

Green Entrepreneurship and Sustainable Innovation for Climate-Resilient Economies

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Abstract: The issue of global climate change has made calls of sustainable low-carbon and resilient economic systems in the developing and vulnerable regions. Green entrepreneurship has also become one of the notable avenues of gathering innovation, renewable technologies, and environmentally accountable business patterns that enable economic progress and climate resiliency. Although the extant scholarship has made progress in understanding the sustainability transitions, the nature of change that is brought about by the green entrepreneurs in the emerging economies is not well understood. This essay looks into green entrepreneurship as a driver of sustainable innovation and climate-reliant economic transformation. It combines modern works on sustainable system of innovation, ecological modernization, circular economy and mission-oriented entrepreneurship. The article claims that the strategic contribution that green entrepreneurs can make to lower environmental risk, boost adaptive and transformative capacities, and increase long-term economic resilience in emerging economies is their frugal eco-innovation, resource efficiency, renewable energy solutions, and circular business models. The research determines that there are significant limitations such as institutional weaknesses, gaps in financing, inconsistencies in policies, and technological limitations. An analytical model of the Ecological Modernization Theory and the Sustainable Innovation System approach is worked out to lead further empirical investigations. The paper ends by giving suggestions to the policymakers, researchers and entrepreneurs on how to empower green entrepreneurship to become climate resilient in its development.

Key words: Green entrepreneurship, sustainable innovation, climate resilience, emerging economies, circular economy, ecological modernization



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Background to the Study

Climate change is here to stay not a phenomenon but a direct socioeconomic problem that impacts ecosystems, world health, agriculture, livelihood, and national development. The rising frequency of extreme weather conditions such as floods and heatwave as well as droughts and coastal

erosion are posing serious developmental threats especially to the new economies. The Intergovernmental Panel on Climate Change (IPCC, 2022) explains that since climate disrupts influence disproportionately, developing areas are particularly vulnerable to and experience long-term effects in their economies. These facts highlight the importance of adaptive, innovative and transformational approaches to making climate resilient economies.

Green entrepreneurship has become a high-value concept in the recent years as one of the ways of solving the climate problems and ensuring a sustainable economic development. The concept of green entrepreneurship involves the entrepreneurial efforts that consider environmental sustainability as the development of environmentally friendly products, services, technologies, and business models (Moser et al., 2022). This type of entrepreneurship goes beyond the conventional profit generation to include ecological conservation, greenhouse gases, effective use of resources, and social welfare.

Green entrepreneurship has been closely associated with the global sustainable development agendas, and specifically with the United Nations Sustainable Development Goals (SDGs), with climate action (SDG 13) as its priority, affordable and clean energy (SDG 7) and sustainable cities (SDG 11), and responsible consumption and production (SDG 12). A shift to the green economic systems is reliant on the introduction of new strategies that will decrease reliance on fossil fuels, increase renewable energy, and create resiliency within industries and communities.

The developing economies have got their own opportunities and challenges towards achieving sustainable development. Although they tend to have institutional weaknesses, technological gaps, and financial constraints, they also have a high potential of green innovation owing to their rich natural resources, young populations, and a growing use of digital and clean technologies (Doherty and Kester, 2021). Green entrepreneurs operating within such environments often engage in frugal innovations, the creation of low-cost, resource-efficient, and context-specific remedies to the environmental problems and the satisfaction of the local demands.

In addition, sustainable innovation is fertilized by the emergence of climate-smart agriculture, off-grid renewable energy systems, waste-to-wealth, low-carbon mobility, and the circular economy models as well. The digital transformation enhances the ability of green entrepreneurs as well, since it allows the provision of data-driven sustainability solutions, remote monitoring, clean-tech diffusion, and smart manufacturing (Feroz et al., 2021).

Nevertheless, the level of green entrepreneurship in building resilience to climate is conditional on a variety of systemic circumstances. They are regulatory systems, green policies, financial incentives, green financing systems, and ecosystems of innovation (Aziz and Wahab, 2023). Effective environmental governance is very important in the generation of enabling environments that the green ventures may flourish.

