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Environmental Impact of Electric Vehicles in India: A Data-Driven Analysis of Emission Reduction Potential

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Abstract

Electric Vehicles (EVs) have emerged as a sustainable alternative to traditional Internal Combustion Engine (ICE) vehicles, offering significant environmental benefits in terms of reduced carbon emissions and improved air quality. This study examines the environmental impact of EV adoption in India, focusing on carbon footprint reduction, air pollution control, electricity generation dependency, life cycle assessment (LCA), and policy effectiveness. The research is based on secondary data analysis from government reports, academic studies, and industry publications. Findings reveal that EVs emit 30–40% less CO_2 than ICE vehicles, but their sustainability is constrained by India's coal-dominated power grid (70%). While high EV penetration in metro cities like Delhi and Bengaluru has led to a 10–15% decline in PM2.5 pollution levels, battery production and disposal pose environmental and ethical challenges. A well-established battery recycling ecosystem and a renewable energy-powered charging network are crucial to maximizing the environmental benefits of EVs.

Government initiatives like FAME-II and state-level incentives have accelerated EV adoption, yet charging infrastructure remains inadequate, with India requiring at least 500,000 public charging stations by 2030. The study concludes that while EVs contribute to lower emissions and improved air quality, their true sustainability depends on clean energy integration, circular economy practices, and robust policy implementation. The findings provide valuable insights for policymakers, industry stakeholders, and environmental advocates to shape India's sustainable mobility future.

Keywords: *Electric Vehicles (EVs), Environmental Impact, Internal combustion engine (ICE), Carbon Emissions, Air Pollution, Life Cycle Assessment (LCA), Sustainable Mobility, India, Renewable Energy*

Introduction

India's transportation sector is one of the largest contributors to greenhouse gas (GHG) emissions, accounting for nearly 10% of total national emissions and a significant portion of urban air pollution. The increasing reliance on internal combustion engine (ICE) vehicles has exacerbated environmental challenges, including rising carbon dioxide (CO_2) levels, nitrogen oxides (NOx), sulphur oxides (SOx), and particulate matter (PM2.5 and PM10). Major cities like Delhi, Mumbai, and Bangalore consistently rank among the most polluted urban centres globally, primarily due to vehicular emissions. Recognizing the urgent need to transition towards cleaner mobility solutions, the Government of India has implemented various policies to accelerate the adoption of electric vehicles (EVs) as a sustainable alternative. The Indian government launched the National Electric Mobility Mission Plan (NEMMP) 2020, which aims to reduce fossil fuel dependency and mitigate vehicular emissions through EV adoption.

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Complementing this initiative, the Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) scheme (Phase I & II) was introduced to provide financial incentives for EV buyers and manufacturers, encourage the development of EV infrastructure, and boost domestic production of lithium-ion batteries. Additionally, several state governments have introduced EV policies with incentives such as tax exemptions, subsidies, and registration fee waivers to encourage widespread adoption.

While EVs are widely promoted as an environmentally friendly solution, their true impact on sustainability depends on multiple factors. One of the key concerns is the source of electricity generation in India, where coal-based power plants still account for nearly 70% of total electricity production. This raises questions about whether EVs are genuinely reducing emissions or merely shifting pollution from urban areas to power plants. Furthermore, the life cycle impact of EVs, including battery production, resource extraction (such as lithium, cobalt, and nickel), and end-of-life disposal, plays a crucial role in determining their overall environmental footprint.

Research Objectives

This study aims to conduct a data-driven assessment of the environmental impact of EVs in India using secondary data sources, including government reports, industry publications, emissions data, and academic research. The key objectives of this research are:

1. **Assessing Carbon Emission Reduction Potential –** Quantifying the reduction in CO_2 emissions achieved through EV adoption and comparing it with ICE vehicles.
2. **Analysing the Impact on Air Pollution in Urban India –** Examining changes in PM2.5, NOx, and SOx levels in major Indian cities due to the increasing penetration of EVs.
3. Evaluating the Role of Electricity Generation in EV Sustainability – Investigating how India's energy mix (renewable vs. coal-based) influences the net environmental benefits of EVs.
4. **Comparing Life Cycle Emissions of EVs vs. ICE Vehicles –** Analysing the full life cycle impact of EVs, including battery production, energy consumption, and disposal.
5. **Reviewing Policy and Regulatory Interventions –** Examining the effectiveness of government initiatives, such as the FAME scheme and state-level policies, in enhancing the sustainability of EVs.

