ethylhexyl)phthalate (DEHP)	
(13)	330-54-1	206-354-4	Diuron	
(14)	115-29-7	204-079-4	Endosulfan	X
(15)	206-44-0	205-912-4	Fluoranthenevi	
(16)	118-74-1	204-273-9	Hexachlorobenzene	X
(17)	87-68-3	201-765-5	Hexachlorobutadiene	X
(18)	608-73-1	210-158-9	Hexachlorocyclohexane	X
(19)	34123-59-6	251-835-4	Isoproturon	
(20)	7439-92-1	231-100-4	Lead and its compounds	
(21)	7439-97-6	231-106-7	Mercury and its compounds	X
(22)	91-20-3	202-049-5	Naphthalene	
(23)	7440-02-0	231-111-4	Nickel and its compounds	
(24)	25154-52-3	246-672-0	Nonylphenols	X
	104-40-5	203-199-4	(4-nonylphenol)	X
(25)	1806-26-4	217-302-5	Octylphenols	
	140-66-9	not applicable	(4-(1,1',3,3'-tetramethylbutyl)-phenol)	
(26)	608-93-5	210-172-5	Pentachlorobenzene	X
(27)	87-86-5	201-778-6	Pentachlorophenol	
(28)	not applicable	not applicable	Polyaromatic hydrocarbons	X
	50-32-8	200-028-5	(Benzo(a)pyrene)	X
	205-99-2	205-911-9	(Benzo(b)fluoranthene)	X
	191-24-2	205-883-8	(Benzo(g,h,i)perylene)	X
	207-08-9	205-916-6	(Benzo(k)fluoranthene)	X
	193-39-5	205-893-2	(Indeno(1,2,3-cd)pyrene)	X
(29)	122-34-9	204-535-2	Simazine	
(30)	not applicable	not applicable	Tributyltin compounds	X
	36643-28-4	not applicable	(Tributyltin-cation)	X
(31)	12002-48-1	234-413-4	Trichlorobenzenes	
(32)	67-66-3	200-663-8	Trichloromethane (chloroform)	
(33)	1582-09-8	216-428-8	Trifluralin	

The table listed EQS priority substances for EU region [16]

Groundwater is assessed by its chemical status and quantitative status. Its chemical status depends on the concentration of some substances, such as nitrate, pesticide and other groundwater pollutants. Its quantitative status

[16] EU commission, https://ec.europa.eu/environment/water/water-dangersub/pri$_{s}ubstances.htm$

is mostly relevant to its availability and balance with the surface water. In summary, the water pollutant indicators should be mostly relevant to the chemical status and ecological status.

The 2018 EEA report regards EU waters status assessment, and pressures indicate that 38 % of surface waters were are in good chemical status, and there is a number of priority substances contributed to the poor chemical status (Kristensen, 2018). Besides, the urban wastewater treatment plants have contaminated more than 13 000 water bodies across EU with polyaromatic hydrocarbons (PAHs), mercury, cadmium, lead and nickel. Figure 5 lists the 15 most frequently reported priority substances in surface waters. It is clear that mercury and brominated diphenyl ethers contributed the most for disrupting the good chemical status, and they have seriously affected 45973 and 23331 waterbodies separately. The other substances seem to have a relatively smaller impact on water bodies.

FIGURE 5 EQS priority substances

Priority substance	Type/use of chemical	Number of water bodies not achieving good chemical status	Number of Member States with water bodies not achieving good chemical status for the listed substance	Contributed by one Member State if that dominates (% of water bodies not achieving good chemical status)
Mercury (a)	Metal	45 973	24	50
Brominated diphenyl ethers (a)	Flame retardant	23 331	8	99
Benzo(g,h,i)perylene + indeno(1,2,3-cd) pyrene (a)	PAH	3 091	15	47
Benzo(a)pyrene (a)	PAH	1 630	12	65
Fluoranthene	PAH	1 390	14	40
Cadmium	Metal	1 014	20	—
TBT (a)	Biocide	663	15	—
Nickel	Metal	654	20	—
Lead	Metal	462	19	—
Benzo(b)fluoranthene + benzo(k)fluoranthene (a)	PAH	460	10	41
Isoproturon	Pesticide	199	8	45
4-Nonylphenol	Surfactant	188	10	52
Anthracene	PAH	123	11	59
Hexachlorocyclohexane	Pesticide	120	11	—
DEHP	Plasticiser	102	11	—

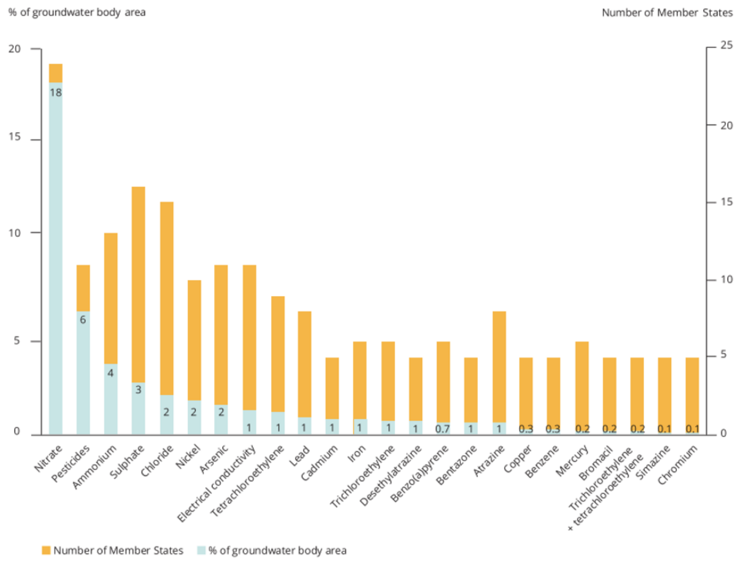
The table listed Priority substances which causing surface water bodies failure to achieve good chemical status (total of 111 062 surface water bodies)