Although there is increasing focus and investment in green innovation, there are still major gaps in the knowledge of the role of green entrepreneurship in supporting climate resilience in emerging economies. The current literature is biased towards developed nations and does not offer much information about the institutional, cultural, infrastructural, and market dynamics that are specific to the developing world and influence sustainability transitions. This paper fills these gaps by combining the modern understanding of sustainable innovation and resilience-building, suggesting an inclusive conceptual model, and providing policy suggestions.

Statement of the Problem

Numerous researches admit the fact that the most susceptible countries to climate change effects are the emerging economies, as the least prepared to adapt to the effects, as they have little technological, financial and institutional resources. The agricultural productivity, infrastructure, and the health, as well as economic stability of people are still threatened by floods, droughts,

increasing sea levels, and heat stress (World Bank, 2023). Conventional policy reactions have targeted mostly on adaptation and mitigation, but have failed to curb the gaps in innovation and transforming the systemic changes to ensure long-term climate resilience.

Green entrepreneurship opens a bright way towards curbing the environmental degradation and promoting sustainable economic development. Nevertheless, there are a number of issues that limit its potential:

Institutional Barriers: The barriers to sustainable innovation by low environmental regulations, unequal application of policies and incentives are not in favor of investments in sustainable innovation.

Inadequate Access to Green Financing: Green projects tend to be very long term and most emerging economies have poorly developed capital markets, low levels of investor confidence and lack access to climate finance (OECD, 2022).

Technological Barriers: most green entrepreneurs have poor technological accessibility to clean technologies, technical know how, and innovation infrastructure.

Market and Cultural Constraints: In a large number of developing areas, consumer awareness and demand of products that are environmentally friendly are very low and this lowers the viability of the markets.

Fragmented Innovation Ecosystems: Cooperation between universities, industries, government agencies and community is still minimal, which hinders the sharing of knowledge and dissemination of innovation.

Poor Research: A lack of empirical studies on the ways in which green entrepreneurship directly benefits climate resilience exists, especially in the economies of Africa and Asia.

These gaps also reveal a critical necessity of more academic insights into green entrepreneurship as a sustainable innovation and tough economic change agent. Unless these systematic limitations are tackled, the emerging economies might not be able to fully utilize the potential of green entrepreneurship to trigger climate resilience.

Literature Review

Conceptualizing Green Entrepreneurship

The most common definition of green entrepreneurship is when business opportunities are pursued to create environmental, social, and economic value at the same time (Gast et al., 2020). In contrast to the conventional entrepreneurship, green ventures directly incorporate ecological objectives in their operations and aim at addressing environmental issues with the help of innovative solutions. These entrepreneurs are frequently institutional change agents- breaking the unsustainable practices, developing green market niches, and shaping consumer and corporate behaviour.

Green Entrepreneurship Dimensions.

Eco-Innovation

Eco-innovation is a collection of technological, organizational, and social innovations that impacts the environment in a smaller way (Schiederig et al., 2021). It encompasses the clean technologies, renewable energy, green materials, energy efficient manufacturing, carbon capture and waste reduction processes.

Circular Business Models

Circular entrepreneurship is based on regenerating resources, recycling, extending the lifespan of products, and closed loops (Bocken & Antikainen, 2021). Circular models reduce wastage and will favor sustainable consumption.

Green Ventures-Social and Community Based.

These projects combine environmental conservation and social development agendas- they usually appear in the rural and marginalized societies.

Enterprise Climate resiliency and Sustainable Innovation.

Sustainable innovation can be described as innovations that focus on the sustainability of the environment, economy, and social level at the same time. It improves resilience by mitigating the exposure to climatic hazards and developing adaptive capabilities within the following sectors: Agriculture (climate-smart farming), Energy (solar mini-grids), Transport (electric mobility), Manufacturing (green production systems) and Waste management (biogas systems).

The emerging economies are more and more taking the advantage of frugal and native innovations to solve environmental issues.

Motivators of Green Entrepreneurship in New Economies.

Climate Threats and Environmental Degradation.

The emerging entrepreneurial prospects of renewable energy, resilient infrastructure against floods and drought-resistant agriculture, and sustainable material production are driven by the emerging ecological risk patterns (IPCC, 2022).

International Climate Politics and Commercial Forces.

Climate agreements and ESG (Environmental, Social, and Governance) standards help firms to become sustainable establishing new market niches.

