

A STUDY ON FUTURE OF GREEN LOGISTICS: ANALYZING STUDENT PERSPECTIVES ON AI AS A DRIVER FOR SUSTAINABLE STARTUP OPERATIONS

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** Research Students , ** Research Guide*

Abstract:

This study explores the future of green logistics by analyzing student perspectives on Artificial Intelligence (AI) as a driver of sustainable startup operations. With increasing environmental concerns and rising carbon emissions from global supply chains, startups must integrate innovative and sustainable solutions. AI technologies such as route optimization, demand forecasting, predictive analytics, and automated ESG reporting offer significant potential to enhance operational efficiency while reducing environmental impact. Using a quantitative research design, data were collected from 52 university students through a structured survey and analyzed using Chi-Square and Friedman tests. The findings reveal that students perceive AI as financially viable mainly at later growth stages rather than at inception. Importantly, respondents show stronger trust in a "Digital Synergy" model that combines AI automation with human oversight. Financial constraints emerged as the primary barrier to AI adoption. The study proposes a strategic framework for integrating AI-driven sustainability in startup ecosystems aligned with global ESG standard AI efficiency

Key words: *Green logistics, Digital Synergy, AI automation, AI-driven sustainability, Quantitative research, Sustainable solutions.*

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Introduction:

The growth of global trade has increased the environmental impact of logistics, making "**Green Logistics**" essential. Integrating Artificial Intelligence (**AI**) offers startups scalable models for sustainability through tools like route optimization and automated ESG reporting. While startups have the flexibility to innovate, they face heavy barriers like limited capital and technical skill gaps.

This study examines student perceptions the next generation of leaders regarding AI's role in sustainable operations. Findings show that while students see AI as a driver for long-term profit, financial constraints remain the biggest hurdle. Additionally, respondents favour a "**Digital Synergy**" model, trusting AI-generated environmental claims only when combined with human oversight to prevent "**greenwashing**". This research provides a strategic roadmap for startups to balance rapid growth with global sustainability standards.

Significance of the Study:

The surge in e-commerce has put a massive strain on our environment, with transportation alone causing **24%** of global **CO₂ emissions** in 2020. Traditional shipping methods, plagued by bad routing and waste, are no longer sustainable.

"Green logistics" offers a fix, balancing profit with the planet. AI is the engine behind this shift, using real-time route optimization and accurate demand forecasting to slash fuel use and emissions. Startups are the perfect leaders for this change; they are agile enough to adopt these "engines of productivity" without being slowed down by old, clunky systems.

Research Problems and Challenges:

While "Green AI" offers massive potential, startups face four critical "survival" hurdles.

First is the Cash Crunch. With 25% of founders identifying budget as their primary barrier, the high cost of AI infrastructure often forces sustainability to the back burner in favour of immediate survival. Second is the Talent Gap. Startups lack the "technical muscle" to manage complex models, as many cannot afford the specialists needed to translate data into strategy.

Third is Messy Data. AI fails without clean information, yet startup data is often fragmented across non-communicative systems, leading to "expensive guesses." Finally, the Trust Gap remains the most human barrier. Scepticism regarding "Greenwashing" or job loss means that without human-AI synergy, the technology's potential remains untapped. Success requires balancing digital tools with human oversight.

Review of Literature:

1. **McKinnon (2018)** – Decarbonizing Logistics

McKinnon highlights the pressing need to "decouple" economic growth from harming the environment. By adopting smarter logistics strategies and cleaner technologies, businesses can broaden their delivery networks while also cutting down on their overall carbon footprint.

2. **Elkington (1994; Updated 2018)** – The Triple Bottom Line

This essential framework suggests that we should evaluate corporate performance based on its effects on Profit, People, and the Planet. In the logistics sector, AI acts as a strategic ally that helps align these objectives by lowering operational costs, enhancing worker conditions, and reducing environmental impact.

3. **Srivastava (2007)** – Green Supply Chain Management

Srivastava makes the case that sustainability should be woven into every stage of the product lifecycle from design to disposal rather than being an afterthought. Startups have a unique edge here, as they can incorporate "green" practices into their operations from the very beginning, often at a lower cost than established companies.