Figure 6 shows the number of EU countries impacted by different types of groundwater Pollutant. Nitrates are the most significant pollutants that disrupted good chemical Status in EU. It has caused good chemical status failure in 18% of groundwater bodies across the EU region. Another major source of pollutant were pesticides, and have caused 6.5 % of groundwater bodies failure to achieve good chemical status. Further details regarding groundwater pollution are available at the WISE-Freshwater WFD [17]. Kristensen (2018) also analysed the source of the listed substances, and find that 20 over 25 EU countries reported that both point and diffuse source resulted in poor chemical status of groundwater. For the diffuse pollution, agriculture seems to be the major pressure which affected 29 % of groundwater bodies. These results are matching with the Figure6 regards substance in groundwater, as nitrates are frequently used in the agriculture sector.

Figure 7 lists several water pollution related EU policy objectives and targets. One of the notable targets is achieving the good chemical status of all surface and groundwater bodies which can all be observed from space.

[17] EEA, https://www.eea.europa.eu/themes/water/european-waters/water-quality-and-water-assessment/water-assessments/groundwater-quantitative-and-chemical-status

FIGURE 6 Pollutants causing poor chemical status in groundwater



The figure shows the number of EU countries in poor chemical statues by types of pollution Kristensen (2018)

Based on the second river basin management plans assessment results, 74 % of EU groundwater and 38% of surface water bodies were in good chemical status. Which means the EU has not achieved this target until 2018. EEA (2019) also suggested that the EU is not on track to meet this objective by 2020.

FIGURE 7 Selected EU water pollutant policy objectives and targets

Policy objectives and targets	Sources	Target year	Agreement
Pollution pressures on water and links to human health			
Achieve good chemical status of all surface and groundwater bodies	Water Framework Directive (2000/60/EC)	2015	Legally binding commitment
Reducing and further preventing water pollution by nitrates from agricultural sources	Nitrates Directive (91/676/EEC)	N/A	Legally binding commitment
To protect the environment in the EU from the adverse effects of urban waste water through collection and treatment of waste water. Implementation period depends on year of accession	Urban Waste Water Treatment Directive (91/271/EEC)	EU-15: 1998-2005 EU-13: 2006-2023	Non-binding commitments
To preserve, protect and improve the quality of the environment and to protect human health	Bathing Water Directive (2006/7/EC)	2008	Legally binding commitment
To protect human health from adverse effects of contamination of water for human consumption	Drinking Water Directive (98/83/EC)	2003	Legally binding commitment
Eliminate challenges to human health and well-being, such as water pollution and toxic materials	7th EAP, PO 3 (EC, 2013)	2050	Non-binding commitment
Improve water quality by reducing pollution	SDG 6.3 (UN, 2016)	2030	Non-binding commitment

The figure listed Selected EU water pollutant policy objectives and targets European Environment Agency (2019)

The Kristensen (2018) report is based on the results of second river basin management plans, which means it has not included the results from Greece, Ireland, Lithuania and Norway. Besides, as the listed priority substances from the Water Framework Directive only include 33 historically significant pollutants, there could exist a knowledge gap regards the other thousands of chemicals which involving in daily use. EEA (2019) also points out that these results need to be interpreted with some cautions as the EU member states have different strategies regards substances measurement. For example, only some of the member states include the mercury and polybrominated diphenyl ethers (PBDEs) in their assessments, as these two substances are considered as ubiquitous.

Compare to these indicators monitored by the regulator; the institutional investor metrics published by Bloomberg include a limited number of water pollutant related parameters in its ESG scores evaluation process. It has been a primary focus on water management and water usage. There are only several indicators regards spill accident and environment fines, which could involve with the illegal water pollutant activities. Figure8 listed relevant indicators of water pollutant in Bloomberg environmental scores calculation.