Digital Transformation

Digital technologies allow to achieve precise agriculture, intelligent energy, carbon accounting, and optimization of the green supply chain (Kais and Miyazaki, 2021).

Growing Consumer Awareness

The rise of urbanization and environmental activism in the world makes people demand products and services that are environmentally friendly.

Government Incentives

Green innovation is encouraged by carbon pricing, renewable energy subsidies and green procurement policies.

Obstacles to Green Entrepreneurship.

Financial Barriers

The barriers to innovation are high initial costs and absence of access to climate finance. Green bonds, carbon credits and blended finance are some of the funds that are not fully used.

Policy and Governmental Obstacles.

This is because of weak enforcement of environmental laws and as a result unsustainable practices are sustained.

Infrastructure and Technological Lack.

Numerous areas do not have recycling plants, clean energy infrastructure and research laboratories.

Cultural Barriers

Low-income economies have consumers who will focus on affordability rather than on environmental benefits.

Green Entrepreneurship: A Role in Building the Economies of the Future.

Enhancing Adaptation

The entrepreneurs come up with products that minimize vulnerability including flood resistant housing, drought resistant seeds and early warning systems.

Endorsing the DE carbonization.

Green entrepreneurs promote renewable energy, energy efficiency and low-carbon manufacturing.

Empowering Local Communities.

Green enterprises generate green employment and incomes.

Full Acceleration of Sustainable Urbanization.

The climate-smart cities are supported by green building materials, green mobility, and waste-to-energy technology.

Theoretical Perspectives

Ecological Modernization Theory.

According to this theory, economic growth and protecting the environment can be combined with the help of the technological innovation and institutional changes (Mol & Spaargaren, 2020).

Sustainable Innovation Systems Theory

This framework provides focus on the role of the actors, networks, institutions and knowledge flows in instigating sustainability transitions.

Resource-Based Theory

Green innovation helps in improving the competitive advantage as it builds peculiar sustainability capabilities.

Theoretical Framework

The Ecological Innovation Theory (EIT)

The Ecological Innovation Theory offers a level of conceptual footing to the way entrepreneurial activities, technology innovation, and organizational capacity can be facilitated towards environmental sustainability and economic growth at the same time. In contrast to the traditional perspectives of innovation with their major focus on efficiency, profitability, or technological excellence, EIT focuses on innovation that minimizes environmental impact, enhances efficiency of resources, waste reduction, or creates environmentally friendly products and processes. According to the theory, the companies - even green entrepreneurs - incorporate the goals of ecology during the initial design and commercialization phases of innovations, thus connecting the goals of ecology with the strategic competitiveness (Carrillo-Hermosilla, del Rio, and Konnola, 2021).

Ecological innovation is of particular relevance within the context of the emerging economies. The existence of structural constraints like infrastructure, insufficient funding of research and development, and lack of energy security, as well as laxity in enforcing regulations, make the

establishment of eco-friendly business a complicated affair. Nevertheless, EIT states that these limitations may provide creative adaptation and resourceful green innovation. The solutions produced by green entrepreneurs can be described as low cost and context-sensitive ecological systems like decentralized renewable energy systems, waste-to-wealth, eco-processing technologies, and community-based resource regeneration models (Agyekum et al., 2022). Ecological innovation therefore plays an important role in establishing climate resilient economies in areas where the environment is undergoing degradation and being challenged by climatic factors.

EIT also assumes that the answer is eco-innovation as a product of various forces: regulatory frameworks, demand of green solutions in the market, organizational learning, and technological opportunities. Environmental regulations, subsidies, tax incentives, and carbon pricing mechanisms that compel firms to cleaner production play an important role by governments. Meanwhile, the need of the society in sustainable products drives entrepreneurs to reconsider the models of production, the packaging, and the channels of distribution, as well as their environmental impact in general (Tripathi and Mishra, 2023). The green entrepreneurial behavior is based on this dual mechanism, which is regulatory push and market pull.

Secondly, the theory lays stress on the part played by knowledge and absorptive capacity and learning process in the process of ecological innovation. Those entrepreneurs involved in investing in R&D capabilities, ecosystem partnering and sustainability skills are more likely to come up with breakthrough ecological solutions. As an example, green entrepreneurs who have embraced digital technology, like energy efficiency through IoT monitoring, waste sorting with AI capabilities, or traceability with block-chain possibilities are the intersection of technology and ecological innovation. Thus, EIT offers a suitable theoretical basis to provide the explanation of how green entrepreneurship improves sustainable innovation and leads to climate-resilient economic change.

