AI+PLANETARY
JUSTICE ALLIANCE

AI SUPPLY CHAIN
IMPACT FRAMEWORK

Evaluating AI's Environmental and Socio-Political Footprint

1. Foreword

Artificial intelligence is often framed as an abstract force, a frontier of innovation detached from the material and social realities of its creation. Yet AI is not immaterial. It is built on the backs of laborers, fueled by vast amounts of extracted minerals, and powered by resource-intensive infrastructures that leave behind deep environmental and social scars. Understanding AI's true costs requires a shift away from narratives of seamless technological progress and toward an examination of its full lifecycle—one that accounts for the planetary and human implications of its production, use, and disposal.

The **AI Supply Chain Impact Framework** emerges from this need. At the **AI + Planetary Justice Alliance**, we recognize that AI is not just code and algorithms but a vast network of **extraction of resources and labor, energy consumption, and waste accumulation**—all of which disproportionately affect communities in the so-called Global South. These realities still remain hidden in many responsible AI conversations. While the focus is often on data ethics, algorithmic fairness, or bias mitigation, the material conditions enabling AI's expansion are rarely discussed. Often, that is because we don't really know much about them–in fact, we sometimes ***don't even know what we don't know***. This framework is an attempt to identify what we don't know, but desperately need to know. What are the questions we need to ask about the supply chain of the AI industry? What do we know? What do we not know? What quantitative and qualitative metrics exist to assess the impacts of the AI supply chain? What impacts should we assess in the first place? Who is "we"? Who gets to tell the story?

Our goal is not just to map the indicators of AI's environmental and social footprint but to make **this knowledge actionable**. The framework is designed to be a **tool for researchers, policymakers, civil society, and communities** to interrogate the AI industry's practices, demand accountability, and push for systemic change. Each stage of the AI supply chain—from **raw material extraction to model training and disposal**—presents unique challenges, and this document provides a structured way to assess them.

However, we acknowledge that this is an **ongoing and imperfect effort**. In perfect concert with the spirit of our Alliance, we are trying this out–the challenges ahead are many. Among them: Much of the AI supply chain operates in secrecy, with corporations withholding critical data on environmental impact, labor conditions, and supply chain sourcing. Many of the key questions we pose in this framework remain **difficult to answer—not because they are unimportant, but because the information is often somewhat obscured**. This framework therefore hopes to be an **advocacy instrument**, meant to highlight these gaps and push for transparency.

As the AI + Planetary Justice Alliance, we are committed to keeping this framework **open, adaptable, and participatory**. We invite those passionate about the intersections of AI and environmental justice to **contribute, refine, and expand on this work**. Please do so by leaving comments on this collaborative document! Only by collectively challenging AI's extractive paradigm can we move toward governance models that center planetary justice, epistemic plurality, and the right to refuse harmful technologies.

This is not just about understanding AI's costs. It is about **imagining different futures**—ones where AI, if it exists at all, serves the needs of people and the planet rather than perpetuating systems of exploitation. This framework hopes to be a step in that direction.

Sara Marcucci, Founder of the AI + Planetary Justice Alliance

2. What is this instrument?

The **AI Supply Chain Impact Framework** is a structured tool designed to assess the **environmental, social, and political impacts of AI systems** across their entire lifecycle. To structure this assessment, we divide our questions according to the **AI supply chain lifecycle** proposed by Sasha Luccioni, Bruna Trevelin, and Margaret Mitchell at Hugging Face.

At its core, this framework is both a **mapping and accountability tool**. It aims to **make visible the extractive and exploitative dimensions of AI production**, particularly those affecting marginalized communities and ecosystems in the Global South.

Going beyond traditional impact assessments that often focus solely on carbon footprints or energy efficiency, on the one hand, or algorithmic fairness or ethical concerns, on the other, this framework extends its scope to include **resource colonialism, labor conditions, and epistemic injustices**—recognizing that AI is not just a technical system but a deeply political one. It seeks to answer critical questions such as:

- **What materials go into AI systems, and at what cost?**
- **Who extracts, processes, and assembles AI hardware, and under what conditions?**
- **How do AI training and deployment affect local communities, energy grids, and environmental stability?**
- **What happens to AI infrastructure when it is no longer in use?**

Ultimately, the AI Supply Chain Impact Framework serves as an **entry point for structured evaluations**, helping stakeholders identify where interventions, regulations, or advocacy efforts are most needed. It is **not a static document**, but a living instrument designed to evolve as new data, research, and community insights emerge.

3. Who is it for?

This framework is intended for any organization, institution, or community that seeks a clearer picture of AI's real-world footprint. It can be used by companies wanting to evaluate the impacts of their own AI initiatives, policymakers designing regulations, NGOs focusing on environmental or social justice, and researchers exploring AI ethics and governance. It also offers local communities and labor representatives an accessible way to examine how AI might affect their environments, livelihoods, and rights.

4. How to use it

This framework is broad by design, but it can be used to **evaluate a specific AI system** if you **tailor** it to your project's scope. Here are a few practical pointers:

Prioritize Key Areas

If certain aspects (like data center energy usage) are critical for your AI system, focus your evaluation efforts there. You can place less emphasis on areas that are minor in your context or already well-documented.

Engage the Right Stakeholders

This framework suggests potential relevant stakeholders that could answer each question. However, no single person or group of people can answer them all. Effective assessment requires collaboration across procurement, data center operations, HR, local communities, and others to collect stage-specific information accurately. Relevant stakeholders will likely change from case to case, but we tried to offer a starting point of people and groups that might be worth engaging with for each question.

Scope Each Question to Practical Metrics

This is an emerging field, and much of the AI supply chain information remains unmeasured/unknown, proprietary, or only partially disclosed. One key purpose of this framework is to highlight the questions we still lack sufficient data to answer.

Whenever exact metrics (e.g., liters of cooling water used) are unavailable, consider estimates, published averages, or similar proxies, while being transparent about those limitations. Throughout the framework, for certain indicators, we explicitly suggest asking if the data is available and, if not, why. However, **we suggest pointing out missing data for each question, at each stage.** We hope that, over time, pushing for better data and practices will help close these information gaps. **This framework hopes to shed light on these gaps and help us push for them to be filled.**

Attribute Responsibility

When assessing the impacts of AI in each stage, it is essential to allocate responsibility based on the share of materials used by the AI system. For example, if an AI company utilizes only a portion of the materials produced by a manufacturer, only that fraction of the associated environmental and social impacts should be attributed to the AI system. This approach ensures that the analysis accurately reflects the contribution of the AI system to the overall impacts, rather than assigning the full burden of materials manufacturing to the AI system alone. To address this complexity in a clear and actionable way, following these steps might be useful:

- **Define Your System Boundaries:** Begin by deciding what stages of the process you will include in your assessment. Sometimes, not all stages are relevant. For example, you might choose a "cradle-to-grave" approach that covers every stage—from raw material extraction (the “cradle”) through manufacturing, model training, deployment, and finally to disposal or recycling (the “grave”). Alternatively, a "cradle-to-gate" approach stops the assessment once the product leaves the manufacturing facility. Clearly defining these boundaries will help you understand exactly which stages of the lifecycle contribute to the overall impact. In addition to outlining which process stages are included, note any contextual factors—such as community history or local environmental conditions—that may influence both the numerical and narrative evaluation of impacts.
- **Collect Baseline Data:** Gather baseline information for each stage of the supply chain. This includes quantitative

data like the total area disturbed, water withdrawn, and GHG emissions, as well as qualitative insights such as stakeholder perceptions and local environmental conditions. These combined data points form the foundation for assessing the overall impact before any attribution is applied.

- **Determine Responsibility Rate:** This step involves figuring out what portion of the overall process is attributable to the AI system at stake. For example, if a company involved in the supply chain of the AI system you are evaluating uses 30% of the materials from a specific mine, then you should assign only 30% of the mine's impacts (such as land disturbance or water withdrawal) to the AI system you are examining.[1]
- **Integrate the Responsibility Rate into Your Calculations:** Now, apply the responsibility rate to the baseline data. For instance, if a mining operation disturbs 300 square kilometers of land, and your company is responsible for 30% of the materials, you would attribute 90 square kilometers (30% of 300 km^2) of the land disturbance to your AI system. Repeat this calculation for each impact area (water usage, emissions, etc.) to ensure that all data reflect your actual share of responsibility.
- **Conduct Sensitivity and Uncertainty Analyses:** Because responsibility rates and baseline data can be uncertain or variable, it's important to assess how changes in your assumptions might affect your results. Develop a range of estimates—such as best-case, worst-case, and mid-range scenarios—and document the assumptions behind each one. This analysis helps you understand the uncertainty in your impact calculations and shows how robust your estimates are.
- **Validate and Refine Your Approach:** Finally, verify your calculations by comparing them with multiple data sources. If possible, use a combination of primary data

[1] If you can't pinpoint exactly how much impact your AI system is responsible for because the data is missing or uncertain, you can still get a useful estimate. For instance, you can use average figures from similar industries as a substitute or compare your system's impact to a baseline (like traditional methods) to see what extra impact is due to AI. You can also develop different scenarios—best-case, worst-case, and average—to understand how your results might vary. Finally, gather insights from stakeholders (such as local community feedback) and clearly explain the assumptions you made. This way, even without perfect data, you can still provide a meaningful assessment of your AI system's impact.