FIGURE 8 Bloomberg water pollutant related indicators

Environmental Fines	ES032	Number of Environmental Fines
	ES033	Environmental Fines (Amount)
	SA231	Number of Significant Environmental Fines
	SA359	Amount of Significant Environmental Fines
Environmental Incidents	ES249	Hydrocarbon Spills
	SA048	Number of Hydrocarbon Spills
	SA021	Number of Environmental Incidents
	SA069	Number of Significant Environmental Incidents
	SA049	Hydrocarbon Spills Recovered
	SA050	Amount Spills in Environmentally Sensitive Areas
	ES028	Number of Spills
	ES083	Amount of Spills (Th Tonnes)
	SA361	Amount of Significant Spills
	SA215	Number of Significant Spills
	SA221	Amount of Spills Recovered

The figure listed Bloomberg water pollutant related indicators Bloomberg(2020)

3.3 | Waste management

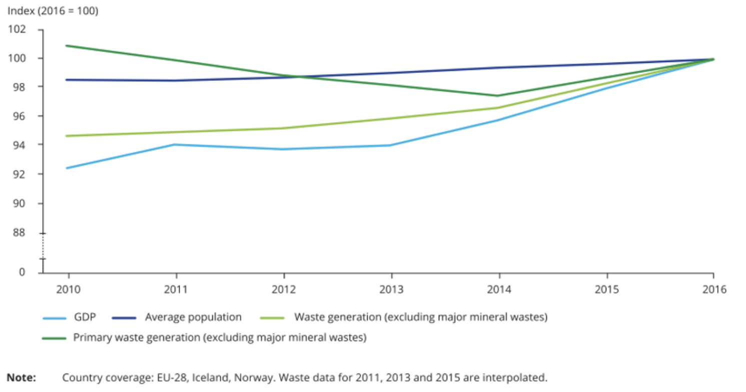
According to the World Bank, 2.01 billion metric tons of municipal solid waste (MSW) are produced annually worldwide. It estimates only 13.5% of this is recycled and 5.5% is composted Webster (2018). Reduction in waste is a a key sustainable policy indicator. The 2008 European Union Waste Framework Directive(EUWFD) defined waste as any substances or objects which discarded by the holder, and hazardous waste as waste which has one or more hazardous properties [18]. Conversely, the non-hazardous waste usually contained limited amount or zero hazard chemicals or microbes, and it may also threat the public health with sufficient quantities [19]. The waste management involves the process of collection, transport, recovery and disposal of waste, it also includes the supervision of these process, disposal sites after-care, and actions taken as a dealer or broker [18]. Besides, the EUWFD provided the waste hierarchy for the waste management process: reduce–reuse–recycle–recover–landfill [18]. This hierarchy means the priority task is minimizing the waste generation; the products and material should then be considered to reuse and recycle. If these tasks are not possible, the waste should be recovered or transferred as energy. The landfill is the least favorable option for waste. Hence, the waste management indicators should contain information for these four stages. Another significant framework regards EU waste management is the circular economy monitoring framework EC (2018a), it

[18] European Union Waste Framework Directive, 2008, p.9
[19] Vallero, 2019, p.171

aims to measure the progress towards a circular economy. A circular economy means to maximize the service life of materials and products, and it aims to improve resource efficiency and lower the virgin materials usage (EEA,2019).

Figure 9 presents the total waste generation trends in EEA 33 countries. It indicates that there was an increasing trend in the waste generation (excluding major mineral wastes) since 2010 alongside GDP growth. The waste generation contains both primary waste and secondary waste generation. As the figure shows, the overall primary waste generation has declined during that period, and the secondary waste would be the main driver for the increasing trend. EEA (2019) defined secondary waste as residues from primary waste sorting and incineration.

FIGURE 9 Waste generation trends (excluding major mineral wastes)



The figure shows an increasing waste generation trend in EU region EEA(2019)

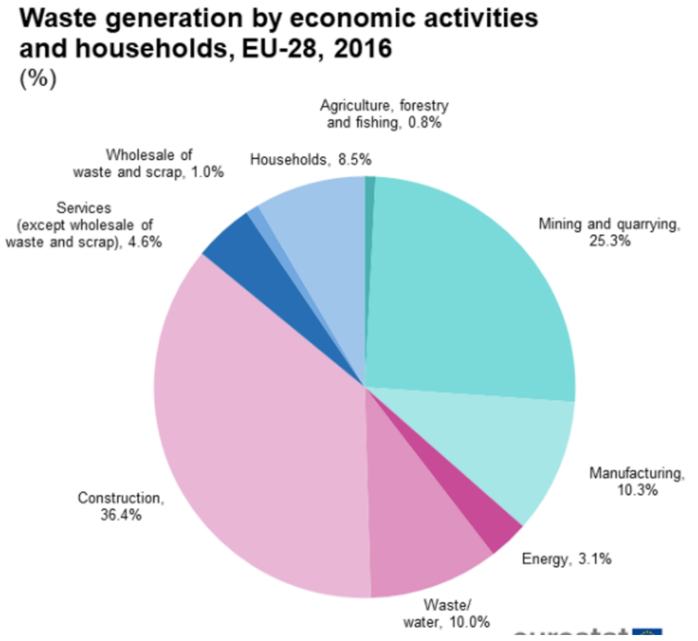
Besides, the Eurostat (2019) statistics claimed that there were 2538 million tons of waste generated by EEA 33 countries in 2016, and 46.8 % of it was disposal. Figure10 presents the source of the EU 28 countries waste generation in 2016 based on economic activity and household. It shows that the constriction waste was the significant contribution of the waste generation, which were 36.4%. The mining and quarrying also were the second-largest source and has contributed 25.3%. These two types of waste are classified as mineral wastes.

