EGT2
ENGINEERING TRIPOS PART IIA

Thursday 8 May 2025 14.00 to 15.40

Module 3E11

ENVIRONMENTAL SUSTAINABILITY AND BUSINESS

*Answer not more than **two** questions.*

All questions carry the same number of marks.

*The **approximate** percentage of marks allocated to each part of a question is indicated in the right margin.*

*Write your candidate number **not** your name on the cover sheet.*

*Please write **readably**; what the examiner cannot decipher with reasonable effort cannot be evaluated.*

STATIONERY REQUIREMENTS
Single-sided script paper

SPECIAL REQUIREMENTS TO BE SUPPLIED FOR THIS EXAM
None

10 minutes reading time is allowed for this paper at the start of the exam.

You may not start to read the questions printed on the subsequent pages of this question paper until instructed to do so.

You may not remove any stationery from the Examination Room.

1 Until 2023 it seemed that environmental policies and business practices were increasing worldwide. However, in 2024, particularly in some regions of the world, there has been a backlash against climate and other environmental policies, a movement the Financial Times coined "*Greenlash*".

(a) Define and describe the concept of "*Greenlash*". How can this phenomenon be explained? How does it differ from "*Greenwashing*", "*Greenlighting*", and "*Greenhushing*"? [30%]

(b) As CSO (Chief Sustainability Officer) of a large corporation, you argue against your company following the *"Greenlash"* trend (as discussed in (a)). You want to show the Board and investors that sustainable business conduct matters for long-term profitability. Which *concepts or frameworks* used in sustainability management and politics (as discussed in class 3E11) would you use in your pitch to the Board members? Remember that your goal is to both stick to the current ambitious sustainability goals and avoid the company being subject to "*Greenlash".* Name and define three concepts. What do these concepts show? [40%]

(c) What are the advantages and the disadvantages of using "*carbon footprints*" to measure and compare the climate impact of activities of businesses, countries, and individuals? Discuss. [30%]

Note to exam reviewers: Question 1 focuses on concepts learned in Sessions 1 and 2 (a) and the Sessions on ESG management (b): The Doughnut Economy, planetary boundaries, and ecological footprints/carbon footprints. All concepts have been discussed in class, highlighted, and repeated in other sessions. In (c), one of the three concepts is named as a hint. Other concepts can be listed if they are a fit. The required reading and pre-assignment of Sessions 1 and 2 cover the question.

(a)

Greenlash is the backlash or societal resistance against environmental policies and climate initiatives, often driven by political, economic, or social factors. This resistance can manifest in various ways, including public scepticism about climate science, policy rollbacks, and pushback from industries or influential individuals perceiving environmental policies as restrictive or costly. Currently, the strongest Greenlash comes from polarised societies and the political right, for instance, in the US.

There are several reasons – economic, political, psycho-social, and tech-enabled – that can help explain the recent Greenlash, among them:

- Economic concerns: Resistance often arises from industries or communities reliant on fossil fuels or resource-intensive practices, fearing job losses or increased costs.

- Political ideology: Climate policies can be divisive, with some political groups framing them as overreach or infringing on individual freedoms.

- Social perception: In regions with low climate awareness, people may not see environmental issues as urgent or critical. Or other topics are much higher on the agenda, e.g., inflation or immigration issues.

- Misinformation and disinformation: The deliberate spread of climate misinformation can amplify scepticism and resistance. It undermines democratic values and manipulates citizens.

While all concepts overlap and come from the same debate, they have marked differences: Greenlash is a societal or institutional resistance to environmental progress. The other three are tactics companies deliberately employ to maximise profits, gain market share, protect early sustainability moves and other managerial reasons:

- Greenwashing refers to businesses misleading consumers by portraying themselves as environmentally friendly without substantive actions to back the claims. It's a deceptive marketing tactic, and regulations explicitly cover it in the EU and the UK.

- Greenlighting (from "gaslighting") occurs when a business highlights a single environmentally friendly practice to divert attention from its broader unsustainable operations.

- Greenhushing occurs when companies deliberately underreport or downplay their sustainability achievements to avoid scrutiny or accusations of hypocrisy. This can be a valid strategy in the early days of an ambitious ESG strategy and/or when companies are particularly under public scrutiny, e.g., large consumer brands.

(b)

Three concepts discussed in class are Planetary Boundaries, Doughnut Economics, and Ecological Footprints. Although they are very different, they provide evidence to support environmental goals and priorities for environmental policy. Together, they can help monitor and measure the ecological impact of economic activities and show the state of "planetary health" regarding different environmental dimensions. Since all three concepts are data-driven, they can help inform citizens, corporations, and policymakers about risks and priorities for action.