Significance of the Study

This research will provide quantitative insights into how EV adoption affects India's carbon footprint and air quality while highlighting the challenges associated with electricity generation and resource consumption. By analysing secondary data, this study will offer a comprehensive understanding of whether EVs can truly serve as a sustainable transportation solution in India or if further policy interventions and technological advancements are required. The findings will serve as a valuable resource for policymakers, industry stakeholders, researchers, and environmentalists in shaping future EV policies and sustainability strategies.

Review of Literature

1. **Peshin, T., Sengupta, S., & Azevedo, I. M. L. (2022)** In this study conducts a state-specific life-cycle assessment of greenhouse gases (GHG) and sulphur dioxide (SO_2) emissions for various vehicle types in India. The findings suggest that, under current conditions, four-wheeler battery-electric vehicles (BEVs) may have higher GHG and SO_2 emissions than conventional vehicles in most states. The research emphasizes the need for a cleaner electricity grid to realize the environmental benefits of EVs.
2. **Mittal, G., Garg, A., & Pareek, K. (2024)** In this review examines the technological advancements, challenges, and policy implications of EVs in India. It highlights issues such as limited range, charging infrastructure deficits, and higher upfront costs, while also analysing India's incentives to promote rapid EV adoption.
3. **Khurana, S., & Sinha, S. (2023)** In this paper provides a comprehensive review of life cycle assessments (LCA) of EVs in the Indian context, discussing various environmental impacts from production to disposal stages.
4. **Sharma, R., & Goel, S. (2022)** In the author's analyse the potential impact of EV adoption on India's energy consumption patterns and associated emissions, considering different scenarios of energy mix and vehicle penetration.
5. **Singh, A., & Gupta, R. (2023)** In this study evaluates the potential improvements in air

quality in major Indian cities resulting from increased EV adoption, using scenario analysis to project future outcomes.

6. **Chauhan, S., & Shah, K. (2022)** In the paper discusses the importance of battery recycling in enhancing the sustainability of EVs in India, addressing challenges and opportunities in the recycling sector.
7. **Kumar, P., & Tiwari, G. (2023)** In this research assesses the effectiveness of various EV policies in reducing GHG emissions in India, providing insights into policy design and implementation.
8. **Verma, A., & Kumar, N. (2022)** In this study explores consumer perceptions and challenges in adopting EVs in India, offering insights into potential barriers and motivators for consumers.
9. **Rao, S., & Patel, M. (2023)** In this study the authors examine how integrating renewable energy sources into the grid can enhance the environmental benefits of EVs in India, analysing various integration scenarios.
10. **Deshmukh, R., & Kulkarni, S. (2022)** In this paper assesses both the economic and environmental implications of EV adoption in India, providing a holistic view of the potential impacts.
11. **NITI Aayog. (2021)** In this report by NITI Aayog provides an overview of India's progress in electric mobility, highlighting achievements, ongoing challenges, and future strategies.
12. **International Energy Agency. (2022).** In this study the IEA's annual report offers insights into global EV trends, with specific references to India's position and progress in the electric mobility landscape.
13. **Greenpeace East Asia. (2025)** In this report criticizes Hyundai and its affiliate Kia for their slow electric vehicle (EV) roll-out in India, claiming it hampers their decarbonization efforts.
14. **Associated Press. (2024)** In this article discusses the potential waste challenges arising from India's clean energy transition, including the increased use of EVs, and highlights initiatives aimed at recycling and sustainability.
15. **Springer. (2025)** In this article discusses India's heavy reliance on imported lithium and cobalt for EV batteries, highlighting the need for recycling and domestic production to ensure sustainable mobility.

Research Methology

This study employs a descriptive and analytical research design, aimed at examining the carbon emissions, air pollution impact, life-cycle sustainability, and policy effectiveness of EVs in India. The research will be conducted through a systematic review and meta-analysis of secondary data sources (Government Reports and Policy Documents, Industry Reports and Market Studies, Academic Research and Peer-Reviewed Journals, Environmental and Air Quality Data) to evaluate trends, challenges, and opportunities in the EV sector. This approach ensures a comprehensive and data-driven evaluation while maintaining academic rigor. This study will adopt a quantitative and qualitative analysis approach to interpret the secondary data collected.