(direct measurements, interviews) and secondary data (industry reports, academic studies) to triangulate your estimates. Engage a multidisciplinary team—such as environmental scientists, supply chain experts, and AI developers—to review your methodology. Their feedback will help refine your attribution process, ensuring that your final assessment is both transparent and accurate.

Document and Iterate

Use the framework as a starting point to create a structured **checklist** or **questionnaire** that is **tailored** to your specific situation and to the AI system you are trying to assess. Document your findings, data sources, and any unresolved issues. Over time, you can refine the questions or add new ones if they become relevant.

There are a few things to map throughout the AI supply chain, regardless of the specific stage. These include:

Geography of the Process: Identify the specific locations where activities occur. For example, note where mining operations take place, where materials are manufactured, and where the AI system is ultimately disposed of. This geographic context helps you understand local environmental, regulatory, and socio-political conditions.

Data Availability: For each indicator, document whether the necessary data is available. If data is missing or only partially disclosed, note the reasons (e.g., proprietary limitations, inconsistent reporting, or measurement challenges). This transparency is key to understanding the reliability of your assessment and identifying areas for improvement.

Responsibility Attribution: Determine the proportion of the overall process attributable to the AI system. For instance, if an AI firm sources 40% of its semiconductor chips from a specific manufacturer, then only 40% of that manufacturer's environmental and socio-political impacts should be assigned to the AI system. This ensures fair allocation of impacts.

Stakeholder Involvement: Identify and document which local communities, regulatory agencies, labor organizations, and other groups are affected by or involved in each stage. This mapping highlights the broader socio-political context and helps ensure that community perspectives and local issues are considered.

Temporal Dynamics: Record any time-based variations or seasonal fluctuations in key metrics (e.g., energy consumption peaks during high production periods). Understanding these dynamics provides insight into the variability and trends in impacts over time.

5. Challenges and Limitations

While this framework provides a structured approach for assessing the environmental and socio-political impacts of AI across its supply chain, it is not without its challenges and limitations. At the AIPJ Alliance, we are learning as we are going. We are just starting to scratch the surface and don’t position ourselves as experts, especially in a field that is so interdisciplinary and constantly evolving. If you find any errors or room for improvement, please do let us know. We would greatly appreciate it. In fact, we believe shedding light on the planetary justice impacts of the AI supply chain can only be done by coming together, collaborating, and integrating our collective knowledge(s).

The complexities of AI development, the opacity of corporate supply chains, and the lack of standardized reporting mechanisms all pose significant obstacles to comprehensive and effective impact assessment. Below are some key limitations and challenges that users of this framework should consider.

Attribution Complexity

As mentioned above, AI systems involve many processes and components, making it challenging to determine which environmental and social impacts—such as those from mining or manufacturing—should be attributed specifically to the AI system. Broadly speaking, indicators that measure direct, quantifiable resource use and emissions—such as energy consumption, water usage, greenhouse gas (GHG) emissions, land disturbance, and waste generation—can typically be adjusted using the attribution process. On the other hand, more complex or qualitative indicators—such as community displacement, cultural or spiritual losses, and broader socio-political impacts—often cannot be fully captured by a simple numerical attribution. These impacts are usually more diffuse and intertwined with broader local or regional dynamics. For these, you may need to rely on a combination of qualitative assessments and stakeholder engagement rather than just adjusting a numerical value by the responsibility rate.

Lack of Transparency and Data Availability

One of the biggest barriers to applying this framework is the scarcity of publicly available data on key aspects of AI's supply chain. Many corporations treat supply chain information—including emissions, water usage, and labor conditions—as proprietary or commercially sensitive, making independent verification difficult. Similarly, while some companies publish environmental reports, they often use self-reported metrics without third-party audits, making it challenging to assess their reliability.

Fragmentation Across the AI Supply Chain

AI's supply chain is highly globalized and fragmented, spanning multiple industries and jurisdictions. This makes it difficult to apply a single set of standards across all stages of AI development. For example, raw material extraction occurs in the Global South under weak environmental regulations, while AI model training is often concentrated in high-income countries where carbon offsets and greenwashing obscure actual energy use.

Limited Adoption and Enforcement Mechanisms

This framework provides a structured method for assessing AI's impact, but without policy enforcement or industry buy-in, its effectiveness remains limited. Governments, regulatory bodies, and AI developers must be willing to engage with these questions and implement structural changes—something that remains rare in the current AI landscape.

This framework is a living document, designed to evolve as new data, methodologies, and advocacy efforts emerge. Mapping the questions that need to be answered, it hopes to serve as a foundational tool for more accountable, just, and sustainable AI governance.

6. AI Life Cycle: An Overview

(Drawing on the "AI Environment Primer" by Sasha Luccioni, Bruna Trevelin, and Margaret Mitchell, Hugging Face, 2024)

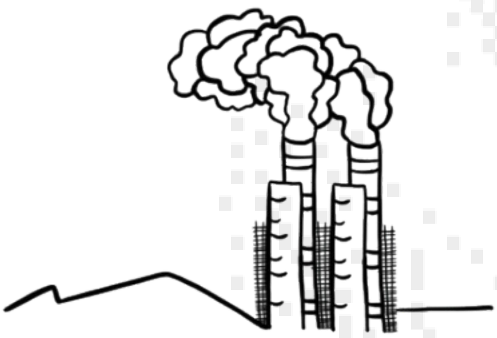
Many analyses of AI's environmental impact focus only on model training, but the **AI Environment Primer** proposes a broader life cycle view—one that acknowledges resource use and emissions before, during, and after training itself. Below is a concise overview of each stage as adapted from their approach, which serves as the foundation for this framework:

Raw Material Extraction

The raw material extraction stage forms the foundation of the AI supply chain, as it involves the mining and collection of critical minerals—such as lithium, cobalt, and silicon—that are essential for building the hardware powering AI systems. This stage can have significant environmental implications, including extensive land disturbance, water withdrawal, biodiversity loss, and pollution. For example, mining operations can alter local water tables and degrade soil quality, while also contributing to greenhouse gas emissions. In addition, the socio-political impacts can be profound. Local and Indigenous communities may experience displacement, loss of access to natural resources, and cultural or spiritual disruptions as a result of these extractive activities. Labor conditions in mining—ranging from worker safety to adherence to labor regulations—further compound the social impact.

Materials Manufacturing

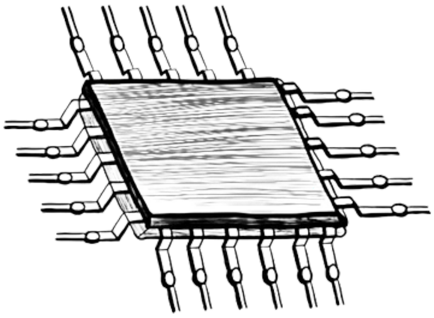
Materials manufacturing is the stage where raw minerals are transformed into intermediate products—such as wafers, semiconductors, and other components—that form the building blocks of AI hardware. This process is typically energy- and water-intensive and can produce both hazardous and non-hazardous waste. In addition to its environmental impacts—such as high energy consumption, significant water use, and pollutant emissions—materials manufacturing can have socio-political implications. These include labor conditions in production



facilities, community disruptions due to industrial operations, and broader impacts on local ecosystems.

Equipment Manufacturing

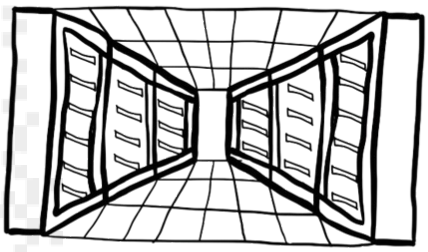
The equipment manufacturing stage involves the assembly and production of the physical hardware—such as servers, GPUs, and cooling systems—that powers AI systems. This phase typically requires significant amounts of energy and water, and it generates greenhouse gas emissions as well as both hazardous and non-hazardous waste. In addition, the production processes often involve complex supply chains that may include multiple sub-processes (e.g., component fabrication, assembly, and testing), each with its own environmental footprint.



