(Green Startups: A Strategic Mechanism for the Transition Toward a Green Economy)

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Abstract: This study highlights the emergence of green start-ups as one of the most prominent modern mechanisms supporting the transition toward a green economy. These enterprises leverage innovation and technology to provide environmentally friendly products and services while generating economic returns that contribute to sustainable development. The focus on these firms arises amid escalating environmental challenges, such as climate change, resource depletion, and pollution, positioning them as effective tools for mitigating these issues and promoting sustainable production and consumption patterns.

Furthermore, the study explores the opportunities presented by this approach in various fields, including renewable energy, recycling, and resource efficiency, alongside challenges related to financing, innovation, and legislation. Successful models of green and eco-friendly start-ups are reviewed, providing insights and ideas that can be adopted locally to strengthen the role of green entrepreneurship in building an environmentally and economically balanced, sustainable economy.

Keyword: green Start-ups, Green Economy, Sustainable Development, Environmental, Innovation.
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1. Introduction :

The contemporary world has witnessed radical shifts in economic models due to escalating environmental challenges, such as climate change, biodiversity loss, and the depletion of natural resources. These challenges have compelled nations and societies to seek more sustainable developmental alternatives that ensure a balance between economic growth and environmental preservation. In this context, the concept of the green economy has emerged as a strategic pathway aimed at achieving sustainable development by enhancing resource efficiency, reducing carbon emissions, and supporting innovation in clean energy and environmental technologies.

Within this transition, green start-ups play a pivotal role as innovative platforms providing practical solutions to complex environmental problems—either through developing eco-friendly products or by integrating sustainability standards into their operations. International experiences have shown that encouraging these enterprises contributes to creating green jobs, stimulating sustainable economic growth, and enhancing competitiveness in global markets.

Research Problem:

How do international experiences support green start-ups within the trajectory of the green economy?

Significance of the Study:

The importance of this study stems from its alignment with global shifts toward the green economy. it highlights the status of green start-ups as a fundamental actor in promoting sustainable development, providing insights that can be utilized in formulating policies and encouraging eco-friendly initiatives.

Objectives of the Study:

This study aims to highlight the role of green start-ups as an innovative mechanism for supporting the transition toward a green

economy by analyzing the opportunities and challenges of this transition, while drawing lessons from international models of green and eco-friendly enterprises.

2. An Introduction to Green Start-ups

Green start-ups are innovative companies that aim to protect the environment by providing sustainable solutions and promoting the green economy.

2.1. The Concept of the Start-up

Several definitions exist, including:

- ✓ **Terminology:** According to English dictionaries, a "Start-up" is a small project that has just begun. The term consists of two parts: "Start," referring to the act of initiation, and "Up," referring to the idea of vigorous growth. The term became popular after World War II with the emergence of venture capital.
- ✓ According to the ***Larousse*** **dictionary**, they are: "Young, creative institutions in the field of information and communication technologies, whose mission is to create and market new technologies. Or, they are young, innovative institutions in the modern technology sector" **(Boudiaf & Zubair, 2020, p. 90)**.
- ✓ **Innovation and Risk:** They can also be defined as: "An institution seeking to market and launch a new product or an innovative service targeting a large market. Regardless of size or sector, it is characterized by high uncertainty and high risk, offset by the possibility of achieving rapid growth and significant profit if successful" **(Bou El-Shour, 2018, p. 42)**.

2.2. Characteristics of Start-ups

Start-ups represent a unique model of modern institutions, distinguished by **(Hussein & Hakim, 2025, p. 54)**:

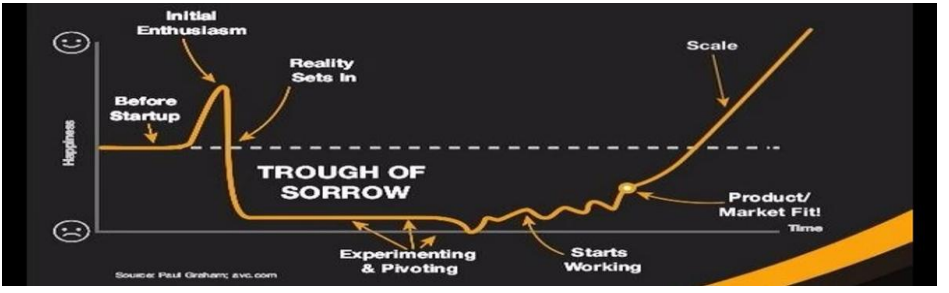
- Newness. - Technological Dependency.
- Creativity and Innovation. - Small, Creative Teams.
- Rapid Growth. - Low Costs.
- Scalability. - Strong Leadership.
- Flexibility and Adaptation**.**