Planetary Boundaries are thresholds within which humanity can safely operate, ensuring the Earth's systems remain stable. They highlight how exceeding boundaries (e.g., CO_2 emissions, biodiversity loss) leads to irreversible environmental and economic consequences.

Doughnut Economics is a visual framework and management approach for sustainable development. It combines the concept of planetary boundaries with the complementary concept of social boundaries. The name derives from the shape of the diagram, which is shaped like a doughnut (or a lifebelt). The centre hole of the model depicts the proportion of people who lack access to life's essentials (such as healthcare, education, and equity). The crust represents the ecological ceilings (planetary boundaries) that life on planet Earth depends on and must not be overshot. Oxford economist Kate Raworth developed the framework in 2012; it is widely used in policy design in practice, e.g. by cities and regions.

Ecological Footprint (EF) measures the demands made by a person or group of people on global natural resources. It has become one of the most widely used measures of humanity's effect on the environment. It highlights the unsustainability of current practices and the inequalities in natural resource consumption between and within countries. EF estimates the biologically productive land and sea area needed to provide the renewable resources a population consumes (sources) and absorb the wastes it generates (sinks). It is measured in "global hectares" (gha) at various scales—for individuals, regions, countries, and humanity.

These three concepts can be used to show that for ethical reasons and long-term economic and social welfare, Greenlash is a short-sighted approach that might maximise profits in the short run but is ultimately not sustainable. Sustainable development needs long-term thinking and planning.

Version LR/6

(c)

Carbon Footprints (CF) are a special type of Ecological Footprint measure. CF is defined as the amount of carbon dioxide (or carbon dioxide equivalents of other greenhouse gases) released into the atmosphere due to the activities of a particular individual, organisation, or community. In sustainability management, one often differentiates between three types: individual, product, and national (or industry) carbon footprints. CF was initially developed for British Petroleum (BP) by an advertising firm and was only later developed into a scientific concept to measure environmental impact.

CF has many advantages: As a quantifiable metric, it provides measurable data to assess the climate impact of activities, enabling comparisons across businesses, countries, and individuals. It also allows monitoring upward and downward trends, for instance, after introducing a new policy or technology. It provides awareness and accountability and potentially encourages stakeholders to understand their environmental impact and take actionable steps to reduce emissions. Individual carbon footprints can, for instance, inform about the different climate impacts of varying consumption choices (e.g., air travel versus train travel) and who in a population has the most extensive and smallest impact (climate justice). Product carbon footprints (including the footprint of the production process) can help inform management in their product strategy (e.g., changing from ICE to EV technology in cars). National or regional comparisons can inform policymakers regarding the transformation of regions and climate justice questions worldwide, e.g. within the COP. The evidence available helps governments and organisations design targeted policies to curb emissions.

There are also disadvantages: Firstly, focusing solely on carbon emissions may overlook other environmental impacts, such as biodiversity loss or water usage. Hence, oversimplification might prevent a broader scope of analysis. Secondly, measurement relies on assumptions and models that can lead to inaccuracies or inconsistencies. Therefore, the analysis might present trends as facts while the evidence is less solid than assumed. Thirdly, by focusing on individual footprints, responsibility and burden of action might be unfairly shifted on individuals rather than systemic change by corporations and governments. Recent studies have revealed that this shift in responsibility from the producer to the consumer has been systematically applied by “Big Oil”, one of the initial promoters of the individual ecological footprint concept.

While carbon footprints are a valuable tool for highlighting climate impacts and prioritising policies and management decisions, they should be part of a broader sustainability strategy.

2 In the past decade, Environmental, Social, and Governance (ESG) has developed into a standard approach to sustainable management practice, particularly in Europe and the US.

(a) Define the *ESG strategy* approach. Give one example for each pillar (E, S, G). Explain why and how it can positively impact businesses (for each example). [30%]

(b) Does ESG really matter for a company's financial success? Share the key arguments of the supporters and critiques of a business case for an ESG strategy. [40%]

(c) How can *Circular Economy* thinking be part of a company's ESG strategy? Describe three examples. [30%]

For exam reviewers: Question 2 covers concepts learned in Sessions 3, 4, and 5: Circular Economy, ESG strategy, ESG regulation, and measurement/reporting. These concepts were applied in the practical case study presented in Session 5. The required readings and the respective slide decks provide everything necessary to answer this question fully.