Alongside these environmental concerns, equipment manufacturing can have considerable socio-political implications. Labor conditions within manufacturing plants, the use of subcontracted work, and impacts on local communities (such as increased industrial activity and associated pollution) are important factors to consider. Moreover, issues related to worker safety, compliance with labor standards, and community engagement are critical in this stage.

Model Training

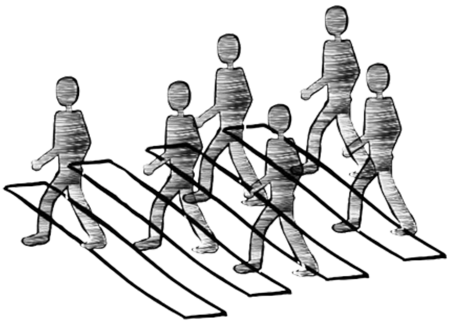
Model training is the stage in which large-scale AI models are developed, typically in data centers equipped with high-performance computing resources. This phase is highly resource-intensive, consuming significant amounts of energy and water, and often generating considerable greenhouse gas emissions due to the high computational demands. The environmental footprint of model training also includes the indirect impacts associated with the infrastructure supporting these processes, such as the energy required for cooling and maintaining the data centers.



In addition to these environmental impacts, model training has important socio-political implications. For instance, the labor conditions of data center staff—who may work in challenging conditions such as long shifts and high-temperature environments—are a critical consideration. Moreover, the local communities surrounding data centers may experience impacts related to energy demand, water usage, and even noise or traffic, which can affect their quality of life.

Model Deployment

Model deployment is the stage where the trained AI models are put into operation, providing real-time inference and decision-making services to end users. This phase



typically occurs in data centers or cloud environments, which support the continuous processing and delivery of AI outputs. The environmental impacts during deployment primarily include ongoing energy consumption and water usage for cooling, as well as associated greenhouse gas emissions. Given that these data centers are often shared across multiple services and applications, it is important to allocate only the proportion of these impacts that can be directly attributed to the AI system under evaluation.

In addition to these environmental considerations, the model deployment stage carries significant socio-political implications. The operational phase can influence local communities through factors such as noise, traffic, and increased demand on local infrastructure, which may affect public health and well-being. Job impacts and labor conditions for those maintaining the data centers are also relevant, as is the level of transparency and fairness in how the deployed system's outputs are communicated to users.

Disposal / End-of-Life

The disposal and end-of-life stage addresses what happens to hardware and equipment once they are no longer needed—such as outdated servers, GPUs, and

other components used in AI systems. This phase can have significant environmental impacts if electronic waste (e-waste) is not managed properly. For example, improper disposal may lead to the release of toxic substances, heavy metals, and other hazardous materials that can contaminate soil, water, and air. Additionally, recycling processes themselves can consume energy and produce emissions, further contributing to the overall environmental footprint. Socio-politically, the disposal stage can affect local communities, especially if waste disposal sites are located near residential or ecologically sensitive areas. Issues such as community health risks, economic disruption, and inequitable exposure to environmental hazards may arise. Labor conditions in e-waste processing facilities and community perceptions of safety and quality of life are also important considerations.

7. Preliminary Context Questions

Before diving into the detailed life cycle questions, it is worth exploring how and why AI was selected as a solution in the first place. This broader context sets the stage for all subsequent assessments, revealing factors such as stakeholder involvement, resource constraints, or overlooked alternatives that may influence the AI system's impacts over time.

Purpose and Alternatives

- **Rationale:** Understanding the core problem the AI aims to solve—and whether simpler or non-AI methods were considered—reveals how well the chosen approach aligns with the project's goals and constraints.
- **Key Questions:**
  - What objectives or issues is the AI system trying to address?
  - Were alternative solutions (e.g., rules-based systems, manual processes) evaluated, and if so, why were they ultimately set aside in favor of AI?
  - Which performance, cost, or scalability factors tipped the balance in favor of AI?

Stakeholder Expectations

- **Rationale:** AI decisions can have far-reaching effects on communities, workers, NGOs, regulators, and other interested parties.
- **Key Questions:**
  - Which stakeholders were informed or consulted before adopting AI?
  - Were there opportunities for them to voice opinions, concerns, or support?
  - Did any disagreements or tensions remain unresolved after the decision to proceed?

Scope and Context

- **Rationale:** The geographic, cultural, and regulatory environment can heavily shape both the benefits and drawbacks of introducing AI.
- **Key Questions:**
  - Is the AI system deployed locally, regionally, or globally?
  - Do local laws or norms (e.g., privacy regulations, cultural traditions) influence how the system is built or used?
  - Are there historical or political factors that might amplify or mitigate the system's potential impacts?

Constraints and Feasibility

- **Rationale:** Practical limitations, such as financial or time pressures, influence the depth of due diligence and the thoroughness of subsequent risk mitigation.
- **Key Questions:**
  - What budget, expertise, and infrastructure were available for the AI project?
  - Were tight deadlines or limited resources significant drivers in choosing this particular AI approach?
  - Are critical data sets or specialized skill sets missing, and how has that shaped the project?

Assumptions and Risk Tolerance

- **Rationale:** Every AI project involves assumptions about its potential benefits and an acceptance of certain risks. These questions gauge whether decision-makers appropriately balanced upsides and downsides.
- **Key Questions:**
  - Which benefits (e.g., efficiency, scalability) were most emphasized, and were they backed by empirical evidence or pilot studies?
  - How were risks (e.g., bias, security vulnerabilities, high energy consumption) identified, and did the organization set thresholds for acceptable exposure?
  - Have clear mitigation strategies been outlined for high-risk scenarios?

Addressing these questions up front, it becomes clearer how initial decisions, pressures, and assumptions shaped the AI initiative. This context then allows for a more nuanced exploration of each life cycle stage, illuminating points of vulnerability and opportunity that may not be evident without a clear picture of how and why the system came to be.

Raw Material Extraction

Dimension: Environmental Impact

LAND USE

- What is the total area of land disturbed during raw material extraction (in hectares[2])?
- What percentage of the disturbed area has been rehabilitated[3] post-extraction?

Where to look for the answer?

- Potential Stakeholders
  - Mining companies managing resource extraction and land use.
  - Environmental conservation groups monitoring deforestation and land degradation.
  - Local communities impacted by land use changes.
  - Government land management agencies.
- Potential Data Sources
  - Environmental Impact Assessments (EIAs) submitted by extractive industries.
  - Remote sensing and satellite imagery to track land changes.

[2] Throughout this framework, we have tried to define functional units where relevant. A functional unit is a standardized measure that enables meaningful comparisons across different systems or products. It provides a common baseline—for example, per training cycle or per inference task—so that even if systems operate at different scales or efficiencies, their environmental impacts can be evaluated on an equivalent basis. This normalization is essential because life cycle assessments involve various assumptions and estimates, and their true value is realized when comparing one system to another. For example, consider energy efficiency in manufacturing: knowing that one process consumes 100 kWh per unit only gains meaning when compared to an industry benchmark of 80 kWh per unit. Similarly, by standardizing the measurement—such as impacts per training cycle or per inference task—it is possible to establish a common benchmark that enables you to evaluate the relative sustainability of different AI systems, rather than relying on standalone measurements.

[3] This could involve re-contouring the land, planting native vegetation, restoring soil health, and ensuring that the ecosystem can function properly again. For example, if 100 hectares were disturbed during mining and efforts have restored 40 hectares to a stable ecological condition, then 40% of the disturbed area has been rehabilitated.

- Government land use and geological survey reports.

WATER USAGE

- How much water is withdrawn annually for material extraction (in cubic meters)?
- How much water has been treated and subsequently released back into the local ecosystem?
- Has the extraction process caused changes in the local water table? If yes, what are the observed changes?

Where to look for the answer?

- Potential Stakeholders
  - Water management authorities overseeing resource use in extractive industries.
  - Mining and industrial operators tracking water withdrawals.
  - Environmental scientists studying hydrological impacts.
  - Communities reliant on local water sources.
- Potential Data Sources
  - Industry water usage disclosures and sustainability reports.
  - Hydrological impact studies.
  - Government water resource databases.

BIODIVERSITY AND HABITAT

- How many species—both animal and plant—have been displaced or endangered due to the extraction process?
- How much habitat area has been lost due to material extraction (in hectares)?

Where to look for the answer?

- Potential Stakeholders
  - Conservation biologists studying species displacement.
  - Extractive industry environmental compliance teams.
  - Local communities advocating for biodiversity preservation.
- Potential Data Sources
  - Biodiversity assessments included in EIAs.
  - Scientific surveys of ecosystem changes.
  - Satellite monitoring of habitat loss.