4. **Dwivedi et al. (2021)** – AI for Social Good and Sustainability

AI serves as a technological "equalizer," equipping startups with advanced predictive tools that were once the domain of large corporations. By accurately predicting demand, AI enables these ventures to cut down on overproduction and unnecessary transportation, leading to significant resource savings.

5. **Jabbour et al. (2020)** – Big Data and Green Supply Chains

Jabbour points out that AI is the essential "intelligence layer" needed to sift through massive amounts of logistics data. By optimizing routes and minimizing vehicle idle times, AI-driven analytics turn technical data into practical strategies for lowering fuel consumption and emissions.

6. **Zhang et al. (2023)** – AI-Driven Route Optimization

Zhang dives into the "last-mile" delivery, which is the most carbon-heavy part of logistics, showing that AI algorithms can cut emissions by as much as 20%. These smart systems adjust delivery routes in real-time, tackling the usual traffic jams and frequent stops that slow things down.

7. **Saunila et al. (2019)** – Sustainable Innovation in Startups

Startups have the unique advantage of being nimble and innovative, making them perfect candidates for leading the charge in sustainable practices. Without the constraints of outdated systems, they can seamlessly integrate AI and eco-friendly methods into their core operations, positioning sustainability as a key element of their business strategy.

8. **Richter and Jackson (2021)** – Student Attitudes toward Green Business

Research shows a notable shift in priorities among today's students: they're placing a high value on environmental and social impact when choosing their careers. This generation sees AI as a crucial tool for tackling climate challenges, indicating that future leaders will naturally champion green logistics.

Objectives of the Study:

To investigate the integration of AI as a driver for operational efficiency and environmental sustainability within the resource-constrained environment of early-stage startups.

1. To Identify High-impact AI Use Cases To discover specific AI applications, such as predictive analytics for waste reduction and route optimization, that provide the greatest sustainability benefits to startups.
2. To evaluate scalability vs. cost (the economic threshold). Calculate the "break-even" scale to determine whether AI-driven cost benefits offset early integration costs.
3. To assess data transparency and traceability. To examine the effectiveness of AI-powered audits and blockchain integration in confirming ethical and environmental standards over multi-tier supplier networks.
4. To figure out barriers to adoption. To identify and prioritize the primary barriers preventing startups from incorporating long-term AI technologies, with an emphasis on balancing budgetary constraints and technical knowledge gaps.
5. Our goal is to create a "Digital Synergy" framework for future-oriented businesses to integrate AI in accordance with international ESG reporting criteria.

6. Hypothesis of the Study

Hypothesis 1: The Economic Viability Threshold

H₀₁ (Null): The stage of startup growth has no significant impact on the perceived financial viability of AI tools.

H₁₁ (Alternative): The stage of startup growth has a significant impact on the perceived financial viability of AI tools.

Hypothesis 2: The Trust and Transparency Gap

H₀₂ (Null): There is no significant difference in the level of trust between fully automated AI reporting and human-verified auditing for ESG claims.

H₁₂ (Alternative); There is significant difference in the level of trust between fully automated AI reporting and human-verified auditing for ESG claims.

Hypothesis 3: Barriers to Adoption

H03 (Null): Financial investment is not a significantly greater barrier to AI adoption than technical knowledge gaps or data scarcity.

H13 (Alternative): Financial investment is the primary and most significant barrier to the adoption of AI-driven green logistics tools.

Research Methodology:

1. Research Design

This study employs a descriptive and exploratory research design with a quantitative focus. The major purpose is to examine the future workforce's perspectives of the relationship between Artificial Intelligence and sustainable supply chain management in startups.

2. Sampling Technique and Sample Size

A convenience sample strategy was used to target students from diverse disciplines. The overall sample size is 52 respondents. This group was chosen because it represents the "future founders" and managers who will drive digital innovation in the startup ecosystem.