(a)

An ESG strategy integrates Environmental, Social, and Governance factors into a company's operations, decision-making, and reporting processes. Ideally, the ESG strategy is not an add-on but an integral part of the overall company strategy. It emphasises sustainable practices, ethical responsibility, and long-term value creation while addressing risks and opportunities related to sustainability. Businesses adopting ESG strategies aim to align their goals with stakeholder expectations, reduce risks, and enhance resilience in an evolving global environment. Here are examples that illustrate the case in E, S, G:

- Environment (E): Adopting renewable energy sources substituting fossil fuels (e.g., solar panels, zero-emission factories) reduces the carbon footprint and aligns with global climate change goals. Since renewable energy sources tend to be cheaper (mainly solar), they lower energy costs over the long term and reduce dependency on access to volatile fossil fuel markets (often exposed to geopolitical risks). They might also attract environmentally conscious investors.

- Social (S): Implementing diversity, equity, and inclusion (DEI) initiatives (e.g., systematic career pathway coaching for minorities) fosters innovation and productivity by leveraging diverse perspectives. It can also improve employee satisfaction and retention, enhance the company's reputation as an attractive employer, and make the company more appealing to scarce talent.

- Governance (G): Establishing transparent reporting and anti-corruption policies builds investor confidence, ensures regulatory compliance, and mitigates risks associated with legal penalties or reputation-damaging scandals (particularly relevant for investors and consumer brand corporations). Good governance rules strengthen decision-making and organisational integrity.

Several industries have evidence that ESG strategies included in corporate strategies also lead to higher value creation and profitability in the long run. The specific industry, the type of company (e.g., publicly listed or start-up), geopolitics, and the regulatory frame will matter in each case.

(b)

This debate centres on ESG’s impact on profitability, risk management, and long-term value creation. Ultimately, profitability and value creation are empirical questions, often long-term rather than visible in quarterly returns, and depend on the individual corporation. Academic literature and major consultancy analysis reports show a moderate to strong business case. However, analysis is retrospective, and future developments depend highly on costs, politics, and regulatory frames.

With this qualification in mind, supporters of a positive business case for ESG bring forth the following – interconnected – arguments:

- More effective risk mitigation: ESG strategies help companies manage operational, product and financial risks related to climate change, regulatory changes, social unrest, and reputation issues. For instance, a strict corruption policy (G) helps avoid financial losses.

- Easier access to capital: ESG-compliant firms attract investors and funds, including those specifically interested in social impact. Banks and pension funds are increasingly factoring ESG into lending and investment decisions, lowering compliant companies' capital costs.

- Improved processes and operational efficiency: Environmental initiatives like energy efficiency and waste reduction (E) reduce operational costs. For instance, adopting renewable energy saves energy costs and reduces dependencies in the long term. It also forces the company to monitor and adapt its energy use.

- Attracting and retaining talent: Social initiatives (S) like diversity and employee well-being programs create a positive workplace culture, leading to higher employee satisfaction, productivity, and retention, also in times of crisis.

- Enhanced brand value and corporate reputation: Due to the above-mentioned advantages, companies prioritising ESG build trust with consumers, partners, and stakeholders, leading to higher sales and customer loyalty, which pays off, particularly in times of crisis. Trusted sustainable product lines often command premium prices and can realise higher margins, particularly in consumer brands (e.g., fashion and food).

- Long-term growth and resilience: ESG-aligned companies are better positioned to adapt to global trends and regulatory changes, ensuring sustained growth. Research shows that ESG leaders outperform laggards in stock market returns over the long term (as discussed in class).

On the other side, more critical voices see the following challenges and limitations of ESG management:

- Financial impact is less clear than often stated: The correlation between ESG performance and financial success is inconsistent or inconclusive. Some studies show little or no significant effect on shareholder returns. (However, it depends on how the "financial impact" is measured, quarterly versus yearly).

- Greenwashing: Companies might engage in ESG activities superficially to enhance their image without delivering substantive benefits, diluting trust in ESG reporting. They might also invest in "cheap green" such as fraudulent or questionable carbon offsets that only look good on reports but have no real environmental impact. The same point can be made for "Social Washing" (S).

- Significant short-term upfront costs: Implementing ESG practices often involves significant upfront costs, which may not yield immediate financial returns. For instance, investing in employee EDI programmes will rarely have short-term results, if any measurable results at all.

- Regulatory and reporting complexity: This is one of the most criticised challenges. Outside the EU, ESG frameworks are diverse, fragmented, not reliable, and lack standardisation, making it challenging for businesses to comply and report effectively. Significant regulations within the EU are still under discussion, and reporting duties are prohibitively high overall, particularly for small and mediumsized companies. Some argue that the results would be better if all these resources spent on reporting were used for actual ESG measures.