2.3. Stages of Start-up Development

A start-up is characterized by real growth, not just a temporary launch. As described by Paul Graham, the realistic growth journey follows a specific curve:

Based on the figure above, a start-up passes through basic stages **(Omar & Kenza, 2024, p. 12)**:

Figure (01): The Foundational Stages of the Startup Lifecycle



Source: Paul Graham, Startup Happiness Curve, available at: http://t.co/P1FDc1MCUB (Graphics by Goodgraphic).

Stage 1: The Pre-launch Phase This stage commences prior to the formal inception of the startup, during which an individual or a collective develops a prototype for a novel, creative concept. Throughout this period, the team engages in rigorous research and feasibility studies, including comprehensive market analysis and audience profiling, to ensure the project's viability, success, and long-term sustainability. Furthermore, the team focuses on evolving the initial idea into a testable model while seeking appropriate seed funding to support the venture's early operations. At this juncture, financing is typically characterized by bootstrapping—relying on the founders'

personal resources—with the potential for limited government subsidies.

Stage 2: The Launch Phase This phase involves the introduction of the first-generation product or service. During this period, the venture often lacks market recognition, and one of the most

significant challenges for entrepreneurs is securing external validation and financial backing. Consequently, founders frequently rely on "Friends, Family, and Fools" (FFF) as their primary source of initial capital. In this stage, the product requires intensive promotional efforts, price points are often high, and the entrepreneur initiates targeted marketing campaigns to build brand awareness.

Stage 3: The Early Traction and Growth Phase In this stage, the team experiences high levels of momentum and enthusiasm as the offering gains market penetration and demand approaches its peak. The venture may begin expanding beyond its initial innovative niche; however, competitive pressures start to intensify as more players enter the market. This increased competition elevates the risk of failure or the emergence of strategic barriers that could potentially lead to a downward trend in the growth curve.

Stage 4: The Trough of Sorrow Despite continued support from venture capitalists, the startup may experience a significant decline, often descending into what is colloquially known as the "Valley of Death." At this critical juncture, the venture faces a high risk of market exit if strategic interventions are not implemented, particularly as growth rates reach their lowest points.

Stage 5: The Upswing and Refinement Phase During this phase, the entrepreneur implements iterative improvements to the product, leading to the launch of an enhanced version. Leveraging strategic adjustments and the team’s accumulated expertise, the startup begins its recovery. A second-generation product is typically introduced with optimized pricing and targeted toward a broader demographic.

Stage 6: The High-Growth Phase In the final stage, the product achieves full market integration and transitions out of the experimental phase toward authentic, large-scale growth. As the target audience's adoption rate reaches between 20% and 30%, the venture enters a period of significant market expansion, ultimately achieving substantial profitability.

2.4. Green Start-ups and the Transition Toward a Green Economy

Green start-ups are central to accelerating the green transition through innovative eco-solutions.

2.4.1. Defining Green Start-ups:

The concept is modern, where the environmental dimension represents a core pillar. It is defined as: "Every start-up created through a pioneering innovative idea, investing primarily in ecology by exploiting natural resources and renewable energies, and focusing on the environment and sustainable development **(Louchen, 2022, p. 578).**

Another definition states: "Every small, medium, or nascent institution based on an innovative business idea aiming to provide a new product or service to the market that contributes to environmental protection" **(Alia & Qamri, 2023, p. 119).**

2.4.2. The Role of Green Startups in Facilitating the Transition Toward a Green Economy

With the emergence of modern technologies such as the Internet and Artificial Intelligence, startups are flourishing worldwide, leading an increasing number of entrepreneurs to launch green ventures across diverse sectors, including information technology, healthcare, commerce, and clean energy. The global startup economy is remarkably expansive, generating nearly 3 trillion USD in value—a figure comparable to the combined GDP of the G7 nations. Furthermore, seven out of ten such enterprises operate within the technology sector, significantly elevating the prominence of green startups in global markets.