Figure11 shows the circular material use (CMU) rate in EU 28 states from 2004 to 2016. The CMU rate is an indicator used in the circular economy monitoring framework, and it measures the recycled materials usage ratio in the overall materials demand EC (2018a). Higher CMU rate means a higher level of recycling and lower usage of primary raw materials. The figure shows the CMU rate in the 28 EU states has continued to rise from about 8 % to around 12 % from 2004 to 2016. This increasing trend indicates that there have been improvements in resource efficiency and recycling awareness in the EU area.

Further, the CMU rate was different based on the material type. The metals seem to had the highest usage of CMU with a steady decreasing trend. The second highest was the metal ores and followed by the non-metallic minerals. These two materials had an increasing trend of CMU usage. The lowest was the fossil energy material, and its CMU usage seemed to be relatively stable during that period. Besides, the British Geological Survey et al. (2017) pointed out that the availability of some primary material has decreased steadily, such as ores. This means it is crucial to improve the recycling becomes, as it would enable the supply of raw materials.

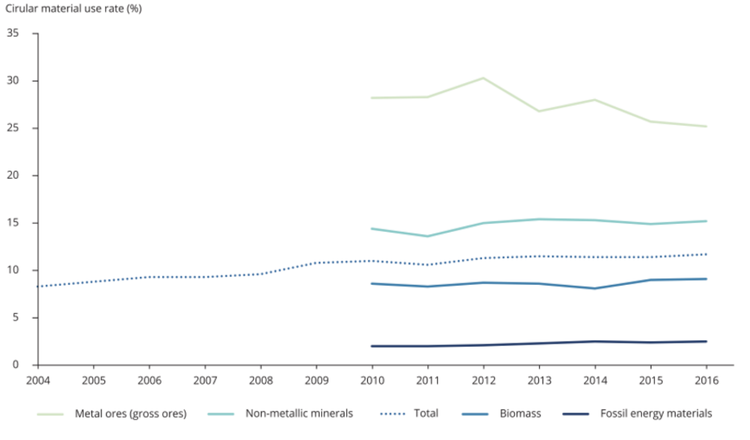
Figure 12 presents the total waste treatment rate of 28 Eu states from 2010 to 2016. There was an increasing trend of total waste treatment rate, including recycling, back-filling, and energy recovering. There was also a decreas-

FIGURE 10 Waste generation by economic activities and household in 2016(EU-28)



The figure shows waste generation by economic activities and household in EU during 2016 Eurostat(2019a)

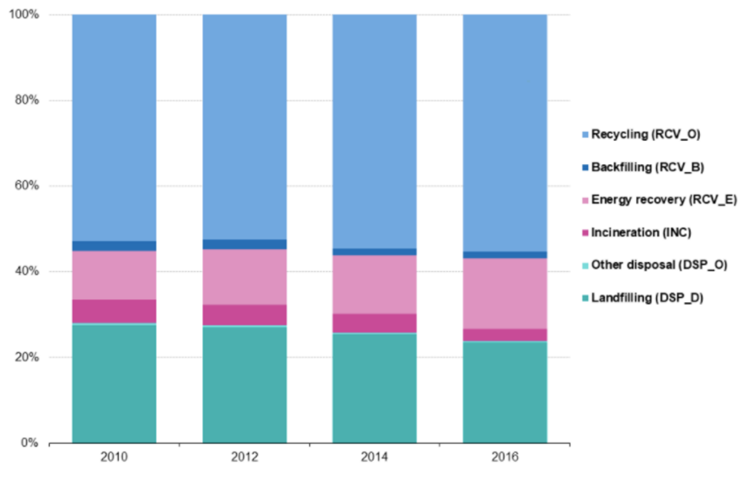
FIGURE 11 Circular material use(CMU) rate 2004-2016(EU-28)



The figure shows Circular material use(CMU) rate from 2004 to 2016 in EU 28 (EEA,2019)

ing trend of waste disposal rate, including incineration, other disposal and land-filling. However, the part of the waste disposal process, the incineration showed a relatively significant increase from 2014 to 2016. The land-filling were continue to decrease across the six-year. The Eurostat (2019a) also found that the total amount of disposal waste has decreased from 1154 million tones to 1081 million tones between 2004 and 2016, and its share in total waste treatment has decreased by around 8%.

FIGURE 12 Waste treatment(excluding major mineral waste) from 2010 t0 2016(EU-28)



The figure shows improving waste treatment(excluding major mineral waste) from 2010 t0 2016 in EU 28 states (Eurostat,2019b)

Figure 13 presents the 2020 policy objectives related to the waste issues in the EU. EEA(2019) suggested that EU states are on track to meet the resource efficiency. There was evidence indicated that the energy efficiency in the EU would improve with increasing demand for biomass for energy EC (2018b). However, as the resource efficiency policy objectives are none binding commitment, the regulator should continue to emphasize its significance with close supervision, The prospect of meeting the 2020 waste generation reduction target seemed to be unclear. The recent data shows that the EU waste generation is increase with the GDP growth (EEA,2019). More specifically, the generation of municipal waste is expected to increase by around 2 % over 2015 to 2035 ETC/WMGE (2018). The electronic waste has been rose continuously since 1995 and 2006, and this trend is expected to continue until 2020 Huisman (2016). Regarding waste management, the EU states seemed to be progressing towards the policy objective along with uneven country performance. EEA (2019) find that there are several countries still need to make more effort to ensure achieving waste management targets, such as Turkey and Malta.