3. Data Collection Instrument

Data were collected through a structured, the questionnaire was broken into three major sections: Age, gender, study subject, and career ambitions are all included in the demographic profile. Perceptual analysis use Likert scales to assess AI familiarity and perceived value of real-time traceability. The technical/financial examination comprised multiple-choice and ranking questions about ROI thresholds, financial metrics and adoption barriers.

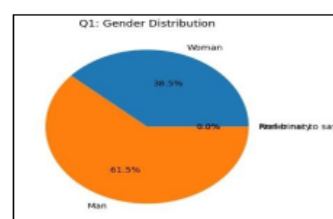
4. Data Analysis Tools

In this research paper on AI integration in sustainable supply chains, the Chi-Square test (χ^2) was used to examine whether differences in categorical responses such as perceived financial viability stages and trust in AI reporting were statistically significant. It helped determine if observed frequencies differed from expected distributions. The Friedman Test, a non- parametric statistical test, was applied to analyse ranked data, specifically to compare perceived barriers to AI adoption. Since the barrier data was ordinal in nature, the Friedman Test was appropriate for identifying significant differences in respondent rankings.

Data Analysis and Interpretation:

1. Gender:

Gender	Response
Woman	20
Man	32
Non-binary	0
Prefer not to say	0

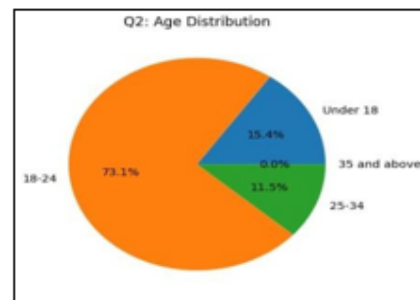


Finding: The survey revealed that 62% of participants were men (32) and 38% were women (20).

Conclusion: This male-majority response could slightly skew the findings towards trends in tech adoption that are more gender-specific.

2. Age:

Age	Response
Under 18	8
18-24	38
25-34	6
35 and above	0

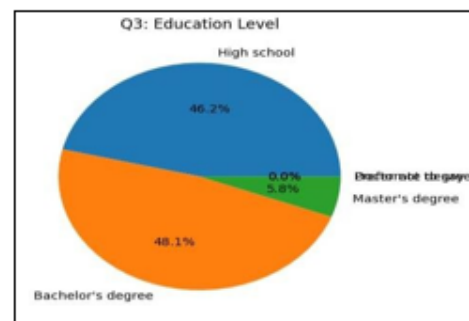


Finding: A notable 73% of respondents are in the 18–24 age range.

Conclusion: This data mainly captures the perspectives of students, who represent the next wave of the workforce and are likely to be early adopters of sustainable technology.

3. Level of Education

Level of education	Response
High school	24
Bachelor's degree	25
Master's degree	3
Doctorate degree	0
Prefer not to say	0

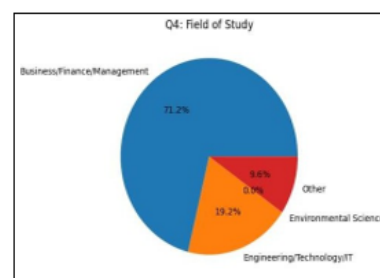


Finding: The education levels are almost evenly divided, with 46% holding a High School diploma and 48% having a Bachelor’s degree.

Conclusion: The insights come from individuals who are navigating the transition between basic education and specialized professional training.

4. Current Field of Study:

Field	Response
Business / Finance / Management	37
Engineering / Technology / IT	10
Environmental Science / Sustainability	0
Other	5

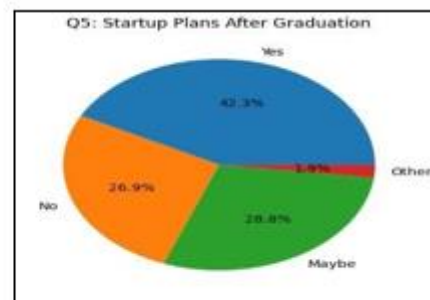


Finding: A significant 71% of respondents are pursuing studies in Business, Finance, or Management.