Because green enterprises consume limited energy and produce lower emissions relative to traditional firms, they play a pivotal role in combating climate change while contributing to economic growth and the creation of "green" and decent employment opportunities. By developing green goods or services, these startups foster markets centered on resolving contemporary environmental challenges. For instance, the Dutch green startup Field Factors utilizes its Bluebloqs technology to provide water treatment systems designed to address urban climate challenges. This innovation offers a decentralized solution for water management and supply, enabling the collection, purification, and underground storage of rainwater for subsequent use in irrigation or firefighting.

In parallel, rising demand for alternative energy sources has intensified the need for solar energy solutions. Founded in 2013, the American startup Aurora Solar provides software for the remote design and sale of solar panel systems. To date, it has designed over 6 million solar projects leveraging advanced Lead Capture AI technology. Similarly, the U.S.-based startup Algenesis, established in 2016, utilizes its patented Soleic technology to produce high-performance, fully biodegradable plastic derived from algae.

The impact of green startups extends beyond environmental concerns to address prevailing social challenges in health, nutrition, and education. A notable example is the French Startup Partnering Robotic, which developed the first fully health-oriented robot. This innovation contributes to human well-being by providing real-time indoor air purification for homes and buildings. Numerous other global models of green investment exist, spanning high-tech equipment for renewable energy, waste recycling and circularity, smart architecture, sustainable urban development, and ecotourism (**Souad 2025, p. 82).**

3. The Transition Toward a Green Economy: Opportunities and Challenges

The transition toward a green economy has become an urgent imperative to keep pace with contemporary environmental and economic shifts. However, this transition presents a complex array of

promising opportunities and significant challenges that necessitate rigorous academic inquiry and analytical scrutiny.

3.1. Concept of the Green Economy

In contemporary discourse, the shift toward a green economy has gained significant momentum, as it centers on eco-friendly and sustainable investments as a core requirement for achieving sustainable development. The green economy serves to strengthen and support the nexus between economic activity, environmental preservation, and long-term developmental goals.

3.1.1. Definition of the Green Economy

- ✓ **Definition:** The World Bank defines it as an economy characterized by efficient use of natural resources that limits air pollution and environmental impacts while being inclusive **(Haddadou, 2021, p. 54)**.
- ✓ **ESCWA Definition:** It aims for poverty reduction and well-being by integrating economic, social, and environmental dimensions **(Hassan & Samir, 2014, p. 431)**.

3.1.2. Importance of the Green Economy

The green economy is regarded as a primary vehicle for achieving economic growth and development through the following mechanisms **(Nasba, Nasba, & Tabni, 2019, pp. 196-197):**

- ➢ **Combating Environmental Degradation:** Actively addressing and mitigating the deterioration of natural ecosystems.
- ➢ **Preserving Biodiversity and Optimizing Resource Management:** Countering the loss of biological diversity and rectifying the inefficient exploitation of natural resources.
- ➢ **Maximizing Clean Resource Utilization:** Enhancing the sustainable exploitation of growth-driving resources to establish a vital and resilient ecological model.
- ➢ **Sectoral Innovation and Green Employment:** Developing technologically advanced industries and green job markets,

while managing the ecological transition of traditional sectors and assessing its impact on employment.

- **Supporting Developing Nations:** Assisting developing countries in ensuring food security and universal access to essential services—such as water supply and sanitation—while preventing the depletion of environmental resources.

3.1.3. Requirements for the Green Economy

To facilitate a seamless transition toward a green economy, several fundamental requirements must be met, as outlined by **(Nasba, Nasba, & Tabni, 2019, pp. 198-199):**

- ✓ **Empowering Civil Society:** It is essential to strengthen the role of civil society by fostering partnerships rooted in a collective vision, encouraging creativity, and ensuring the active engagement of all societal stakeholders.
- ✓ **Advancing Green Technology:** Efforts should focus on the development, dissemination, and accessibility of green technologies, alongside the promotion of innovative public-private partnerships.
- ✓ **Collaborative Research and Financing:** This transition requires the establishment of collaborative centers and the implementation of novel financing mechanisms to accelerate the deployment of green technologies.
- ✓ **Integrating Innovation Ecosystems:** A strong link must be established between innovation and research systems by coordinating relationships between academic research institutions and the private sector.
- ✓ **Prioritizing the Social Dimension:** A comprehensive approach to labor is necessary to create high-quality employment opportunities, focusing on improved working conditions, career development pathways, and equitable wage structures.
- ✓ **Policy Support and Regulatory Reform:** Transitioning requires strategic public spending, policy reforms, and regulatory adjustments to ensure that the development trajectory preserves natural capital rather than relying on wealth creation through traditional "brown" economic models.