Figure 14 shows the waste management related included in Bloomberg ESG score evaluation. As mentioned before, these indicators are also a part of the water pollution evaluation. Only include water waste is not sufficient for waste management evaluation. Hence, this project will suggest Bloomberg ESG evaluation should include more indictors about water pollutant and waste management, as these are significant areas within the environment evaluation.

FIGURE 13 Selected 2020 policy objectives related to the waste issues in EU

Policy objectives and targets	Sources	Target year	Agreement
Resource use and efficiency			
Improve resource efficiency	7th EAP (EU, 2013); Roadmap to a resource efficient Europe (EC, 2011a)	2020	Non-binding commitments
Strive towards an absolute decoupling of economic growth and environmental degradation	7th EAP (EU, 2013)	2020	Non-binding commitments
Waste generation and management			
50 %/55 %/60 %/65 % of municipal waste is prepared for reuse or recycled (differing calculation method for the 50 % target)	Waste Framework Directive (EU, 2008, 2018b)	2020/2025/2030/2035	Legally binding
Waste generation to decline absolutely and per capita, and reduction and sound management of hazardous waste	7th EAP (EU, 2013)	2020	Non-binding commitments
Energy recovery to be limited to non-recyclable waste	7th EAP (EU, 2013)	2020	Non-binding commitments

The figure listed 2020 policy objectives related to the waste issues in EU (EEA,2019)

FIGURE 14 Bloomberg waste management related indicators

Wastewater Management	Wastewater Management	ES018 Discharges to Water
		SA062 Produced Water and Flowback
		SA064 Percentage of Produced Water Discharged•
		SA066 Percentage of Produced Water Injected•
		SA068 Percentage of Produced Water Recycled•
		SA077 Fracturing Fluid Use Policy
		ES242 Total Water Recycled
		SA063 Produced Water Discharged
		SA065 Produced Water Injected
		SA067 Produced Water Recycled
		F1588 Percentage of Water Recycled per Total Water Used•
	Water Use Policies	ES247 Water Policy

The figure listed Bloomberg waste management related indicators (Bloomberg,2020)

3.4 | Nature resource management

Nature resource are the fundamental support of every economy[20]. According to the World Bank around 60% to 70% world's ecosystems are degrading faster than their recovering speed. Excessive use of natural resources could lead to severe environmental damage and potential economic loss. For instance, the estimated economic losses caused by mismanagement of ocean fisheries are $80 billion Per year. Nature resource management refers to the preserving and sustainable utilization of a wide range of natural resource such as miners, forest, land, wilderness and watershed area Muralikrishna and Manickam (2017). This section will mainly focus on the natural resource management of forest

Pawar and Rothkar (2015) defined forest as an area with a high density of tree, and it benefits to air temperature, air quality, wildlife diversity, water quality and many other aspects. There are two main types of forest destruction, forest degradation and deforestation. Forest degradation refers to the changes that have negative impact on forest' structure or function of its stand or site over many decades, and it could lower forest' supply and ecosystem services capacity WWF (2015). Deforestation means to converse the forest to another land use permanently or significant long-term reduction of forest area (WWF,2015). According to the EU commission, the significant reasons of worldwide deforestation include agricultural expansion, urban areas expansion, logging activity and natural or human-induced disasters [21]

EEA (2019) stated the forest area in EU is overall stable, and around 90% of EU forests are available for wood

[20] EU Commission,2019, https://ec.europa.eu/environment/archives/natres/index.htm

[21] EU Commission,2019, https://ec.europa.eu/environment/forests/impact$_d$eforestation.htm

supply. However, Forest Europe(2015) and Sabatini (2018) pointed out that only less than 5 % of EU forest areas were considered to be undisturbed, and less than 1 % were primary or virgin forests. Besides, Eurostat (2020) found that the roundwood production in EU 28 states has continued to increase since 2000 and reached 490 million m3.

In 2018, While 23% of the 2018 production were used as fuelwood and the rest were consumed by industrial activity including sawn and veneers, pulp and paper production. Currently, the statics provided by EU regulators such as EU Commission and Eurostat are mostly about deforestation, and there limited information about forest degradation. Europe (2015b) also pointed out that the data availability of forest degradation indicator in EU region was at poor condition, and the 2020 State of Europe's forests report would not be able to analyze this indicator quantitatively.

From the EU regulatory perspective, the sustainable forest management (SFM) concept was defined at the pan-European Ministerial Conference on the Protection of Forests in Europe (MCPFE) in 1993.[22]. The SFM has been applied to the European forestry since 1998, and it provides criteria and indicators for measuring the success of production function balancing regards forest ecological concerns, such as amounts of deadwood and biological diversity. According to EEA(2019), although the SFM has not given specific recommendations regards management regimes, there was increasing evidence emphasized that SFM should include more considerations regards uneven-aged forests. The Forest Law Enforcement Governance and Trade (FLEGT) Action Plan is another crucial EU policy, which aims to fight illegal logging and associated trade [22]. Based on the FLEGT, EU Commission has adopted an EU Communication on Stepping up EU Action to against deforestation and forest degradation on 23 July 2019 [23]. Overall, EU region currently do not have specific EU policy target of forest management and has limited data regards forest degradation data.