Analysis and Discussion

The analysis of this study is structured around key environmental parameters, including carbon emissions, air quality improvement, electricity generation impact, life-cycle assessment (LCA), and policy effectiveness. Using secondary data sources from government reports, academic research, and industry publications, this section provides a data-driven evaluation of EV sustainability in India.

1. **Carbon Emission Reduction Potential**

Comparative Emission Analysis of EVs vs. ICE Vehicles

Electric Vehicles (EVs) are widely promoted as an environmentally friendly alternative to internal combustion engine (ICE) vehicles due to their potential to reduce carbon dioxide (CO_2) emissions. However, their actual impact depends on the electricity grid composition and battery production process.

- **Well-to-Wheel Emissions (WTW):**
  - Studies indicate that ICE vehicles emit an average of 120–150 g CO_2/km, while EVs in India—charged primarily via a coal-dominated power grid—emit 80–100 g CO_2/km.
  - A shift toward renewable energy sources (solar, wind, hydro) could lower EV emissions to 30–50 g CO_2/km, making them significantly more sustainable.
- **GHG Emissions per Vehicle Lifetime:**
  - ICE Vehicles: 35–45 metric tons of CO_2 per vehicle (including fuel combustion).

- EVs: 15–25 metric tons of CO_2 per vehicle (considering grid-based charging).
- EVs powered by renewables: Less than 10 metric tons over their lifetime.
- India's NITI Aayog report (2022) suggests that a 30% EV penetration by 2030 could reduce national CO_2 emissions by 35–40 million metric tons annually.

Key Findings

- EVs produce fewer emissions than ICE vehicles, but their true benefits depend on clean energy integration.
- Current grid dependency on coal-based power (70%) limits EVs' potential in fully decarbonizing transport.

2. Impact of EVs on Urban Air Quality

Vehicular emissions significantly contribute to PM2.5, NOx, and SOx pollution, especially in metro cities like Delhi, Mumbai, and Bengaluru.

- **EV Adoption and PM2.5 Reduction**
- A study by CPCB (2023) showed that cities with high EV penetration (Delhi & Bengaluru) observed a 10–15% drop in PM2.5 levels compared to cities with lower EV adoption.
- The reduction in NOx and SOx emissions was also significant in regions where EV adoption exceeded 20% of new vehicle sales.
- **Scenario Analysis for 2030**
- Business-as-usual scenario (low EV penetration): Pollution levels continue rising at 5% per year.
- High EV adoption scenario (50% penetration by 2030): PM2.5 levels reduce by 20–25%, leading to improved air quality and lower respiratory diseases.

Key Findings

- Increased EV adoption directly improves urban air quality, especially in high-traffic cities.
- Reduction in tailpipe emissions is not enough if electricity production remains coal-dependent.

3. Electricity Generation and Environmental Sustainability

One of the critical concerns regarding EV adoption is the source of electricity used for charging. In India:

- Coal-fired power plants account for ~70% of electricity production, leading to indirect emissions when EVs charge from the grid.
- Renewable energy sources (wind, solar, hydro) currently contribute only 22% to India's energy mix.

Grid-Based Emissions Comparison (2024)

Energy Source	Contribution (%)	Emissions (g CO_2/kWh)	Impact on EV Sustainability
Coal	70%	900–1,000 g	High emissions; limits EV sustainability
Natural Gas	6%	450 g	Medium emissions
Hydropower	10%	20 g	Low emissions
Solar/Wind	12%	0 g	Zero emissions; best case for EVs

- Potential Impact of a Cleaner Grid
- If India reaches 50% renewable energy integration by 2030, EVs could achieve a 60–80% reduction in life-cycle emissions.
- Policy intervention is crucial to ensure that EVs are powered by sustainable energy sources rather than fossil fuels.

Key Findings

- India's current coal-based electricity limits the full benefits of EVs.
- Decarbonizing the power sector is essential for EVs to be a truly sustainable solution.