3.1.4. Domains and Principles of the Green Economy

the green economy aims to mitigate environmental risks and preserve natural resources for both current and future generations, thereby establishing a balance between economic development and sustainable growth while maintaining a clean environment.

According to **(Sahraoui, 2023, p. 301)**, the green economy operates within five fundamental domains:

- **Circular Supply:** This domain focuses on providing renewable energy and utilizing bio-based or fully recyclable materials.
- **Resource Recovery:** This involves extracting energy from discarded products or by-products and reclaiming useful raw materials.
- **Product Life Extension:** The lifecycle of a product is lengthened through repair, upgrading, and resale.
- **Sharing Platforms:** Product utilization rates are increased by facilitating shared access and collaborative ownership.
- **Product-as-a-Service:** This model provides access to a product while the manufacturer retains ownership to capture the productivity benefits of circular resources.

In contrast to the linear industrial economy, which relies on depleting finite reserves to create products that ultimately end up in landfills, the green economy is built upon five highly interconnected principles. For any organization seeking to adopt a circular approach within its production system, it must integrate these principles and understand their mutual dependencies:

- Organizing Reverse Cycles
- Resource Efficiency
- Systems Thinking
- Prioritizing the Future.
- Creating Mutual Benefit

3.1.5. Challenges of the Transition toward a GreenEconomy

The transition from a "brown" economy to a green economy encounters several structural obstacles and challenges, as identified by Mokhtar (2017):

- A primary barrier is the lack of rigorous and well-coordinated planning within developmental policy frameworks.
- There is a heightened risk of new protectionist policies emerging, alongside the implementation of additional technical barriers and incentives that may hinder international trade.
- Poverty continues to affect approximately seventy million individuals in the Arab world. This includes over forty-five million people lacking access to basic healthcare and clean water. Such conditions are compounded by a lack of efficiency in freshwater and energy utilization, as well as insufficient investment in green economic systems and technologies.
- The high cost of environmental degradation in Arab countries, estimated at 95 billion USD annually, places a severe financial burden on the transition process.

3.2. The Role of the Green Economy in Emissions Reduction and Climate Change Mitigation

The green economy, global warming, and environmental pollution are deeply interconnected themes. Addressing climate change, reducing harmful gas emissions, and mitigating pollution have become central challenges that the green economy seeks to confront. Within this framework, the green economy plays a vital role in poverty eradication, improving living standards, and achieving sustainable development by enhancing resource efficiency and developing renewable energy sources.

The transition to a green economy can lead to a significant reduction in greenhouse gas (GHG) emissions. In a conceptual investment model where 2% of global GDP is allocated to key green sectors—with more than half dedicated to energy efficiency and the expansion of renewable energy, including second-generation biofuels—the results are substantial. This approach could lead to a 36% reduction in global energy intensity (measured in millions of tonnes of oil equivalent per

unit of GDP) by 2030. Furthermore, energy-related carbon dioxide co2 emissions could drop from 30.6 gigatonnes in 2010 to 20.0 gigatonnes by 2050.

If current energy consumption patterns persist, the International Energy Agency (IEA) and the Intergovernmental Panel on Climate Change (IPCC) estimate that global temperatures could rise by an average of 6°C. Such an increase would likely cause irreversible environmental damage. Economically, these unchecked emission levels are projected to result in annual losses ranging from 5% to 10% of global GDP.

Mitigating these risks and adapting to climate change is critical. Investing in a low-carbon, resource-efficient green economy is a definitive pathway to addressing this challenge. Some nations have already begun integrating these strategies into their economic stimulus packages. Notably, 2008 marked the first year that investments in alternative energy sources (140 billion USD) surpassed investments in fossil fuel power generation (110 billion USD).

While these trends are promising, further action is required. The IPCC asserts that GHG emissions must be reduced by 50% to 85% by 2050 to limit the global temperature increase to between 2°C and 2.4°C. The IEA estimates that achieving this will require cumulative investments of 45 trillion USD by 2050, averaging slightly over 1 trillion USD annually.