In summary, forests are a valuable natural resource and is closely associated with agriculture, industrial and energy sector. The EU states should propose more specific policy targets and improve their measurement, regards forest indicator. Besides, the institutional investor should also include deforestation and reforestation indicator within their ESG scores evaluation process. Currently, Bloomberg only includes natural resource management indicators regards land conservation, oil and gas drilling and biodiversity under the ecosystem protection. Figure15 presents the natural resource management indicators used in Bloomberg ESG evaluation.

FIGURE 15 Natural resource management indicators used in Bloomberg ESG evaluation

Ecological Impact	Ecosystem Protection	SA071 Number of Sites in Environmentally Sensitive Areas
		ES041 Environmental Quality Management Policy
		ES088 Biodiversity Policy
		SA085 Arctic Drilling Oil and Gas
		SA072 Land Disturbed
		SA073 Land Restored
		SA074 Percentage of Land Restored*

The figure listed the natural resource management indicators used in Bloomberg ESG evaluation(Bloomberg,2020)

3.5 | Compliance

As discussed above, all these environmental indicators are associated with a massive amount of legislation, and these compliance requirements could be legally banding or under the voluntary standard. For the regulator, close monitoring the compliance level of these legislations and commitment is crucial for achieving the policy objectives. This section

[22] EU Commision, https://ec.europa.eu/growth/sectors/raw-materials/industries/forest-based/sustainable-forest-management_en

[23] EU Commision,2020, https://ec.europa.eu/environment/forests/eu_comm_2019.htm

will firstly review the current air pollution, water pollution, waste management and forest management compliance requirements in the EU region. Then reviews some selected literature regards compliance monitoring and compliance measurements.

EEA (2019) summarized the policy content of air pollution into clean air policy package, air pollutant emissions and air quality. The clean air policy package is adopted by the EU Commission in 2013, and it includes full compliance requirements with existing air quality legislation until 2020.[24] The air pollutant emission is mainly based on the National Emission Ceilings Directive (NEC Directive), it imposes emission ceilings for EU member states since the years from 2010 and new commitments for 2020 to 2030 period(EEA, 2019d). EU legislation also includes specific source air pollution emission requirement, such as transportation emission commitment- European Strategy for Low-Emission Mobility. [25]. The 2008 Directive on Ambient Air Quality and Cleaner Air for Europe and the 2004 Directive on heavy metals and polycyclic aromatic hydrocarbons in ambient air address air pollution built the basic principles of air quality assessment and management, and set the pollutant concentrations thresholds(EEA, 2019d).

As discussed in the water pollution section, the WFD was adopted in 2000 and it sets the policy targets regards water quality. The EU Commission summarizes the water pollution requirements into urban water waste, industrial emission, agriculture and chemical pollution. [26]. The Urban Waste Water Directive was adopted in 1991, and it aims to manage the discharge, collection and treatment of urban wastewater and some certain industrial wastewater.[27]. The industrial emission is mainly managed by Directive 2010/75/EU on industrial emissions (IED), Directive (EU) 2015/2193 on medium combustion plants (MCPD) and Directive 1994/63/EC and Directive 2009/126/EC on petrol storage distribution.[28]. This legislation established the principles regards industry emission and emission ceiling for specific substances. The Council Directive 91/676/EEC is the primary instructions regards water pollution caused by nitrates from agricultural sources, and it was adopted on 12 December 1991 [29]. It designs the Nitrate Vulnerable Zones(NVZs), and set the nitrogen use standard for these areas [29]. Aside from the priority substances legislation mentioned in the water pollution section, the chemical pollution requirement also includes Commission Directive 2009/90/EC on technical specifications for chemical analysis and monitoring of water status.

The EU waste management legislation involves waste framework, waste management operations and specific waste streams. There are three main waste frameworks, Directive 2008/98/EC, Regulation (EC) No 1013/2006 and Decision 2000/532/EC. The Waste Framework Directive or Directive 2008/98/EC is the general framework of EU waste management requirements [30]. Regulation (EC) No 1013/2006 on shipments of waste specifies the waste conditions on cross boarder shipment [30]. Decision 2000/532/EC establishes the classification system for wastes and identifies hazardous and non-hazardous wastes [30]. The Directive 2000/76/EC on the incineration of waste, Directive 2000/59/EC on port reception for ship and cargo generated waste facilities and Council Directive 1999/31/EC on the landfill of waste constitute the waste management operations legislations [31]. Major EU, specific waste streams legislations, are Directive 2000/53/EC on end-of-life vehicles, Council Directive 96/59/EC on polychlorinated biphenyls and polychlorinated terphenyls (PCB/PCT) disposal, Council Directive 91/157/EEC and Corrigendum to Article 12(4) of the Directive 2006/66/EC on batteries and accumulators, European Parliament and Council Directive 94/62/EC on packaging and packaging waste, Council Directive 86/278/EEC on agricultural use of sewage sludge and Council

[24] EU Comission,https://ec.europa.eu/environment/air/clean$_{a}ir/review.htm$

[25] EU Commission, https://ec.europa.eu/clima/policies/transport$_{e}ntab-0-1$

[26] EU Commission, https://ec.europa.eu/environment/water/index$_{e}n.htm$

[27] EU Commission, https://ec.europa.eu/environment/water/water-urbanwaste/index$_{e}n.html$

[28] EU Commision, https://ec.europa.eu/environment/industry/stationary/index.htm

[29] EU Commision, https://ec.europa.eu/environment/water/water-nitrates/index$_{e}n.html$

[30] EU Commision, https://ec.europa.eu/environment/waste/legislation/a.htm

[31] EU Commission, https://ec.europa.eu/environment/waste/legislation/b.htm

Directive 75/439/EEC on waste oils disposal[32].