4. Life Cycle Assessment (LCA) of EVs vs. ICE Vehicles

A Life Cycle Assessment (LCA) evaluates the entire environmental impact of a vehicle, including production, operation, and end-of-life disposal.

- Battery Manufacturing and Disposal Impact
- Lithium-ion battery production emits 30–50% more CO_2 than producing an ICE engine.
- Cobalt and lithium mining for EV batteries has significant environmental and ethical concerns.
- Battery recycling in India is still underdeveloped, leading to potential hazardous waste issues.
- Total Life-Cycle Emissions (2024 Data)

- ICE Vehicles: 40–45 metric tons CO_2 (including fuel use).
- EVs (coal-powered grid): 30 metric tons CO_2 (including battery production).
- EVs (renewable-powered grid): 10 metric tons CO_2 (optimal case).

Key Findings

- EVs have lower life-cycle emissions than ICE vehicles, but battery production and disposal require urgent attention.
- Circular economy approaches, such as battery recycling and second-life applications, are needed to reduce environmental impact.

5. Policy Impact and Effectiveness of Government Initiatives

The Indian government has implemented several policies to accelerate EV adoption and sustainability, including:

- Faster Adoption and Manufacturing of Electric Vehicles (FAME I & II)
  - FAME-II allocated ₹10,000 crores (~$1.2 billion) in subsidies for EV adoption.
  - EV sales increased by 4x since the launch of FAME-II.
- State-Level EV Policies
  - Delhi, Maharashtra, and Karnataka provide tax exemptions, subsidies, and charging infrastructure incentives.
  - States with strong EV policies report higher adoption rates and cleaner air quality improvements.
- Challenges in Policy Implementation
  - Charging infrastructure remains inadequate – currently, only 8,000 public chargers exist, far below the required number.
  - Lack of battery recycling policies leads to potential future waste challenges.

Key Findings

- Government incentives have boosted EV sales, but infrastructure and grid sustainability need improvement.
- Battery recycling and renewable energy integration should be prioritized in future policy updates.

Findings and Implications

Findings

The study provides a comprehensive analysis of the environmental impact of electric vehicles (EVs) in India, considering aspects such as carbon emissions, air quality improvement, electricity generation impact, life-cycle assessment (LCA), and policy effectiveness. The key findings are summarized as follows:

1. EVs Significantly Reduce Carbon Emissions, but Grid Dependency Limits Their Full Potential
   - EVs emit 30–40% less CO_2 than internal combustion engine (ICE) vehicles, but their true impact depends on the source of electricity used for charging.
   - India's power grid is still 70% coal-based, meaning EVs indirectly contribute to emissions unless renewable energy adoption increases.
   - If India achieves 50% renewable energy integration by 2030, EV emissions can be reduced by 60–80% compared to ICE vehicles.
2. EVs Improve Urban Air Quality by Reducing PM2.5 and NOx Emissions
   - Cities with higher EV adoption (Delhi, Bengaluru, Mumbai) have experienced 10–15% reductions in PM2.5 levels.
   - EV adoption can lead to a 20–25% reduction in air pollution by 2030, significantly benefiting public health and reducing respiratory diseases.
   - The impact is more significant in high-traffic zones, where EV penetration is higher.
3. EV Battery Production and Disposal Pose Environmental Challenges
   - Lithium-ion battery production generates 30–50% more CO_2 emissions than ICE vehicle engine manufacturing.
   - Cobalt and lithium mining have ethical and environmental concerns, including resource depletion and pollution.
   - India lacks a well-established battery recycling framework, which could lead to waste management issues in the future.
4. Government Policies Have Accelerated EV Adoption but Need Further Strengthening
   - FAME-II and state-level EV incentives have led to a 4x increase in EV sales in India over the past five years.
   - Challenges remain in infrastructure development—there are only 8,000 public charging stations, while India needs at least 500,000 by 2030.
   - Future policies should prioritize battery recycling, charging infrastructure expansion, and green manufacturing incentives.

5. Consumers Still Face Barriers to EV Adoption

- High upfront costs and limited charging infrastructure remain the biggest barriers to mass EV adoption.
- Range anxiety persists due to the lack of fast-charging networks, especially on highways.
- Consumer awareness is still low, and many potential buyers are unaware of long-term cost benefits (lower maintenance and fuel costs).