ENERGY USE

- What is the total energy consumed (in kWh) per unit of material extracted (e.g., per ton of ore)?
- What percentage of the energy used in the extraction process is derived from renewable versus non-renewable sources?
- How does the energy intensity of this extraction process compare to industry benchmarks or alternative extraction methods?
- What energy efficiency measures or technologies are implemented to reduce energy consumption during extraction, and how effective[4] are they?
- How has the energy consumption per unit of material extracted changed over time, and what factors are driving these changes?

Where to look for the answer?

- Potential Stakeholders
  - Mining companies and extraction operators responsible for energy management
  - Environmental and sustainability teams within the mining or resource extraction industry
  - Government agencies or regulatory bodies monitoring industrial energy use and emissions
  - Energy auditors and consultants specializing in industrial processes
- Potential Data Sources
  - Internal energy consumption reports and audits from mining operations
  - Environmental Impact Assessments (EIAs) and sustainability reports that detail energy use
  - National or regional databases on industrial energy statistics and renewable energy usage
  - Industry benchmarks and technical white papers comparing energy intensity across extraction methods
  - Third-party verification reports or certifications (e.g., ISO standards for energy management)

GHG EMISSIONS

[4] In this context, "effective" refers to the degree to which the implemented energy efficiency measures or technologies actually reduce energy consumption compared to a baseline scenario. This can be measured in terms of percentage reduction, absolute energy savings (e.g., kWh saved), cost savings, or improvements in energy performance metrics (like Power Usage Effectiveness, PUE).

- Is it possible to know or estimate the total GHG emissions (including CO_2 equivalent, CH_4, and N_2O) released during the extraction process (in metric tons)? If so, what is the amount? If not, why is it not possible?
    - Is it possible to know or estimate this for all sub-stages of the extraction process, i.e. location of materials, infrastructure takeover, extraction, and transportation? If not, is it possible to know or estimate this only for some of these?

Where to look for the answer?

- Potential Stakeholders
    - Climate scientists and GHG accounting experts involved in the extraction of materials at stake.
    - Regulatory bodies setting emissions reporting standards.
    - Extractive industries' sustainability officers tracking emissions.
- Potential Data Sources
    - National greenhouse gas emissions inventories.
    - Industry sustainability reports with Scope 1, 2, and 3 emissions.
    - Life cycle assessments (LCAs) covering mining and material processing.
    - Instruments such as land use change carbon flux models for estimates.

Dimension: Socio-Political Impact

LABOR CONDITIONS

- What proportion of workers in extraction operations have permanent contracts versus temporary or subcontracted arrangements?
- How do workers rate the safety of their working conditions, including factors such as shift length, availability of protective gear, and overall compliance with safety standards?
- What is the incidence of workplace injuries or fatalities, and how do these figures compare to local or industry benchmarks?
- What mechanisms are in place for workers to report safety concerns, and how effectively are these concerns addressed?

Where to look for the answer?

- Potential Stakeholders
  - Trade unions representing mine workers.
  - Occupational safety agencies overseeing labor protections.
  - Human rights organizations monitoring working conditions.
- Potential Data Sources
  - Labor inspection reports.
  - Worker safety audits.
  - Compliance certifications for ethical labor practices.

COMMUNITY & CULTURAL IMPACT

- How many people have been displaced as a result of raw material extraction?
- Do displaced individuals have access to resettlement programs or compensation schemes?
- What reports exist of cultural or spiritual losses among Indigenous groups due to extraction?
- What formal consultation processes have been established with local and Indigenous communities, and how effective have they been in influencing decision-making?
- What material losses have local communities experienced, such as reduced access to natural resources, directly attributable to mining activities?

Where to look for the answer?

- Potential Stakeholders
  - Indigenous and local community representatives.
  - Social impact researchers studying displacement and cultural impacts.
  - NGOs focused on land rights and social justice.
- Potential Data Sources
  - Reports on community displacement and resettlement programs.
  - Case studies on social and cultural losses due to mining.
  - Public consultations and grievance mechanism records.

ECONOMIC DISRUPTION ON LOCAL COMMUNITIES

- How has raw material extraction impacted traditional livelihoods in affected regions?
- What changes have occurred in local economic activity levels due to extraction?
- Do displaced communities perceive the compensation they received as fair and adequate?

Where to look for the answer?

- Potential Stakeholders
  - Indigenous and local community representatives.
  - Local business owners assessing economic shifts.
  - Economic development agencies.
  - Governments tracking employment and income changes.
- Potential Data Sources
  - Local economic impact assessments.
  - Case studies on industry-driven economic transformation.
  - Community perception surveys on economic stability.

COMMUNITY HEALTH AND WELL-BEING

- What are the local community's perceptions of health risks associated with the extraction process?
- Are healthcare provisions and access for affected communities satisfactory?
- How has raw material extraction impacted local air quality?
  - What quantitative data (e.g., pollutant levels, particulate matter measurements) are available to assess these air quality changes?
- How has raw material extraction affected noise pollution levels in the surrounding areas?

- What evidence or data exist regarding the incidence of health issues related to these environmental impacts in the affected areas?

Where to look for the answer?

- Potential Stakeholders:
    - Local community health clinics and public health departments
    - Community-based organizations and Indigenous groups
    - Environmental justice advocates
    - Local government health agencies
- Potential Data Sources:
    - Health impact assessments related to mining projects
    - Public health records and epidemiological studies
    - Community surveys and local news reports
    - Government and NGO reports on mining-related health risks

COMMUNITY ENGAGEMENT

- How many consultations or public meetings have been conducted with local communities regarding the mining operations?
- What level of transparency is provided by the mining company about their operational practices, environmental impacts, and supply chain data?
- Are there grievance or feedback mechanisms in place for local communities to express concerns or influence decisions related to the mining activities?

Where to look for the answer?

- Potential Stakeholders:
    - Local community councils and advocacy groups
    - Regional government liaison offices
    - NGOs working on community impact and environmental justice
    - Corporate social responsibility (CSR) teams
- Potential Data Sources:
    - Records of public consultations and stakeholder meetings
    - Community feedback surveys and case studies
    - Media reports and independent research on engagement practices
    - Corporate transparency and CSR reports

Materials Manufacturing

Dimension: Environmental Impact

ENERGY USE

- What is the energy consumption per unit of material produced (in kWh per kilogram)?
- What percentage of the energy used during material production is sourced from renewable energy?

Where to look for the answer?

- Potential Stakeholders:
    - Factory operators monitoring energy efficiency.
    - Government agencies regulating industrial emissions.
    - Renewable energy providers advocating for sustainable practices.
- Potential Data Sources:
    - Factory-level energy audits.
    - Sustainability reports on manufacturing energy intensity.
    - Government energy consumption databases.

WATER USAGE

- How much water (in cubic meters) is consumed per unit of material manufactured?
- What percentage of the water used in the manufacturing process is sourced from freshwater, groundwater, or recycled water?
- How much wastewater is generated, and what treatments are applied before discharge?
- Is there a closed-loop water system in place to reduce overall water consumption?
- How does water withdrawal for manufacturing affect local water availability for surrounding communities and ecosystems?
- Are there seasonal variations in water use, and how does the facility adjust its operations accordingly?

- How does the facility monitor and report its water consumption and discharge, and are the reports publicly accessible?

Where to look for the answer?

- Potential Stakeholders:
  - Facility water management and operations teams
  - Environmental compliance and sustainability departments
  - Local water utilities and resource management authorities
  - Suppliers of water treatment and recycling systems
  - Regulatory agencies overseeing water usage and discharge
- Potential Data Sources:
  - Internal water consumption and discharge reports or audits
  - Environmental Impact Assessments (EIAs) for the facility
  - Public sustainability reports and water stewardship documentation
  - Regulatory permits and filings related to water withdrawal and wastewater treatment
  - Third-party environmental monitoring reports and industry benchmarks

POLLUTION AND TOXICITY

- What are the average concentrations of air pollutants (e.g., SO_2, NO_x, particulate matter) emitted during the manufacturing process?
- What levels of heavy metals (e.g., lead, mercury, cadmium) or other toxic substances are detected in water discharges from manufacturing facilities?
- How do the measured pollutant levels compare to national or international regulatory limits?
- What technologies or measures are in place to control and reduce emissions during production?
- How frequently are emissions and effluent quality monitored, and are the results publicly reported?
- What trends have been observed in pollutant levels over time—are there measurable improvements or deteriorations?

Where to look for the answer?

- Potential Stakeholders:
  - Industrial compliance teams monitoring emissions.
  - Environmental health experts studying pollution impacts.
  - Local communities affected by industrial pollution.