Figure 16 summarized main policy instruments for archiving sustainable forest management in the EU. Once again, this is best monitored from space. The EU Forestry Strategy was firstly adopted in 1998, and embraced the SFM concept into its overall principles.[33].In 2006, the Commission Adopted the EU Forest Action Plan (expired in 2011), and served as an important framework for existing EU forest policyPülzl et.al. EU has also engaged international voluntary scheme FLEGT to fight illegal logging activities, and have adopted Timber Regulation (EU) No 995/2010 in 2013[34].

FIGURE 16 EU main policy instruments for archiving sustainable forest management

2019 Council Conclusions on the mid-term review of the EU Forest Strategy.

2018 The Commission adopted the Report on the progress in the implementation of the EU Forest Strategy.

2015 The Commission adopted a Multi-annual Implementation Plan of the new EU Forest Strategy

2014 Council conclusions on the new EU Forest Strategy, Brussels, 19 May 2014, 9944/14

2013 The Commission adopted a Communication on a new EU Forest Strategy, accompanied by a Staff Working Document and took note of a Blueprint for the EU forest-based industries

2011 The Arsenis Report of the environmental committee of the European Parliament gave a series of recommendations on the follow up of Commission's Green Paper on forest protection and information.

2010 The Commission adopted the Green Paper on forest protection and information.

2006 The EU Forest Action Plan was adopted on 15 June 2006. It builds on the report on implementation of the EU Forestry Strategy and consequent conclusions by the Council.

2005 The Commission has presented to the Council and the European Parliament a Communication reporting on the implementation of the EU Forestry Strategy accompanied by a detailed Staff Working Document.

1998 The European Commission presented a Communication on a Forestry Strategy for the EU
The EU Council adopted a Resolution on a Forestry Strategy for the EU. This document is considered to be the basic political charter for Community involvement in forest issues.

1995 The Thomas Report of the environmental committee of the European Parliament gave a series of recommendations for the development of an European Union (EU) Forest Policy.

The figure listed the main policy instruments for archiving sustainable forest management in EU [35]

In order for sustainable goals to be achieved, the primary focus should be on State level compliance. That said, much of the literature focuses on business-led compliance. Koliads (2008), Ly (2008), Kharbili and Stein (2018) proposed framework and standard for business process compliance management. Morrison (2009) and Lu (2008)developed a method for measuring the degree of compliance within the business process. Both state-level and business level compliance can benefit from data inputs gathered by satellite. Next section, will review the literature regards satellite and AI application in measuring the air pollution, water pollution, waste management and forest management.

3.6 | Discussion and examples

There is a considerable amount of literature assessed the air pollutant emission, water pollution, waste management and forest management relevant indicators based on satellite data and imagery. The biggest impediment to greater use of satellite data appears to be unfamiliarity with the sourcing of information and how to handle the big data and imagery it creates.

Typical of the sort of application is Streets et al. (2013). They researched the capability of using satellite retrievals to measure primary emissions. Their study found that the estimation of NOx and SO2 is quite promising, and some emission substances such as NH3 and CH4 are reactively challenging to measure. They found that uncharacterized model errors and systematic errors are a critical challenge in their satellite retrievals. They also pointed out the po-

[32] EU Commission, https://ec.europa.eu/environment/waste/legislation/c.htm
[33] EU Commission, https://ec.europa.eu/environment/forests/index_en.htm
[34] EU Commission, https://ec.europa.eu/environment/forests/timber_regulation.htm

tential benefits of having new geostationary satellites like GEO-CAPE and TEMPO over North America, which could provide high spatial measurements and continues resolution. However, as their study was completed a few years earlier with single-source satellite retrievals, some of the issues they identified are already answered by current research.

Another good application of satellite data was provided by Filonchyk Yan (2020.). They studied air pollution and its way to enter an urban city, LanZhou. Their study was based on satellite's data of Moderate-resolution imaging spectroradiometer (MODIS) and Landsat during 2003–2016. Their study used a comprehensive approach to analysis multi-seasonal characteristics, spatial and temporal characteristics of air pollution indicators including PM2.5, PM10, SO2, NO2 and CO. Although their study was able to define the primary pollution source and pollution cause based on multiple sources long time period data, their dataset is only targeted on one particular place, and further research regards regional, or country analysis should be recommended.