Sustainable Innovation Systems (SIS) Framework.

The Sustainable Innovation Systems (SIS) framework broadens the conceptualization of ecological innovation by considering the wider context of innovation ecosystem which facilitates or hinders the establishment, dissemination and institutionalization of sustainable technologies and practices. Compared to traditional models of National Innovation Systems (NIS) and Sectoral Innovation Systems (SIS), which put emphasis on technological competitiveness, the Sustainable Innovation Systems view integrates sustainability shifts and ecological goals into the scope of innovation research. It treats innovation as a system that brings together the activities of the public institutions, private enterprises and universities, civil society participants, intermediaries and natural resource systems (Andersen and Markard, 2020).

As the SIS framework entails, sustainable innovation requires an enabling ecosystem that is typified by:

Well-established policy and regulatory frameworks (e.g., renewable energy policy, green finance policy, waste management regulations);

Research and knowledge bases (universities, research, research institutes, innovation hubs);

Financial sources and Green investment systems (impact investment funds, venture capital, climate financing);

Incubators, sustainability clusters, accelerators (and networks); and

Pressures and environmental rules on society (consumer cognizance, activist groups, ESG anticipations).

Green entrepreneurship therefore functions in an interdependent system which defines the opportunity structures and availability of resources. To illustrate, an enabling policy environment, e.g. feed-in tariffs or net-metering policy; R&D cooperation with universities; financing by investors with climate interest; and acceptance of clean energy solutions by consumers; is needed to enable a renewable energy start-up. The SIS framework postulates that systematic interactions on these institutional and socio-technical dimensions bring about sustainable innovation.

The SIS framework in the emergent economies brings to light the opportunities as well as the systemic barriers. Although the area is frequently characterized by poor institutional coordination, insufficient sustainability funding, and inadequate innovation ecosystems, the framework identifies the opportunities of sustainability transitions through local knowledge systems, indigenous technologies, local eco-innovation of grassroots, and regional groups of green entrepreneurs. Indicatively, African waste-recycling innovations, Indian frugal green technologies or Southeast Asian circular bioeconomy models represent how systemic interactions, and not independent entrepreneurial activity, lead to sustainable innovation performance (Mendonca, 2021).

Moreover, it is emphasized in SIS that sustainable innovation is a path-dependent process that is both a long-term and iterative process that needs institutional alignment and policy coherence. The industrial policy, environmental policy, and science/technology policy need to be in line with policies that promote renewable energy. Universities should imitate sustainability education and work with industries in the co-creation of green knowledge. The civil society has to create the demand pressures by exerting sustainability and consumer activism pressure. Green entrepreneurs act as the operators of the central system that hastens the transition by commercializing greener technology and confronts unsustainable socio-economic systems (Markard et al., 2023).

The Sustainable Innovation Systems model thus offers a structural explanation in a wider scope of how green entrepreneurship helps towards climate resilient economies. It demonstrates that not only personal competencies, but also systemic interactions in the world of innovations, are what contribute to entrepreneurial success. Sustainable innovation can then be scaled, diffused, and institutionalised when these systems align, and then these systems become faster in developing climate-friendly economic systems.

Combining the Two Theories to the Conceptual Model.

The combination of Ecological Innovation Theory and the Sustainable Innovation Systems framework can offer a comprehensive theoretical foundation on which this study will rest. EIT describes the innovation behaviour of green entrepreneurs in terms of micro behaviour and how eco-innovation is motivated by environmental drives, technology abilities and market forces. SIS describes the system dynamics in the macro-level: institutions, networks, policies, financing, and knowledge systems, which facilitate or constrain sustainable innovation.

Both theories can be used to explain that:

Green entrepreneurship is also an agent as well as a product of the sustainable innovation systems.

The system-wide interactions create ecological innovation, rather than individual capabilities.

Climate resilient economies develop when the eco-innovations spread by promoting institutional, financial and technological networks.

This synthesized theoretical framework will inform empirical research, provide the basis of variable selection, and infuse the conceptual model of the study.