- Potential Data Sources:
    - Industrial pollution control reports
    - Air and water quality monitoring datasets
    - Regulatory compliance filings

WASTE GENERATED

- What is the total volume of hazardous waste produced annually (in tons or kilograms)?
- What is the total volume of non-hazardous waste produced annually (in tons or kilograms)?
- What percentage of the total waste generated is recycled, repurposed, or otherwise diverted from landfill disposal?
- What waste minimization strategies or technologies have been implemented, and what measurable impact have they had?
- How do waste generation rates compare to industry benchmarks or regulatory standards?
- What are the methods and effectiveness of waste treatment and disposal (e.g., incineration, recycling, landfilling)?

Where to look for the answer?

- Potential Stakeholders:
    - Waste management teams in manufacturing facilities.
    - Circular economy experts promoting sustainable waste practices.
    - Environmental advocacy organizations tracking industrial waste.
- Potential Data Sources:
    - Industry waste reports categorizing hazardous and non-hazardous materials.
    - Recycling and waste reduction performance metrics.
    - Government waste tracking databases.

GHG EMISSIONS

- What is the total amount of GHG emissions (including CO_2, CH_4, N_2O, and fluorinated gases) released during materials manufacturing (in metric tons)?
    - If exact figures are unavailable, what are the primary sources of emissions and why is comprehensive data lacking?
- Which processes or stages within materials manufacturing are the primary sources of these emissions (e.g., energy consumption, chemical processing, transportation)?

- What uncertainties exist in the current GHG emissions data, and what steps are taken to address these uncertainties (e.g., sensitivity analyses, use of proxy data, third-party verification)?

Where to look for the answer?

- Potential Stakeholders:
    - Manufacturing environmental compliance teams
    - Internal sustainability and operations departments
    - Regulatory agencies overseeing industrial emissions
    - Third-party environmental auditors
- Potential Data Sources:
    - Factory-level sustainability or emissions reports
    - Environmental Impact Assessments (EIAs) and Life Cycle Assessment (LCA) studies
    - National and regional greenhouse gas inventories
    - Regulatory filings and ISO certification documents related to emissions monitoring

Dimension: Socio-Political Impact

ECONOMIC DISRUPTION ON LOCAL COMMUNITIES

- How has raw material extraction or manufacturing affected traditional livelihoods in the impacted regions?
- What changes have occurred in local economic activity levels as a result of extraction or manufacturing operations?
- Do displaced communities perceive the compensation (not just monetary) they received as fair and adequate?
- How do local communities view the balance between economic benefits and environmental and social costs of the operation?

Where to look for the answer?

- Potential Stakeholders:
    - Local business associations and economic development agencies.
    - Community leaders and local government representatives.
    - Labor unions and worker advocacy groups.
    - NGOs focused on sustainable development.
- Potential Data Sources:
    - Regional economic impact studies and employment statistics.
    - Local government reports on economic activity shifts.
    - Surveys and case studies documenting community experiences.
    - Media investigations and academic research on industry impacts.

LABOR CONDITIONS

- What proportion of workers in the operation have permanent contracts?
- How do workers perceive the fairness and safety of their working conditions?
- Do workers have access to benefits such as healthcare, insurance, or retirement plans?
- How many injuries or fatalities are reported annually at the workplace?
- How frequently are safety compliance audits conducted, and what is their effectiveness?
- How do average wages at the operation compare to regional living wage benchmarks?

- How do average wages at this location compare to wages paid by the company in other locations?

Where to look for the answer?

- Potential Stakeholders:
  - Labor unions and workers' rights organizations.
  - Occupational health and safety regulators.
  - Local community advocacy groups.
  - Industry-specific certification bodies.
- Potential Data Sources:
  - Labor inspection reports and safety audit records.
  - Internal company reports on working conditions.
  - NGO and watchdog assessments.
  - Government labor statistics and compliance filings.

COMMUNITY ENGAGEMENT

- How many consultations or public meetings have been conducted with local communities regarding the materials manufacturing operations?
- What level of transparency is provided by the materials manufacturing company about their operational practices, environmental impacts, and supply chain data?
- Are there grievance or feedback mechanisms in place for local communities to express concerns or influence decisions related to the materials manufacturing activities?

Where to look for the answer?

- Potential Stakeholders:
  - Local community councils and advocacy groups.
  - Regional government liaison offices.
  - NGOs working on community impact and environmental justice.
  - CSR teams.
- Potential Data Sources:
  - Records of public consultations and stakeholder meetings,
  - Community feedback surveys and case studies.
  - Media reports and independent research on engagement practices.
  - Corporate transparency and CSR reports.

Equipment Manufacturing

Dimension: Environmental Impact

ENERGY USE

- What is the energy consumption per equipment unit produced (in kWh per unit)?
- How much energy is consumed during the construction of the data center?

Where to look for the answer?

- Potential Stakeholders:
  - Facility managers and production engineers
  - Energy auditors and industrial efficiency experts
  - Government energy regulators
  - Suppliers of industrial machinery and renewable technologies
- Potential Data Sources:
  - Factory-level energy consumption reports
  - Third-party energy audits
  - Industry benchmarks and technical white papers
  - Government databases on industrial energy use

GHG EMISSIONS

- What is the total amount of GHG emissions (including CO_2, CH_4, N_2O, and fluorinated gases) released during equipment manufacturing (in metric tons)? If data is unavailable, why is it not being reported?

Where to look for the answer?

- Potential Stakeholders:
  - Environmental compliance teams.
  - Carbon accounting experts and third-party auditors.
  - Regulatory agencies monitoring industrial emissions.
  - Industry sustainability councils.
- Potential Data Sources:

    - Emissions inventories and internal sustainability reports.
    - Life cycle assessment (LCA) studies for equipment production.
    - National GHG reporting databases.
    - Third-party verification reports.

MATERIAL EFFICIENCY AND RECYCLING

- What percentage of raw materials used in equipment production is utilized effectively?
- Are the components of the equipment recyclable, and to what extent?

Where to look for the answer?

- Potential Stakeholders:
    - Recycling industry experts and circular economy advocates.
    - Sustainability officers in manufacturing firms.
    - Environmental NGOs and certification bodies.
    - Technical consultants on resource efficiency.
- Potential Data Sources:
    - Internal material use and waste reduction reports.
    - Industry benchmarks on resource efficiency.
    - Certification reports (e.g., ISO standards for recycling).
    - Academic studies on manufacturing material flows.

WATER USAGE

- How many liters or cubic meters of water are consumed per unit of equipment produced?
- What proportion of the water used is sourced from freshwater, groundwater, or recycled water?
- Which specific processes in equipment manufacturing are the most water-intensive (e.g., cleaning, cooling, chemical processing)?
- Are there water recycling or reuse systems in place, and what percentage of water is recaptured?
- How is water usage monitored and reported at the manufacturing facility, and how does it compare to industry benchmarks?

Where to look for the answer?

- Potential Stakeholders:
    - Plant operations managers and water resource engineers.
    - Environmental compliance and sustainability teams.

- Suppliers of water treatment and recycling systems.
- Regulatory agencies overseeing industrial water use.

- Potential Data Sources:
    - Facility water audit reports and internal sustainability reports.
    - Environmental Impact Assessments (EIAs) for the manufacturing facility.
    - Government water resource databases and permits.
    - Industry benchmarks and technical white papers on water efficiency in manufacturing.

Dimension: Socio-Political Impact

LABOR CONDITIONS

- What proportion of workers are covered by collective bargaining agreements?
- How adequate are the safety protocols for handling hazardous materials, according to worker perceptions?
- How many labor violations have been reported annually?
- How do workers feel about their own labor conditions?
  - Are there mechanisms for them to file complaints and for those complaints to be acted upon?

Where to look for the answer?

- Potential Stakeholders:
  - Workers and labor unions in manufacturing plants.
  - Local occupational health and safety bodies.
  - NGOs focused on industrial labor rights.
  - Community representatives in impacted areas.
- Potential Data Sources:
  - Company HR and labor practice reports.
  - Safety inspection and accident records.
  - Independent labor rights assessments.
  - Regulatory compliance documentation.

ECONOMIC DISRUPTION ON LOCAL COMMUNITIES

- How has the establishment or operation of manufacturing facilities affected traditional livelihoods and local economic activity in the area?
- Have local communities experienced shifts in employment opportunities, such as job losses in traditional sectors or the creation of new jobs?
- Do local residents feel that the economic benefits (e.g., wages, community investments) provided by the manufacturing facility adequately offset any negative environmental or social impacts?

Where to look for the answer?

- Potential Stakeholders:

- Local business associations and chambers of commerce.
    - Economic development agencies and local government economic offices.
    - Community leaders and representatives of affected local communities.
    - Labor unions and workers' rights organizations.
    - NGOs and research institutions focusing on regional economic impacts.
- Potential Data Sources:
    - Regional economic impact studies and employment statistics from government agencies.
    - Local government reports on economic activity and business performance.
    - Surveys and case studies documenting community experiences and perceptions of economic change.
    - Media investigations and academic research on the impact of manufacturing operations on local economies.
    - Financial and sustainability reports from the manufacturing companies that include community investment data.