- Trade-offs with profit maximisation: Focusing on ESG can divert resources from core profit-generating activities. Critics argue that this regularly conflicts between (short-term) shareholder interests and broader stakeholder goals (i.e., employees and customers).

- “The business of business is business”: Some investors and Supervisory Boards view ESG as distracting from financial performance, particularly in industries where environmental or social factors may seem peripheral.

In conclusion, while all these arguments are valid in principle, the true impact of a specific ESG strategy can only be tracked in the long term and with high-quality monitoring. Better metrics and standardised reporting (underway in many markets worldwide) will lower implementation hurdles. Ultimately, whether ESG contributes to financial success depends on the company’s industry, geographic location (regulatory frame and geopolitical risk), stakeholder base, and quality, fit, and sincerity of its ESG efforts.

(c)

Circular Economy (CE) thinking is an approach to economic systems that emphasises reducing waste, extending product lifecycles, and regenerating natural systems. It contrasts with the traditional linear economy, which follows a "take-make-dispose" model by focusing on designing products, processes, and business models that enable continuous resource use and minimal environmental impact.

CE is built on some core principles: Design out waste and pollution, keep products and materials in use, regenerate natural systems, and decouple growth from resource use. These principles of CE thinking can well be included in a company’s Environmental, Social, and Governance (ESG) strategy to enhance the sustainability of products and processes, reduce waste, and support long-term value creation. Circular Economy principles align with ESG goals by addressing resource efficiency, ethical practices, and transparent governance. By embedding CE thinking into ESG strategies, companies can meet regulatory and stakeholder demands and create innovative, sustainable, and profitable business models. Here are some examples:

Regarding Environment (E): CE thinking can help reduce waste, pollution, and carbon emissions through resource efficiency and sustainable production methods. Designing products for durability, reuse, and recyclability (e.g., a tech company creating modular devices that allow easy repairs or upgrades) aligns with environmental goals. Closed-loop manufacturing processes minimise resource depletion since materials are reused to create new products. For instance, fashion brands offer take-back programs to recycle or upcycle old garments. Others offers sharing resources or leasing products (e.g., fashion, machines, cars) instead of selling them outright. These measures can improve key environmental metrics such as carbon footprints, material use per product, or specific plastic or toxic waste targets.

Regarding Social (S): CE thinking encourages fair labour practices and community engagement through localised resource sourcing and recycling initiatives. It can create new jobs in the repair, recycling, and remanufacturing sectors. For instance, partnering with communities to develop recycling programs or educate consumers on sustainable practices can be integrated as an “S” activity with the goal of enhancing social equity and community well-being and being a “good neighbour” in the community of production or service.

Regarding Governance (G): CE thinking can encourage transparent and truthful reporting on waste, emissions, and material usage in the supply chain. This supports accountability in managing supply chain impacts, which can be particularly relevant in source countries with a less strict regulatory frame, such as many developing countries. Transparent, truthful, and measurable sustainability goals and performance reviews can build confidence in the company’s long-term resilience and ethical operations, relevant to investors, customers, and employees.

3 Sustainable Engineering aims to design and operate products, infrastructure, and processes that support (rather than harm) planetary boundaries.

(a) Discuss one example of Sustainable Engineering for each of the following: products, infrastructure, and processes. [30%]

(b) The pervasive *digitalisation* of society and businesses poses opportunities and risks for sustainable development. Discuss how and when digitisation goes hand in hand with sustainable engineering practices and when it does not. [40%]

(c) Building on (b), discuss the role of *Artificial Intelligence* in this debate. [30%]

Note to exam reviewers: Question 3 covers mainly Session 8; all keywords have been taught and discussed.

(a)

Sustainable Engineering (SE) is defined as designing, developing, and operating products, infrastructure, and processes to minimise environmental impacts, conserve resources, and support long-term ecological and societal well-being. SE emphasises solutions that respect planetary boundaries while meeting current and future human needs. SE integrates environmental science, economics, and social equity principles to balance technological progress with sustainability and equitable welfare. It considers lifecycle impacts, from resource extraction to product disposal, and aims for efficient, renewable, regenerative, and welfare-promoting innovations.

Here are examples:

- Product: A reusable water bottle made from recycled PET bottles. Reusable water bottles reduce single-use plastic waste, lower carbon emissions in production compared to virgin materials, and encourage sustainable consumer behaviour.

- Infrastructure: Sustainable student housing buildings with energy-efficient designs, solar panels, and rainwater harvesting systems. These built infrastructures reduce energy consumption, promote renewable energy use, and conserve water resources while enhancing occupant well-being.