In line with the green transition:

- ✓ Half of these investments will cover the costs of replacing conventional technologies with environmentally sound, low-carbon alternatives.
- ✓ Expected investments in the renewable energy sector alone are projected to create at least 20 million additional jobs, making it a significantly larger source of employment than the contemporary fossil fuel industry.
- ✓ Investing in forest conservation is a vital green solution, as emissions from deforestation and forest degradation currently account for approximately 20% of global GHG

emissions. Increasing investments in REDD+ (Reducing Emissions from Deforestation and Forest Degradation) and sustainable forest management is essential for enhancing carbon sequestration**. (Takrarat, Merdaci & Boutabba, 2017, pp. 570–571)**

4. International Models of Green and Eco-Friendly Start-ups

Green startups have increasingly assumed a pivotal role globally, centered on providing a comprehensive suite of sustainable and eco-friendly solutions. These enterprises leverage the principles of the green economy and eco-innovation to develop products and services that significantly mitigate greenhouse gas emissions and environmental pollution. Consequently, they contribute to ecological preservation while simultaneously achieving high profitability and strengthening their competitive positioning in global markets.

In the following section of this research, we will examine several international case studies that exemplify the operations and impacts of leading environmentally friendly green startups.

4.1. Green Startups in the Middle East and the Arab World

The following startups are actively enhancing the environmental sector in the Middle East through diverse eco-friendly initiatives: **(Jabbour, 2017)**

- **Blink My Car (Lebanon):** This startup addresses water scarcity by offering an on-demand car wash service that utilizes only one cup of water per vehicle. Through a dedicated mobile application, users can request services at any location. The company employs technicians on motorcycles who use biodegradable products and minimal water. The venture has successfully secured investments totaling 1.2 million USD.
- **Eco-dome Maroc (Morocco**): Specializing in sustainable construction, this startup utilizes traditional materials for both new builds and restorations. Their method employs a mixture of 90% soil and 10% cement to construct eco-friendly, disaster-

resistant domes. These structures provide natural thermal insulation and are 50% more cost-effective and faster to build than conventional housing solutions.

- **Recyclobekia (Egypt):** Founded in 2011 by Egyptian students, this venture focuses on transforming electronic waste (e-waste) management. As one of the few regional providers in this sector, Recyclobekia collects or purchases e-waste from individuals and corporations, refurbishes viable components for resale, and exports remaining materials to international recycling plants.
- **Saphon (Tunisia):** This firm specializes in wind energy through the development of "Saphonian" blade-less wind turbines. This innovative design is reportedly twice as efficient as traditional models at half the production cost. Furthermore, the blade-less design eliminates noise pollution and mitigates risks to avian wildlife.
- **Taka Solutions (UAE):** Launched in 2014, this engineering firm focuses on energy efficiency retrofitting for buildings in Dubai. Utilizing performance-based contracts, the company generates revenue by taking a percentage of the actual energy costs saved by the client, thereby incentivizing maximum efficiency.
- **Zero Mass Water (Jordan):** Addressing regional water scarcity, this startup utilizes advanced solar panels that extract and purify water directly from the air. Supported by grants from organizations such as USAID, the company is currently expanding its footprint across the Middle East.
- **SpaceFarm (UAE):** This startup establishes autonomous vertical farms utilizing hydroponic and aeroponic systems. Their Smart Farm Management System (FMS) is an AI-driven platform that automates vertical farming environments, allowing growers to optimize nutrient delivery by monitoring humidity, pH levels, and CO2 concentrations. **(Adarsh R., 2025)**

4.2. Green Startup Models in Europe

While European nations compete to foster startup ecosystems, Germany leads in the volume of eco-friendly ventures. Germany accounts for 252 of the 800 major European green startups, including successful firms like Lilium, which develops electric vertical take-off and landing (eVTOL) jets. Other notable successes include Infarm, an indoor urban farming company that secured 170 million USD in funding by late 2020. German startups dominate sectors such as pollution reduction, agriculture, energy, and transportation, while the UK leads primarily in sustainable finance. **(Germany Leads Europe in Eco-Friendly Startups, 2021)**