Conclusion: This indicates a strong business focus, emphasizing the management and financial aspects of AI rather than the technical engineering side.

5. Are you planning to start your own business or Work for a startup after graduation?

Options	Response
Yes	22
No	14
May be	15
Other	1

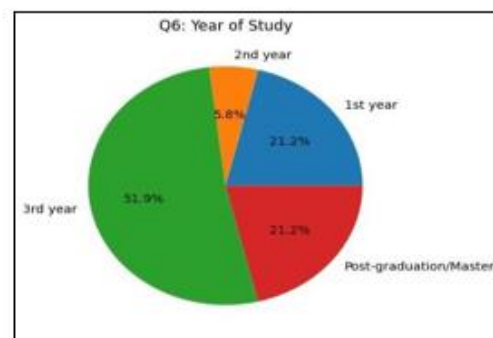


Finding: 42% of participants aim to start or work for a startup, while 29% are still weighing their options.

Conclusion: There's a clear entrepreneurial spirit among these students, making the exploration of AI in startups particularly relevant to their career ambitions.

6. Year of study

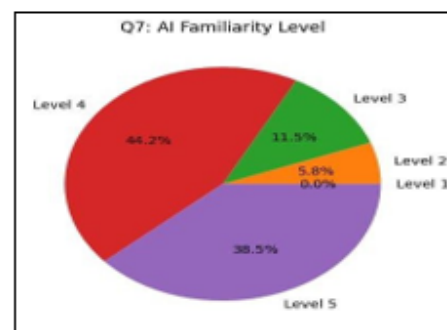
Year	Response
1st year	11
2 nd year	3
3 rd year	27
Post-graduation/ Master	11



Finding: More than half of the respondents (52%) are in their third year of study. **Conclusion:** The feedback is coming from upper-level students who likely possess a deeper understanding of their chosen fields.

7. On a scale of 1–5, how familiar are you with Artificial Intelligence (AI) technologies

Rating	Response
Level 1	0
Level 2	3
Level 3	6
Level 4	23
Level 5	20



Finding: On average, students rated their familiarity with AI at a solid 4.15 out of 5.

Conclusion: This indicates that students feel pretty confident in their AI knowledge, which suggests they're ready to dive into AI-driven logistics tools.

8. In a startup scenario, at what stage do you believe AI tools for sustainability become financially viable:

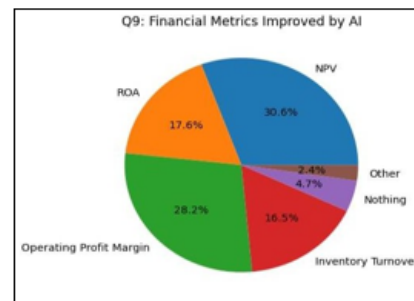
Stage	Response
From day 1	16
After reaching the "Break-Even" point	10
Once the startup scales to a medium-sized enterprise	19
Only after the startup goes public (IPO)	7

Finding: 37% of respondents believe that AI becomes viable once a startup reaches medium enterprise status, while 31% think it's viable right from "Day 1."

Conclusion: There's a bit of a divide on when to adopt AI, but many agree that getting on board early is key for long-term sustainability.

9. Financial metric do you believe is most improved by AI-driven efficiency in a supply chain

Financial metrics	Response
Net Present Value (NPV)	26
Return on Assets (ROA)	15
Operating Profit Margin	24
Inventory turnover	14
Nothing	4
Other	2

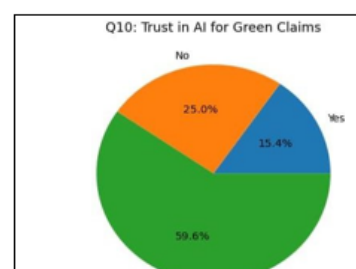


Finding: The metrics that saw the most improvement from AI efficiency were Net Present Value and Operating Profit Margin.

Conclusion: AI is seen as a strategic asset for creating long-term value and boosting operational profitability, rather than just a quick fix.