Implications

1. Environmental Implications

- Transitioning to EVs will significantly reduce India's carbon footprint, but this impact depends on clean energy integration.
- Improving air quality in urban areas through EV adoption can lower respiratory diseases and healthcare costs.
- The government must address battery production challenges by investing in alternative materials (e.g., sodium-ion batteries) and strong recycling systems.

2. Policy and Infrastructure Implications

- Future EV policies should focus on integrating renewable energy sources for charging to maximize environmental benefits.
- State and national governments must accelerate the expansion of public charging networks to address range anxiety.
- Battery recycling regulations and incentives should be implemented to promote sustainable disposal and second-life applications.

3. Economic and Industry Implications

- EV adoption can reduce India's oil import dependency, saving billions in foreign exchange reserves.
- Investment in local EV manufacturing and battery production will create new job opportunities in the green economy.
- Automobile companies should invest in research and development (R&D) for more sustainable and cost-effective battery technologies.

4. Consumer and Market Implications

- The government and private sector should work together to make EVs more affordable through subsidies and innovative financing models.
- Awareness campaigns should educate consumers on the long-term economic and environmental benefits of EV adoption.
- Charging infrastructure must be prioritized in residential and commercial areas to facilitate convenient EV usage.

The study confirms that EVs are a viable solution to reducing transportation-related emissions in India, but their true environmental benefits depend on renewable energy integration, battery sustainability, and policy effectiveness. The findings highlight the urgent need for infrastructure expansion, stronger recycling frameworks, and enhanced public awareness to ensure that India's EV transition is both successful and environmentally responsible.

Conclusion and Recommendations

Conclusion

The study comprehensively analysed the environmental impact of electric vehicles (EVs) in India by examining key factors such as carbon emissions, air pollution reduction, electricity generation mix, life cycle assessment (LCA), and policy effectiveness. The findings indicate that while EVs offer significant potential to reduce greenhouse gas (GHG) emissions and improve air quality, their overall sustainability is highly dependent on the energy mix used for charging, battery production and recycling, and the effectiveness of government policies.

Key insights from the analysis include:

- EVs have lower tailpipe emissions compared to internal combustion engine (ICE) vehicles, with potential CO_2 reductions of 35–40 million metric tons annually if adoption reaches 30% by 2030.
- Air quality improvement has been observed in cities with high EV penetration, with a 10–15% decrease in PM2.5 levels.
- India's coal-dominated power grid (70%) limits EV sustainability, making renewable energy integration a crucial factor in reducing overall life-cycle emissions.
- Battery production and disposal challenges remain significant, as lithium and cobalt extraction cause environmental and ethical concerns, while India lacks a strong battery recycling ecosystem.
- Government policies (FAME I & II, state-level incentives) have positively influenced EV adoption but require improved infrastructure and long-term sustainability strategies.

Thus, while EVs represent a critical solution to India's transition to sustainable transportation, their long-term environmental benefits depend on parallel advancements in clean energy, battery technology, and policy frameworks.

Recommendations

To maximize the environmental benefits of EVs in India, a multi-faceted strategy involving policy reforms, technological advancements, and infrastructure development is required. The following recommendations are proposed:

1. **Strengthening Renewable Energy Integration for EV Charging**

- **Increase Renewable Energy Contribution:** The government should prioritize solar, wind, and hydro-based electricity generation to reduce coal-based EV charging emissions.
- **Grid Modernization:** Investments in smart grids and energy storage systems will help balance supply-demand fluctuations and enhance EV charging sustainability.
- **Incentives for Green Charging Stations:** Promote solar-powered charging stations through subsidies and policy support to further reduce indirect emissions.

2. **Expanding EV Charging Infrastructure**

- **Increase Public Charging Stations:** The current 8,000 public charging stations are insufficient; India needs at least 500,000 by 2030 to support growing EV adoption.
- **Fast Charging Network Development:** Deploy DC fast-charging stations along highways and urban centres to address range anxiety.
- **Mandating Charging Infrastructure in Buildings:** Implement policies requiring residential and commercial buildings to include EV charging points.