COMMUNITY ENGAGEMENT

- How many consultations or public meetings have been conducted with local communities regarding the equipment manufacturing operations?
- What level of transparency is provided by equipment manufacturers about their operational practices, environmental impacts, and supply chain data?
- Are there grievance or feedback mechanisms in place for local communities to express concerns or influence decisions related to the equipment manufacturing activities?

Where to look for the answer?

- Potential Stakeholders:
    - Local community councils and advocacy groups.
    - Regional government liaison offices.
    - NGOs working on community impact and environmental justice.
    - CSR teams.
- Potential Data Sources:
    - Records of public consultations and stakeholder meetings.
    - Community feedback surveys and case studies.
    - Media reports and independent research on engagement practices.

- Corporate transparency and CSR reports.

Model Training

Dimension: Environmental Impact

ENERGY USE

- How many kilowatt-hours (kWh) are consumed per training iteration or epoch?
- Is there a Power Usage Effectiveness (PUE) metric reported by the data center? If so, what is that?
- What percentage of total training energy is sourced from renewables?
- Is energy reused? What is the Energy Reuse Effectiveness (ERE)?

Where to look for the answer?

- Potential Stakeholders:
  - AI research teams optimizing model efficiency.
  - Data centers operators.
  - Sustainability consultants evaluating AI training footprints.
- Potential Data Sources:
  - Power consumption reports from AI training facilities.
  - Energy efficiency benchmarks for computational processes.
  - Carbon intensity analyses for cloud computing.

WATER USAGE

- How many liters or cubic meters of water are consumed for cooling during each training cycle or per training session?
- Is there a Water Usage Effectiveness (WUE) metric reported by the data center, and what is its value?
- How do water usage levels during model training compare with industry benchmarks for similar high-compute processes?
- What water recycling or reuse systems are in place at the training facilities, and what percentage of water is recaptured or recycled?

- Are there seasonal or operational variations in water usage during training, and how are these managed?

Where to look for the answer?

- Potential Stakeholders:
    - Data center engineers managing cooling systems.
    - Environmental scientists assessing water stress impacts.
    - Local communities near AI infrastructure.
- Potential Data Sources:
    - Water use disclosures from cloud computing providers.
    - Environmental impact studies of data center operations.
    - Government water resource reports.

GHG EMISSIONS

- What is the total amount of GHG emissions produced per training cycle, expressed in metric tons of CO_2 equivalent (CO_2e), including emissions from electricity consumption, cooling systems, and other operational processes?
- Which components of the data center's operations (e.g., compute power, cooling, networking) are the primary sources of these emissions?
- What percentage of the energy used for model training is derived from renewable sources, and how does this influence the overall carbon footprint?
- Are there carbon offset programs or renewable energy certificate schemes in place to mitigate these emissions? If so, what is their impact?
- What methodologies or models are used to estimate these GHG emissions, and what are the key uncertainties or assumptions in these calculations?

Where to look for the answers?

- Potential Stakeholders
    - Cloud service providers operating AI training infrastructure.
    - Data center operators tracking energy and cooling emissions.
    - AI research teams responsible for training models.
    - Climate impact analysts studying emissions from AI computing.
- Potential Data Sources
    - Power usage reports from data centers (tracking electricity consumption and efficiency metrics like PUE).
    - GHG emissions inventories from cloud providers (Scope 1, 2, and 3 reporting).
    - Life cycle assessments (LCAs) of AI model training.

- Energy grid carbon intensity databases (to estimate emissions based on local power sources).

CIRCULARITY

- Are there plans for recycling or reusing hardware from decommissioned servers or data centers (e.g., older GPUs)?
- What percentage of heat from data centers is recaptured and reused?

Where to look for the answer?

- Potential Stakeholders:
  - AI research teams and data center managers
  - Sustainability experts and circular economy advocates
  - Technology vendors promoting hardware refurbishing
  - Environmental NGOs and recycling cooperatives
- Potential Data Sources:
  - Internal plans or reports on hardware reuse and recycling initiatives
  - Case studies on circular economy practices in tech industries
  - Industry benchmarking reports on equipment lifecycle management
  - Academic and consultancy research on e-waste and resource recovery

Dimension: Socio-Political Impact

LABOR CONDITIONS

- How are data center staff employed (directly or via contracts), and what proportion of staff work in high-risk environments (e.g., night shifts, intensive cooling areas)?
- How do workers perceive their job security, wages, and access to benefits compared to local industry standards?
- What regular safety audits and employee feedback mechanisms exist, and what improvements have resulted from these evaluations?

Where to look for the answer?

- Potential Stakeholders:
  - Internal HR and operations teams
  - Data center facility managers
  - Labor representatives and union contacts
  - Workers themselves through surveys or focus groups
- Potential Data Sources:
  - Internal labor and safety reports
  - Data center work schedules and contract documents
  - Employee satisfaction and incident reports
  - Third-party audits or labor rights assessments

REPRESENTATION IN DATA

- What percentage of marginalized demographic groups is in the training datasets?
- Are there known gaps or biases that might cause inequitable outcomes?
- How inclusive do stakeholders (internal reviewers, external experts, interested data subjects) perceive the training datasets to be?
- Was the dataset enriched by a diverse group of community members through participatory methodologies?

Where to look for the answer?

- Potential Stakeholders:
  - Data governance and ethics teams
  - Diversity and inclusion officers

    - External academic or community experts
    - Representatives of impacted demographic groups
- Potential Data Sources:
    - Documentation or metadata accompanying the datasets
    - Internal/external audit reports on dataset diversity and composition

AUDITS AND BIAS

- Are internal audits conducted to assess the quality and fairness of datasets? If so, how effective are they?
- Have there been any external audits to detect algorithmic bias?
- How many bias issues have been identified in model outputs?
- What measures have been implemented to reduce algorithmic bias, and how effective are they?

Where to look for the answer?

- Potential Stakeholders:
    - Internal AI ethics and quality assurance teams.
    - External auditors and academic researchers in fairness.
    - Regulatory bodies or industry standard organizations.
    - Affected user groups or civil society organizations.
- Potential Data Sources:
    - Internal audit reports and review logs.
    - External bias audit findings and published case studies.
    - Public documentation on implemented bias mitigation strategies.
    - User feedback and independent evaluations.

ACCESSIBILITY

- Do low-resource regions have access to the computing resources or knowledge needed to replicate or improve upon the model?
- Is the project reliant on proprietary data center infrastructure that smaller competitors cannot access?

Where to look for the answer?

- Potential Stakeholders:
    - Internal research and development teams.
    - Technology transfer and partnerships teams.
    - Representatives from low-resource or underrepresented regions.
- Potential Data Sources:

- Documentation on infrastructure and technology sharing policies.
- Internal records on partnerships and licensing agreements.
- Surveys or case studies on regional access to computing resources.
- Public reports on competitive landscape and technology democratization.

GOVERNANCE AND TRANSPARENCY

- Is there an internal process to evaluate the environmental, ethical, and/or social implications of the AI system?

Where to look for the answer?

- Potential Stakeholders:
    - Internal ethics committees or AI governance boards.
    - CSR teams.
    - Legal and compliance departments.
    - External advisors or independent watchdogs.
- Potential Data Sources:
    - Internal policy documents and review process records
    - Minutes from ethics and governance meetings
    - Public transparency reports on training impacts
    - Third-party assessments and regulatory filings

Model Deployment

Dimension: Environmental Impact

ENERGY USE

- How many kWh are consumed per inference task or per unit of deployed AI service?
- Have efficiency improvements reduced energy costs over time?

Where to look for the answer?

- Potential Stakeholders:
  - Internal product and engineering teams responsible for deployment
  - Data center operations and infrastructure management teams
- Potential Data Sources:
  - Energy consumption reports from data centers
  - Technical benchmarks and performance metrics
  - Internal audits of energy efficiency improvements

INFRASTRUCTURE AND COOLING

- How many servers or data centers support the AI system?
- How is heat managed? Are advanced cooling solutions in place (liquid cooling, outside air cooling)?
- Is there a known ratio of cooling energy to total IT load?

Where to look for the answer?

- Potential Stakeholders:
  - Data center managers and IT infrastructure teams
  - Facilities management teams overseeing cooling systems
- Potential Data Sources:
  - Data center specifications and design documents
  - Technical reports on cooling system performance

- Energy usage logs and operational benchmarks

WATER USAGE[5]

- What is the Water Usage Effectiveness (WUE) of the data centers hosting the deployed AI system?
- How many liters or cubic meters of water are used for cooling during the inference operations?
- Are there measures in place to optimize water use during peak inference loads, and what is the impact of these measures over time?
- How does water usage during the deployment phase compare to the baseline water usage for similar data center operations?