- **Climeworks:** Founded in 2009 at ETH Zürich, this company utilizes Direct Air Capture (DAC) technology to remove CO2 from the atmosphere. The captured gas is stored underground—specifically in basalt rock formations in Iceland—where it mineralizes. The founders plan to expand operations with multiple plants in the United States. (Wilms, 2024)
- **Plastic Fischer:** Established in 2019, this German startup prevents ocean plastic pollution by installing floating barriers in small rivers across India and Indonesia. By intercepting plastic before it reaches the sea, they prevent its degradation into microplastics. Collected materials are sorted locally, with non-recyclable components converted into industrial fuel. **(Wilms, 2024)**
- **Intra Pore:** Founded in 2015, this firm specializes in "minimal intervention" groundwater remediation. Using underground conduits, they deploy nano-particles that react with and neutralize heavy metals, chlorinated hydrocarbons, and pesticides. The company currently manages over 100 purification sites across Europe. **(Wilms, 2024)**
- **BIOELEKTRA (Poland):** A leader in circular business models, this firm specializes in sterile waste separation and mechanical resource recovery. Founded in 2013, it aims to recover up to 96% of municipal solid waste, treating waste as a valuable resource. Their emission-free, thermo-mechanical treatment technology complies with stringent EU standards regarding biodegradable waste. **(Houhou, 2023, p. 101)**

- **Italian Green Startups:** Italy hosts a growing ecosystem of over 12,000 startups, leveraging its global standing in the fashion and design industries. A prominent example is Exo Lab Italia (est. 2020), which utilizes plant-based nanovesicles derived from organic produce to create sustainable products using advanced nanotechnology. **(Mouloud & Naguez, 2022, pp. 141-142)**

4.3. Green Startup Models in the United States

The U.S. remains a global hub for green initiatives in renewable energy, urban agriculture, and green fintech:

- **EcoFLOW (California):** Founded in 2018, this firm designs portable power stations and solar solutions to provide reliable, sustainable energy for mobile use, emphasizing accessibility and clean energy integration. **(Howarth, 2024)**
- **Global Energy Generation (Pennsylvania):** Established in 2019, this company operates large-scale wind and solar farms designed for industrial and personal use, covering over 100,000 acres globally. **(Howarth, 2024)**
- **Common Energy (New York):** This platform connects households to local renewable energy projects. With over 100,000 connected households, it facilitates community-based carbon footprint reduction. **(Libby, 2024)**
- **Enernet Global (New York):** Founded in 2015, this company finances and operates microgrids, replacing expensive fossil fuels with high-efficiency renewable systems with zero upfront costs for clients. **(Libby, 2024)**
- **Public Grid (New York):** Established in 2022, this startup provides an energy management platform that integrates with existing electricity accounts to facilitate a seamless transition to green power without requiring new infrastructure investment. **(Libby, 2024)**
- **Recycle Track Systems (RTS) (New York):** Recycle Track Systems (RTS) represents a paradigm shift in the American waste management sector, evolving from its 1990 origins in New York City into a technology-driven leader in

environmental stewardship following a strategic restructuring in 2015. By integrating advanced data analytics and proprietary IoT technologies, the firm provides commercial and industrial clients, as well as government entities, with customized solutions that prioritize high-efficiency recycling and operational sustainability. Guided by the vision of a "world without waste," RTS has achieved a notable 75% waste recovery rate, enabling the reintegration of materials into the circular economy while simultaneously optimizing logistical costs and reducing carbon footprints. The company's sophisticated tracking platform empowers stakeholders with real-time, transparent data, facilitating a transition from traditional disposal methods toward a more innovative and ecologically responsible industrial routine **(Houhou, 2023, pp. 102–103).**

- **Tesla & the Electric Vehicle (EV) Boom**: By 2025, EVs have become a standard in American transportation, with sales exceeding 40% of the new car market. This shift is supported by the federal "Clean Car Act" and a national plan to deploy 500,000 charging stations by 2030. Tesla, as a pioneer, has popularized high-performance models (S and 3) while expanding into energy storage (Powerwall) and solar roof tiles. **(Technology, 2025; Greenfield, 2023)**

5. Conclusion

In light of global environmental and economic challenges, green start-ups have become a strategic choice to support the transition toward a green economy and achieve sustainable development. They represent a model that harmonizes innovation, economic profit, and environmental preservation. Drawing inspiration from successful international experiences can contribute to developing a local supportive environment through legislation, financing, and incentives.

Key Findings:

- Green start-ups are strategic tools for balancing environmental and economic goals.

- Environmental innovation and clean technology significantly reduce resource depletion.
- While the transition offers promising investment opportunities, it faces challenges like limited financing and weak legislative frameworks.
- International models serve as a vital blueprint for local eco-friendly projects.
- An integrated "incubator" environment—including legislation and funding—is essential for start-up sustainability.

Recommendations:

- Enact specific laws and incentives to support green start-ups.
- Provide accessible financing for innovative environmental projects.
- Promote environmental awareness among entrepreneurs and society.
- Adapt successful international experiences to the local economic *context.*

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