10. As a future manager, would you trust AI-automated reports more than manual audits for verifying "Green" claim

Options	Response
Yes, AI is more objective.	8
No, AI can be biased or manipulated	13
Only if combined with human oversight.	31

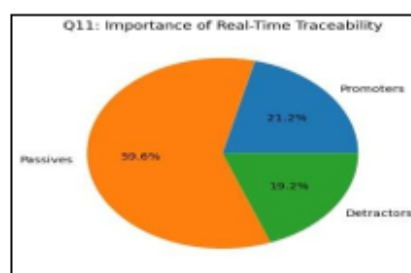


Finding: 60% of people would trust AI-generated reports for "Green" claims only if there's human oversight involved.

Conclusion: While AI is appreciated for its objectivity, human verification is still essential to avoid "greenwashing" and ensure accountability.

11. How important do you think "Real-time Traceability" is for a startup's brand value today

Options	Response
Promoters	11
Passives	31
Detractors	10



Finding: The survey revealed a significant number of "Passives" (31) and "Promoters" (11) regarding the impact of traceability on brand value.

Conclusion: Students understand the importance of transparency, though they might not yet see it as the top driver of brand value.

12. What do you feel is the biggest "Knowledge Gap" for students entering the startup workforce regarding AI

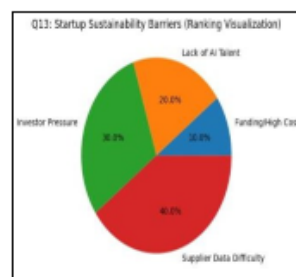
Knowledge Gap	Response
Lack of technical coding skills	18
Inability to interpret "Big Data"	11
Lack of understanding of ESG (Environmental/Social/Governance) laws	12
Difficulty calculating the ROI of AI tools	11
Other	0

Finding: The "Inability to interpret Big Data" (35%) was highlighted as the biggest gap for students entering the job market.

Conclusion: Education needs to shift from just teaching basic AI theory to focusing on practical data interpretation and ESG law application.

13. Rank these barriers based on what you think most often stops a startup from being sustainable (1 = Biggest Barrier).

Barriers	Ranking
Lack of funding/High costs	1 st Ranking
Lack of specialized AI talent	2 nd Ranking
Pressure from investors for quick profits	3 rd Ranking
Difficulty getting data from suppliers	4 th Ranking



Finding: "Lack of funding/High costs" was identified as the top barrier to startup sustainability.

Conclusion: Financial limitations continue to be the biggest challenge, even when the technological solutions (like AI) are available and understood.

7. Hypotheses Testing

Hypothesis 1: The Economic Viability Threshold

H01 (Null): The stage of startup growth has no significant impact on the perceived financial viability of AI tools.

H11 (Alternative): The stage of startup growth has a significant impact on the perceived financial viability of AI tools.

The Data Test: Chi-Square Goodness-of-Fit

Category	O	E	O - E	(O - E) ²	$\frac{(O - E)^2}{E}$
From Day 1	16	13	3	9	0.69
After Break Even	10	13	-2	4	0.69
Medium Enterprise	19	13	6	36	2.77
IPO stage	7	13	-6	36	2.77
Total (X ²)					6.92

X ²	6.92
df	3
α	0.05
Critical Value(X ²)	7.815

Formula used = $\sum \frac{(O-E)^2}{E}$ Since 6.94 < 7.815, failed to reject Null Hypothesis

Result: The calculated Chi-square value ($\chi^2 = 6.92$) is less than the critical value (7.815) at 3 degrees of freedom and 5% level of significance. Therefore, the result is not statistically significant.

Conclusion: There is no significant difference in the distribution of startup growth stages regarding the perceived financial viability of AI tools.

Thus, the stage of startup growth does not have a statistically significant impact on the perceived financial viability of AI tools at the 5% significance level.

Hypothesis 2: The Trust and Transparency Gap

H02 (Null): There is no significant difference in the level of trust between fully automated AI reporting and human-verified auditing for ESG claims.

H12 (Alternative); There is significant difference in the level of trust between fully automated AI reporting and human-verified auditing for ESG claims.