Where to look for the answer?

- Potential Stakeholders:
  - Data center operations and facility management teams
  - Environmental compliance or sustainability departments
  - Infrastructure engineers specializing in cooling systems
  - External environmental auditors or consultants
- Potential Data Sources:
  - Internal water usage reports and audit records from the data centers
  - Environmental Impact Assessments (EIAs) and sustainability reports related to data center operations
  - Regulatory filings or permits that include water withdrawal and discharge data
  - Industry benchmarks and technical white papers on Water Usage Effectiveness (WUE) in data centers

GHG EMISSIONS

- What portion of the AI system's operational carbon footprint during deployment is attributable to data center usage?
- What are the annual GHG emissions (in metric tons CO_2e) associated with inference operations?
- Is this data available, at all? If not, why?

[5] While water usage is a critical metric during the model training phase due to high compute and cooling demands, its relevance in the deployment stage may be lower if the same infrastructure is used continuously. However, if the inference load varies significantly or if specialized cooling strategies are implemented for deployment, these questions can provide useful insights into the operational efficiency and environmental impact of the deployed system.

Where to look for the answer?

- Potential Stakeholders:
  - Corporate sustainability or ESG teams
  - Environmental impact analysts and data center operations
  - Procurement teams handling energy contracts
- Potential Data Sources:
  - Public sustainability and carbon footprint reports
  - Carbon accounting disclosures and life cycle assessments (LCAs)
  - Documentation on renewable energy or offset programs implemented by data centers

Dimension: Socio-Political Impact

COMMUNITY REACH

- What percentage of underserved communities are reached or catered to by the AI system?
- Are there differences in how different communities are reached or catered to by the system? If so, what are those differences?

Where to look for the answer?

- Potential Stakeholders:
  - Internal user research and product teams
  - Community outreach and marketing teams
  - Local community organizations and advocacy groups
  - Representatives from underserved user groups
- Potential Data Sources:
  - User demographic and engagement analytics
  - Surveys and focus group feedback from diverse communities
  - Customer support and regional usage reports
  - Community forum discussions and social media insights

COMMUNITY HEALTH AND WELL-BEING

- Are there any communities located nearby the data center(s)? If so, how do they experience the vicinity to the facility (e.g. noise, land degradation…)?
- Have there been any documented health impacts (e.g., increased respiratory issues, stress, or other conditions) in communities adjacent to the deployment facilities?
- What measures are in place to monitor and mitigate potential adverse health impacts on local populations?
- How do local residents and community representatives perceive the overall impact of the data center on their quality of life and well-being?

Where to look for the answer?

- Potential Stakeholders:
  - Local public health departments and community clinics
  - Environmental justice groups
  - Municipal planning and zoning authorities

- Local advocacy organizations and resident associations
- Potential Data Sources:
  - Health impact assessments and environmental quality reports
  - Government data on local air, noise, and water quality
  - Community surveys and case studies on living conditions near data centers
  - NGO reports on public health impacts of industrial facilities

LABOR CONDITIONS

- How visible is the role of workers involved in the deployment and maintenance of the AI system?
- What are the working conditions for data center staff, including details about shift patterns (e.g., night shifts), safety protocols, and overall workplace environment?
- Are the staffing and maintenance teams employed as permanent staff or on a contract basis, and how might this affect job security and benefits?
- How frequently are safety and labor conditions reviewed or audited, and what improvements have been implemented based on these evaluations?

Where to look for the answer?

- Potential Stakeholders:
  - Internal HR and operations teams responsible for data center staffing
  - Data center facility managers
  - Labor unions or worker representatives (if available)
  - Employee feedback channels and safety committees
- Potential Data Sources:
  - Internal labor and safety reports or audit records
  - Work schedules, contract documentation, and employment policies
  - Employee surveys and satisfaction reports
  - Third-party or regulatory compliance audits related to occupational health and safety

JOBS IMPACT

- How many jobs have been created versus displaced due to the deployment of the AI system?
- How fair is the transition perceived by affected workers and stakeholders?

Where to look for the answer?

- Potential Stakeholders:
    - HR departments and internal company reports
    - If present, local labor unions and workforce representatives
    - Community economic development agencies
    - Trade associations and industry groups
- Potential Data Sources:
    - Employment impact studies and regional labor statistics
    - Company HR reports and public disclosures on job creation/displacement
    - Surveys and interviews with affected workers
    - Economic development and workforce transition assessments

TRANSPARENCY

- How many user-facing explanations or audit trails are provided to explain the AI system's decisions or outputs?
- How often are these explanations updated or reviewed for clarity and accuracy?
- Are there mechanisms for users to request further transparency or clarification regarding the system's decisions?
- How is transparency maintained across software updates or changes in the deployment infrastructure?
- Are internal transparency policies and practices documented and publicly accessible?

Where to look for the answer?

- Potential Stakeholders:
    - Internal product teams (e.g., product managers, UX designers, technical writers)
    - Community members (e.g., early adopters, beta testers, user focus groups)
- Potential Data Sources:
    - Published FAQs, help guides, and online documentation on the company website
    - Internal release notes and audit trails of system updates
    - User feedback records and community forum discussions
    - Public transparency reports or blog posts detailing AI system changes and decision processes

DECISION-MAKING FAIRNESS

- How is the AI system designed to ensure fairness in decision-making for diverse user groups?
- What specific mechanisms (e.g., bias mitigation algorithms, fairness audits) are in place to monitor decision outputs for potential bias?
- Have there been documented instances of unfair or biased outcomes in the system's decisions, and how were these instances identified?
- What processes are used to review and update fairness measures in response to new data or user feedback?
- How are affected users involved in assessing and improving the fairness of the system's decision-making?

Where to look for the answer?

- Potential Stakeholders:
  - Internal ethics committees and AI governance boards
  - Civil rights organizations and advocacy groups
  - Academic researchers in algorithmic fairness
  - Affected user groups and community representatives
- Potential Data Sources:
  - Documentation of fairness audits and internal review processes
  - Public reports on bias incidents and mitigation efforts
  - External academic or independent studies on AI fairness
  - User feedback and complaint logs

BIAS MONITORING

- What systems or processes are in place to continuously monitor the AI system for bias during deployment?
- How frequently are bias audits or reviews conducted on the system's outputs?
- What metrics or indicators are used to detect and quantify bias in decision-making?
- What protocols are in place for addressing any detected bias or unfair outcomes?
- Have there been documented instances of bias during deployment, and how were these incidents resolved?

Where to look for the answer?

- Potential Stakeholders:

    - AI research teams and bias monitoring units
    - External auditing firms specializing in algorithmic fairness
    - Regulatory bodies and consumer protection agencies
    - Civil society organizations focused on equitable technology
- Potential Data Sources:
    - Real-time monitoring dashboards and bias audit reports
    - Third-party evaluation reports and case studies
    - Regulatory disclosures and compliance filings
    - Internal incident logs and mitigation strategy documents

COMPLIANCE

- Does the deployment comply with relevant local, national, and international ethical guidelines and regulations?
- How are breaches of compliance reported and addressed?

Where to look for the answer?

- Potential Stakeholders:
    - Legal and regulatory compliance departments
    - External auditors and regulatory agencies
    - Industry watchdogs and consumer advocacy groups
    - Internal ethics and governance committees
- Potential Data Sources:
    - Compliance audit reports and regulatory filings
    - Internal policies and standard operating procedures
    - Certification documents (e.g., ISO, GDPR compliance reports)
    - External evaluations and media investigations

ACCESSIBILITY

- Is the system accessible to users with disabilities or those who use non-standard devices or languages?
- Does the system's user interface adhere to established accessibility standards (e.g., WCAG guidelines)?
- How frequently is the interface reviewed and updated based on feedback from users with accessibility needs?

Where to look for the answer?

- Potential Stakeholders:
    - User experience and accessibility experts

- Disability advocacy organizations
    - Community representatives from diverse user groups
    - Technology inclusivity consultants
- Potential Data Sources:
    - Accessibility audit reports and user testing data
    - Feedback from inclusive design workshops and focus groups
    - Compliance reports with accessibility standards (e.g., WCAG)
    - Public evaluations and case studies on digital inclusivity

COMMUNITY UNDERSTANDING

- How easy is it for users to understand and trust the outputs of the AI system?
- What steps have been taken to improve the clarity of user-facing explanations?
- How do users rate their trust in the AI system's outputs, and what factors influence their perceptions?
- Are there established channels for users to seek clarification or provide feedback on the AI's decisions?
- How is user comprehension and trust monitored over time, and what adjustments are made based on this feedback?

Where to look for the answer?