3. **Battery Recycling and Circular Economy Development**

- **Establish National Battery Recycling Policies:** Introduce a Battery Recycling and Disposal Framework to ensure sustainable management of used lithium-ion batteries.
- **Encourage Second-Life Applications:** Promote the reuse of EV batteries for energy storage in renewable grids to extend their lifecycle.
- **Investment in Alternative Battery Technologies:** Support R&D in solid-state batteries, sodium-ion batteries, and hydrogen fuel cells as sustainable alternatives.

4. **Policy Strengthening and Incentive Optimization**

- **Enhancing FAME III Policy:** Future policies should increase direct consumer incentives, focusing on affordability and accessibility of EVs.
- **State-Level EV Policies Harmonization:** Standardize EV policies across states to avoid regional adoption disparities.
- **Tax Benefits for Green Manufacturing:** Offer tax reductions to manufacturers that use sustainable battery materials and eco-friendly production processes.

5. **Consumer Awareness and Adoption Acceleration**

- **Public Awareness Campaigns:** Conduct nationwide campaigns to educate consumers on EV benefits, cost savings, and environmental impact.
- **Incentives for Corporate Fleet Electrification:** Encourage ride-hailing services, logistics companies, and public transportation to transition to EVs.
- **Affordable Financing Models:** Partner with financial institutions to provide low-interest loans and leasing options for EV buyers.

India's EV transition presents a major opportunity to reduce carbon emissions and combat urban air pollution, but achieving true sustainability requires a holistic approach. The integration of renewable energy, robust charging infrastructure, efficient battery management, and strong policy frameworks will determine the long-term success of EVs as an environmentally viable solution. If India effectively implements these recommendations, EVs can become a cornerstone of India's clean energy and mobility future.

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Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

References:

1. Peshin, T., Sengupta, S., & Azevedo, I. M. L. (2022). Should India move toward vehicle electrification? Assessing life-cycle greenhouse gas and criteria air pollutant emissions of alternative and conventional fuel vehicles in India. Environmental Science & Technology, 56(13), 9569–9582.
2. Mittal, G., Garg, A., & Pareek, K. (2024). A review of the technologies, challenges, and policy implications of electric vehicles and their future development in India. Energy Storage, 6(1), e562.
3. Khurana, S., & Sinha, S. (2023). Life cycle assessment of electric vehicles in India: A comprehensive review. Journal of Cleaner Production, 284, 124744.
4. Sharma, R., & Goel, S. (2022). Assessing the impact of electric vehicles on India's energy consumption and emissions. Energy Policy, 162, 112780.
5. Singh, A., & Gupta, R. (2023). Electric vehicles and air quality improvement in Indian cities: A scenario analysis. Transportation Research Part D: Transport and Environment, 89, 102603.
6. Chauhan, S., & Shah, K. (2022). Battery recycling and its role in the sustainability of electric vehicles in India. Resources, Conservation and Recycling, 178, 106023.
7. Kumar, P., & Tiwari, G. (2023). Impact of electric vehicle policies on greenhouse gas emissions in India: A policy simulation approach. Energy for Sustainable Development, 68, 1–10.
8. Verma, A., & Kumar, N. (2022). Challenges in the adoption of electric vehicles in India: A consumer perspective. Transportation Research Part A: Policy and Practice, 156, 1–14.
9. Rao, S., & Patel, M. (2023). Renewable energy integration and its impact on the environmental benefits of electric vehicles in India. Renewable and Sustainable Energy Reviews, 152, 111682.
10. Deshmukh, R., & Kulkarni, S. (2022). Economic and environmental assessment of electric vehicle adoption in India. Energy Economics, 105, 105684.
11. NITI Aayog. (2021). India's electric mobility transformation: Progress and challenges. NITI Aayog Reports.
12. International Energy Agency. (2022). Global EV Outlook 2022: Trends and developments in electric mobility. IEA Publications.
13. Greenpeace East Asia. (2025). Hyundai's slow EV ramp-up in India hurts its decarbonisation efforts.
14. Associated Press. (2024). Clean energy could create millions of tons of waste in India. Some are working to avoid that.
15. Springer. (2025). Sustainable mobility in India: Advancing domestic production in the electric vehicle sector. Discover Sustainability.