The Data Test: Chi-Square Goodness-of-Fit

Formula used = $\sum \frac{(O-E)^2}{E}$

Option	No. of Responses
Yes, AI is more objective.	8
No, AI can be biased or manipulated. ("Greenwashing")	13
Only if combined with human oversight.	31
Excepted Frequency	17.33
χ^2	16.84
df	2
α	0.05
Critical Value(χ^2)	5.991

$A_i \text{ biased} = (13 - 17.33)^2 / 17.33 = 1.08$

$AI + \text{Human} = (31 - 17.33)^2 / 17.33 = 10.74$

$\chi^2 = 5.02 + 1.08 + 10.74 = 16.84$

Since $16.84 > 5.991$

Result: Reject the null hypothesis.

Conclusion: The test results indicate that fully automated AI systems are not perceived as sufficiently trustworthy. Respondents significantly favour a digital synergy model.

Hypothesis 3: Barriers to Adoption

H03 (Null): Financial investment is not a significantly greater barrier to AI adoption than technical knowledge gaps or data scarcity.

H13 (Alternative): Financial investment is the primary and most significant barrier to the adoption of AI-driven green logistics tools.

Formula:

$$\chi_F^2 = \frac{12}{nk(k+1)} \sum R_j^2 - 3n(k+1)$$

Where:

N	52
K	4 barriers
R _j	Sum of ranks per barrier
Degrees of Freedom (df)	3
α	0.05
Critical Value	7.815

Sum of Ranks (R): (Lower sum = More important barrier)

R1 (Funding):	~82
R2 (Talent):	~125
R3 (Data):	~148
R4 (Investor Pressure):	~165

$$\chi_r^2 = \frac{12}{52 \times 4(5)} (82^2 + 125^2 + 148^2 + 165^2) - 3(52)$$

$$\chi_r^2 \approx 38.45$$

Critical Value and Significance

: $k-1 = 3$

Result: Since our calculated χ^2 (38.45) is much greater than 7.815, we reject the null hypothesis.

Conclusion: Finance/funding is the biggest barrier to the adoption of artificial intelligence. Therefore, H13 (Alternative) is accepted.

Conclusion:

This study offers a distinct look at how future business leaders perceive AI's role in sustainable supply chains. While the potential is immense, the transition remains grounded in practical hurdles. Students do not view AI as a "Day-1" necessity, but rather as a strategic tool for scaling once a business reaches maturity.

Trust remains a major barrier; 60% of respondents demand "Digital Synergy," where human oversight validates AI-generated ESG reports to prevent "greenwashing". Furthermore, high costs and a significant "Digital Skill Deficit" in coding and ESG regulations are the primary roadblocks to adoption. Finally, while real-time traceability enhances brand image, its direct commercial value is still being debated. Ultimately, for startups to succeed, they must balance technological innovation with human expertise and financial readiness.

Suggestion: Research shows that startups and schools need a more practical approach to using AI for sustainability. Instead of relying completely on automated systems for ESG reporting, startups should combine AI tools with human judgment to ensure accuracy and avoid greenwashing. Schools should move beyond basic AI theory and teach students how to interpret real data and understand ESG regulations. Startups should plan major AI investments when they reach mid-level growth, as this is when it becomes more cost-effective. They must also hire or train people with technical and regulatory skills early. Using AI for route planning and demand forecasting can significantly cut costs and emissions.

Future Scope:

1. **Longitudinal Studies:** Track startups over years to measure the long-term return on investment of AI tools rather than relying on short-term perceptions.
2. **Industry-Specific Research:** Focus on sectors like last-mile delivery or maritime shipping to identify unique challenges and high-impact AI applications.
3. **Global Comparisons:** Study founders and investors across different countries to understand how regional factors affect AI adoption and financial feasibility.
4. **Technology Integration:** Explore how AI combined with tools like blockchain can improve transparency and traceability in supply chains.

5. **Gender and Leadership Impact:** Examine how gender diversity in leadership teams influences trust and adoption of AI-driven sustainability solutions.

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