Elias et al., (2014) applied and assessed groundwater pollution risk mapping technique based on satellite observations to identify the primary pollution sources in the Evros catchment. Their study used Landsat 5 satellite data to classified the types of land use and normalized-differ- ence vegetation index (NDVI) estimation. The K-MEANS algorithm has been used for land use type classification and achieved 20% higher performance compared to other land use information source. Their study found that untreated urban waste disposal and overused fertilizers from agricultural sectors are dominant pressures for the Evros river. Besides, they suggested that hazardous human activities in high vulnerability areas are a significant cause of groundwater pollution.

Satellite data is real time. Mohamed (2015) assessed the approaches for generating real-time quantitative water quality parameters for Manzalah river through Medium-Spectral Resolution Imaging Spectrometer (MERIS) imagery. Their results suggested that regression models based on top-of-atmosphere (TOA) reflectances is a suitable approach for acquiring earth observation-based water quality data, and Chlorophyll-a(CHL) and Turbidity(TUR) are more appropriate remote sensing technologies for acquiring water quality parameters from MERIS imagery. Besides, their research indicated that combining real-time water quality(RTWQ), EO, and communications technologies could generate valuable information for water quality monitoring. However, their research is based on a limited size dataset, further research based on a larger volume of data to test these results is recommended.

Satellites can also geo-position things. Lanorte et al. (2017) proposed a methodology that using satellite data to georeferencing agricultural plastic wastes, and assessed its accuracy based on kappa coefficient and comparison with institutional land use map. The data was based on the Landsat 8 satellite image, and one of the supervised automatic algorithms Support Vector Machines (SVMs) has been used for image classification. Their accuracy assessment results indicated that the accuracy of waste map was 94.54%, and there was only 1.74% difference compared to the institutional land use map. This methodology contributed to solving the difficulties of obtaining input and output data on the use of plastics in agriculture.

Sensors can be added to satellites to make them even more data rich sources of information. Gerlein-Safdi et al. (2020) assessed natural reforestation in northern China based on satellite data. Their research has included the indicator vegetation water content and photosynthetic activity to quantifying the biomass and productivity of the vegetation. They have used microwave remote sensing data, and solar-induced chlorophyll fluorescence (SIF)49 data, and this dataset was collected by the QuikSCAT satellite and Global Ozone Monitoring Experiment 2 (GOME-2) satellite. Their results indicated that there is a strong correlation between vegetation activity and natural and traditional active reforestation, which provided a further option for using satellite data to monitor reforestation performance.

All the advantages of satelitees can be enhanced by AI. Victor Nobre Carrijo et al. applied artificial intelligence into satellite data to estimate the energy capacity in Brazilian savanna, a vegetation type in Brazil. Their research has included six indices including basal area and a set of vegetation index retrieved from the remote sensor. There best artificial neural networks (ANNs) results show an error of 11.3%, by using a structure of two neurons in the input layer, eight in the hidden layer, and one in the output layer. Their validation tests indicated there is no significant difference between the observed and ANN generated values, which means combining ANNs and satellite data would enable remote monitoring the energy capacity of the savanna. This research may initiate another option for the Gerlein-Safdi et al., (2020), as both of the study estimated the vegetation biomass. If feature research could use ANNS and satellite data together to exam a wider area of vegetation, this could contribute to the effective measure of reforestation.

Hemanth explained how to apply artificial intelligence techniques into satellite imagery analysis. It details an automated system for crop classification and agriculture land mapping. It is based on land satellite data and advances machine learning classification techniques such as ANNS and Iterative Self-Organizing Data Analysis (ISODATA). Their produced classification results have 88% accuracy of correct classification. Chapt 11 classified the advance machine learning techniques that could be applied to satellite imagery analysis. Their research summarized that the satellite images data processing and the extensive data-sets evaluation are two common areas that AI could be applied. They also suggested that storage and archival of satellite data is a critical challenge for AI application, and utilizing cloud computing could be a potential solution. Besides, their research found that the AI application has been restricted by data type, sensors type, etc., and pointed out the demand for a common platform which eliminating these limitations. It proposed a Wavelet-based Water Index (WaWI) which addressing the water body extraction issues. Their research has assessed the WaWI with both the spectral- and clustering-based water body extraction results and proved that it has outstanding performance compare to the other results.

4 | CONCLUSION

This paper reviewed EU legislation with respect to sustainable management of selected ESG indicators. It extended the conclusions of these to encompass the application of satellite imagery. It included research into air pollutant emission, water pollution, waste management, natural resource management specifically forest management and compliance. The relevant policies objective and measurements of these indicators was discussed. It was concluded that institutional metrics such as those found on Bloomberg were insufficient and would be improved by greater use of satellite data. It is suggested that for sustainable finance, financial institutions must review wider ESG indicators and provide more reliable ESG performance measurement. In order to achieve a sustainable feature, it is recommended that the regulator needs to ensure the state-level compliance with close supervision. To facilitate this, it was demonstrated that there is now ample satellite data and imagery that can be used for analyzing environmental indicators. The use of such data has achieved superior results compared to manual monitoring.

In summary, although there are still challenges about analyzing the extensive amount of satellite data and imagery, AI seemed to be a potential solution for that. It is concluded that data processing, classification and evaluation using AI techniques, combined with satellite data and imagery, could improve monitoring efficiency and effectiveness of environmental goals.

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