- Potential Stakeholders:
    - End users and consumer advocacy groups
    - Public relations and communications teams
    - Local educational institutions and community centers
- Potential Data Sources:
    - User surveys and feedback forms
    - Documentation of user interface and explanation design efforts
    - Reports from community engagement sessions
    - Academic studies on technology literacy and user trust

SYSTEM SECURITY

- What safeguards are in place to prevent unauthorized access or adversarial attacks on the deployed AI system?
- How are system vulnerabilities identified and monitored on an ongoing basis?
- How frequently are security audits or penetration tests conducted, and what key findings have been reported?

- What protocols exist for detecting, reporting, and mitigating privacy breaches or security incidents?
- How does the system ensure the integrity, confidentiality, and availability of data during its operation?

Where to look for the answer?

- Potential Stakeholders:
    - Cybersecurity teams and IT security auditors
    - Data protection officers
    - Regulatory agencies in cybersecurity
    - Industry certification bodies (e.g., ISO/IEC 27001)
- Potential Data Sources:
    - Security audit reports and incident response logs
    - Penetration testing and vulnerability assessment reports
    - Certification and compliance documents
    - Internal policies on cybersecurity and data privacy

Disposal/End-of-Life

Dimension: Environmental Impact

ENERGY USE

- What is the total energy consumed (in kWh) per unit of decommissioned hardware during recycling processes?
- How much energy (in kWh) is used to transport and dispose of products that are not recycled?

Where to look for the answer?

- Potential Stakeholders:
    - E-waste recycling companies and facility operators
    - Government agencies or regulators overseeing waste management
    - Sustainability and environmental performance teams
    - Academic researchers or industry consultants specializing in circular economy and waste-to-energy processes
- Potential Data Sources:
    - Internal energy audits or operational reports from recycling facilities
    - Industry benchmarks and technical white papers on e-waste recycling energy use
    - Government or local NGO reports on energy efficiency in waste management
    - Life Cycle Assessment (LCA) studies of the disposal stage
    - Academic publications on the energy requirements of e-waste processing

RECYCLING AND WASTE MANAGEMENT

- What is the total weight of equipment sent for recycling annually (in kilograms or metric tons)?
- What percentage of e-waste generated is not recycled?

Where to look for the answer?

- Potential Stakeholders:
  - E-waste recycling companies managing hardware disposal.
  - Government agencies regulating hazardous waste.
  - Environmental researchers evaluating material circularity.
- Potential Data Sources:
  - Electronic waste recycling statistics.
  - Government regulations on e-waste disposal.
  - Reports on circular economy initiatives.

POLLUTION AND TOXICITY

- What are the levels of heavy metals (e.g., lead, mercury) detected in waste streams from disposal or recycling operations?
- What proportion of materials from recycled equipment is reused in the manufacturing of new products?

Where to look for the answer?

- Potential Stakeholders:
  - Environmental health scientists assessing toxic material exposure.
  - Regulatory agencies setting safety thresholds for electronic waste.
  - Community health organizations near disposal sites.
- Potential Data Sources:
  - Toxicology reports on e-waste contamination.
  - Pollution control studies at waste processing facilities.
  - Industrial safety compliance reports.

GHG EMISSIONS

- What is the total amount of GHG emissions (including CO_2, CH_4, N_2O, and fluorinated gases) produced during the disposal or recycling processes (expressed in metric tons)?
- What are the primary sources of these emissions (e.g., transportation of e-waste, energy used in processing, incineration of hazardous waste)?
- What uncertainties exist in quantifying these emissions, and how are they addressed (e.g., through sensitivity analyses or use of proxy data)?

Where to look for the answer?

- Potential Stakeholders:
  - Waste management companies and recycling facility operators

    - Government environmental regulatory agencies that oversee waste disposal and emissions
    - Sustainability teams within companies handling e-waste
    - Academic researchers or consulting firms specializing in life cycle assessments of waste management
    - Third-party certification bodies and auditors for waste and emissions reporting
- Potential Data Sources:
    - Internal energy and emissions reports from e-waste recycling and disposal facilities
    - Environmental Impact Assessments (EIAs) specific to waste management operations
    - National or regional greenhouse gas inventories that include industrial waste sectors
    - Industry benchmarks, technical white papers, and research studies on e-waste processing emissions
    - Third-party audit reports or certification documents (e.g., ISO standards) related to emissions in waste management processes

BIODIVERSITY AND HABITAT

- Are disposal sites located in or near vulnerable ecosystems?
- How do disposal or recycling processes impact local habitats?

Where to look for the answer?

- Potential Stakeholders:
    - Local and regional conservation organizations
    - Academic ecologists and biodiversity researchers
    - Government environmental protection agencies
    - Community groups representing Indigenous and rural populations
- Potential Data Sources:
    - Environmental impact assessments for disposal or recycling sites
    - Satellite and remote sensing data tracking habitat changes
    - Biodiversity surveys and ecological research publications
    - Reports from governmental and international conservation bodies

E-WASTE STANDARDS

- Do disposal or recycling methods meet national or international e-waste regulations?

- Is there third-party certification (e.g., R2 or e-Stewards) for proper recycling?

Where to look for the answer?

- Potential Stakeholders:
    - Certification bodies (e.g., R2, e-Stewards)
    - Environmental regulatory agencies
    - Industry associations for electronics recycling
    - Third-party auditors specializing in e-waste management
- Potential Data Sources:
    - Certification and audit reports from recycling facilities
    - Government regulatory filings and compliance records
    - Industry guidelines and best practice documentation
    - Reports and assessments published by environmental NGOs

Dimension: Socio-Political Impact

LABOR CONDITIONS

- How do workers perceive the safety of their working environment, particularly regarding health risks from handling e-waste?
- What is the incidence of health issues reported by workers involved in waste processing activities?
- Are there protections or safety protocols in place (e.g., protective gear, training)?

Where to look for the answer?

- Potential Stakeholders:
  - Workers and–if present–labor unions at e-waste recycling facilities
  - Occupational health and safety organizations
  - NGOs focusing on labor rights and environmental justice
  - Local community advocacy groups representing recycling workers
- Potential Data Sources:
  - Labor inspection and safety audit reports from recycling facilities
  - Health and safety records maintained by companies and local regulators
  - Surveys and interviews conducted by NGOs or academic researchers
  - Certification and compliance documents from occupational safety bodies

COMMUNITY HEALTH AND WELL-BEING

- What health risks have been documented among communities living near e-waste disposal or recycling sites (e.g., increased respiratory issues, elevated cancer rates, or other conditions)?
- Have health impact assessments been conducted for the disposal facilities, and what were their key findings regarding air quality, noise, or toxic exposure?
- How do local residents perceive the impact of disposal activities on their quality of life and overall well-being?

- What mitigation measures have been implemented to reduce potential health risks from e-waste disposal, and how effective have these measures proven to be?
- How frequently are environmental and public health parameters (such as air, noise, and water quality) monitored around disposal sites, and are these findings publicly available?
- Is there a process for communities located near disposal or recycling sites to file a complaint? If so, have any complaints been filed?

Where to look for the answer?

- Potential Stakeholders:
  - Local residents and community leaders near e-waste disposal sites
  - Environmental justice organizations
  - Municipal public health departments
  - Local advocacy groups and community forums
- Potential Data Sources:
  - Community surveys and public consultation records
  - Local government reports on environmental and health impacts
  - Case studies and media reports on community responses
  - NGO assessments and independent research on regional quality of life

COMMUNITY ENGAGEMENT

- How many consultations or public meetings have been conducted with local communities regarding the disposal operations?
- What level of transparency is provided by the disposal company about their operational practices, environmental impacts, and supply chain data?
- Are there grievance or feedback mechanisms in place for local communities to express concerns or influence decisions related to the disposal activities?

Where to look for the answer?

- Potential Stakeholders:
  - Local community councils and advocacy groups
  - Regional government liaison offices
  - NGOs working on community impact and environmental justice
  - CSR teams
- Potential Data Sources:
  - Records of public consultations and stakeholder meetings
  - Community feedback surveys and case studies

    - Media reports and independent research on engagement practices
    - Corporate transparency and CSR reports

ECONOMIC OPPORTUNITIES

- Do local communities or workers benefit economically from refurbishment or recycling programs?
- Are there job training programs for recycling or equipment refurb?

Where to look for the answer?

- Potential Stakeholders:
    - Local economic development agencies and workforce training organizations
    - Recycling industry representatives and entrepreneurs
    - Community leaders and local government representatives
    - NGOs focusing on sustainable economic development
- Potential Data Sources:
    - Economic impact studies on recycling and refurbishment initiatives
    - Company reports on job creation and training programs in e-waste management
    - Local government employment and economic statistics
    - Surveys and case studies documenting economic benefits from circular economy programs