- Production process: Closed-loop manufacturing in the fashion industry utilises recycled textiles, minimises waste, and reduces water and energy consumption during production. If made transparent, e.g. via a respective consumer label, it can grab consumer attention and help change attitudes.

(b)

The use of digital tools provides ample opportunities to promote sustainable development. Based on the definition of Sustainable Engineering provided in a), digitisation can support and enhance Sustainable Engineering's principles and goals, as the following examples show:

- Digital tools like IoT sensors and smart grids enable real-time monitoring and optimisation of energy, water, and materials, reducing waste. For instance, smart agriculture uses digital sensors to optimise water usage and (quantity and type of) fertiliser application, thereby minimising environmental harm.

- Digital platforms facilitate sharing economies (e.g., ridesharing, equipment rental) and enable product traceability for recycling and reuse (circular economy). For instance, Blockchain technology tracks material usage, ensuring accountability in supply chains. Furthermore, Blockchain tech can also track other sustainability dimensions such as the time and place of mining and respect of workers' safety and human rights. Hence, it simplifies supply chain management and provides reliable data for ESG management.

- Digital simulations and modelling allow engineers to design systems and test sustainability scenarios without physical prototypes, saving resources and costs. For example, simulating energy performance in building designs can help maximise the efficiency of heating and cooling systems.

On the other hand, digitisation also brings substantial risks that must be weighed against the advantages for a complete assessment of sustainability impact:

- Data centres, cryptocurrency mining, and intensive use of digital devices (such as streaming or building models with large language models) consume significant energy and generate electronic waste, hence having a very high carbon footprint. For instance, the energy consumption of Bitcoin mining often exceeds that of entire countries, undermining sustainability goals. Some of the socially most controversial forms of energy supply – nuclear reactors and fossil fuels – are now revived mainly due to the substantial additional energy demand through these applications.

- Manufacturing digital hardware relies on often scarce, finite resources (e.g., rare earth metals), leading to unsustainable extraction practices. These resources are often sourced from conflict areas and regions with substandard working conditions. Also, the demand for lithium-ion batteries can lead to habitat destruction and water depletion.

- Digitalization can exacerbate socio-economic inequalities by disproportionately benefiting wealthier regions with access to advanced technologies. (However, others argue that digitisation provides a unique opportunity for leapfrogging technology, such as fostering IT skills for “AI in Africa”.

In conclusion, digitalisation supports sustainable engineering by enhancing efficiency, transparency, and circular practices. However, unchecked digitalisation may create new environmental, ethical, and social challenges, requiring careful governance. AI plays a unique and massive role in this debate (see c).

(c)

As digital tools in general (see b), artificial intelligence (AI) brings enormous opportunities and risks for sustainable development and Sustainable Engineering (SE).

On the one hand, AI analyses large datasets to optimise resource use, energy consumption, and production efficiency. For instance, AI-driven energy management systems reduce electricity usage in smart grids by predicting demand patterns. AI also accelerates innovation and, therefore, accelerates sustainable engineering by identifying novel materials, designing energy-efficient products, and optimising supply chains. In chemical engineering, for instance, AI algorithms assist in developing biodegradable polymers for packaging. Furthermore, AI supports predictive maintenance, reducing downtime and resource waste. For example, AI in manufacturing predicts equipment failures, avoiding unnecessary repairs and resource losses. AI-enhanced management decisions can be made earlier and more informed.

On the other hand, recent public discourse has increasingly highlighted the substantial environmental risks associated with, e.g., the enormous energy demands of AI Models: Training large AI models requires considerable computational power, consumes significant energy, and generates carbon emissions. The carbon footprint of training an advanced AI model can be equivalent to several years of individual energy consumption. It is highly unlikely that renewable resources will cover this excess demand in the short and medium term.

Beyond environmental risks, social and ethical concerns also matter for society's welfare: AI systems can perpetuate biases or make decisions prioritising short-term efficiency over long-term sustainability. For instance, AI in logistics might optimise costs but ignore environmental impacts like increased emissions or social impacts like accessibility for all. Another issue is that overreliance on AI may lead to less accountability and loss of human oversight in sustainable practices.

These are just a few elements of the increasingly pressing discourse on AI's role in sustainable development. AI is a powerful tool for advancing sustainable engineering, but its deployment must be balanced with energy-efficient practices, ethical frameworks, and robust oversight. When aligned with sustainability goals, AI can drive transformative progress; when mismanaged, it risks amplifying existing challenges.

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