Empirical Review

The past few years have seen a substantial growth in the body of empirical research on green entrepreneurship, sustainable innovation, and climate-resilient development as the world undergoes sustainability transitions and with growing alarm over the vulnerabilities associated with climate change. The experience of developing, emerging, and developed economies proves that there is a definite connection between green entrepreneurial activity and the creation of a sustainable and climate-friendly economic system. Nonetheless, the level of empirical results will differ based on the capacity of the institutions, infrastructure of innovation, regulation, financial accessibility, and socio-technical dynamics of the wider sustainable innovation regime.

Green Innovation and Sustainable Entrepreneurship.

The empirical research has provided good evidence of green entrepreneurship playing a significant role in sustainable innovation in terms of product development as well as process transformation. Liu, Wei, and Chen (2022) conducted a cross-country study of 38 emerging economies and discovered that green entrepreneurship orientation positively influences the performance of eco-innovation particularly with governmental green stimulus and national knowledge base. On the same note, Abubakar et al. (2023) with the help of Nigerian SMEs revealed that the green entrepreneurial alertness and opportunity recognition are important predictors of sustainable innovation outcomes, and the use of digital technology serves as a moderating variable that reinforces the innovation output of green entrepreneurial actions.

Empirical evidence also highlights the importance of the entrepreneurial capabilities in the determination of innovation patterns. Indicatively, the research by Youssef and Al-Kabbani (2021) established that the competitive eco-innovations in the Middle East and North Africa (MENA) region are more generated by green entrepreneurs who have a high absorptive capacity, which refers to the capacity of these entrepreneurs to recognize, absorb, and utilize external knowledge. These findings correspond to the ecological innovation theory that emphasizes that knowledge acquisition and learning processes are critical to the emergence of ecological innovation.

Moreover, the research at a company level in Asia and Latin America indicates that green entrepreneurial strategies improve the emergence of clean technologies in terms of renewable energy, sustainable agriculture, waste valorization, and circular production framework. Gadhavi and Sharma (2022) in India established that green entrepreneurs in the waste-recycling industry created a significant impact on the sustainable material recovery and minimized urban waste pollution through the incorporation of frugal ecological innovations. In a related study, Oliveira and Barbosa (2024) found that green startups in bioeconomy sector enhance energy efficiency and greenhouse gas emissions reduction, which is possible through process eco-innovations facilitated by local university-industry innovation networks.

Green Business and Economic Resilience to Climate.

The available empirical data has continuously demonstrated that the more green the entrepreneurship established in an economy, the more resilient it has towards climatic shocks partly owing to the sustainable utilization of resources, diversified sources of energy, and mitigation of environmental risks. Based on panel data on 24 African economies, Mensah and Boateng (2023) identified green entrepreneurship as a significant buffer to the adverse impacts of climate-related disturbances on agricultural production and the local economic well-being. They report that their analysis reveals that the areas with the operational green entrepreneurial ecosystems, particularly those in solar irrigation, sustainable agriculture, and environmentally friendly processing, are less vulnerable to climate change and that of the post-shock recovery is higher.

In Southeast Asia, Tran and Hoang (2022) empirically determined that green entrepreneurship improves climate resilience by fostering the growth of decentralized renewable energy systems which lessen the reliance on fossil fuel-powered national grids. According to their results, local renewable energy projects had a positive impact on energy security and economic stability of rural regions in case of extreme weather. These findings are in line with the claims made under the Sustainable Innovation Systems (SIS) framework which emphasises the systemic interactions between entrepreneurs, technological organisations, and regulatory organisations as sources of climate resilience.

Moreover, the findings of empirical research show that green entrepreneurship also has an impact on the indicators of the environmental performance at the State level. In a research done by Garcia-Perez et al. (2021) on Latin American economies, it was shown that the rise in green entrepreneurial activity is associated with a reduction in the carbon intensity and increment in environmental sustainability indexes, particularly when the green finance systems are well-developed. This implies that supportive financial mechanisms have strong effects on enhancing environmental impacts of green entrepreneurial ventures.

Drivers, institutional and Systemic Drivers of Green Entrepreneurial Outcomes.

Empirical studies stress the importance of institutional quality and the conditions of the innovation framework that is critically important in determining the success of green entrepreneurship. As an illustration, Agyekum et al. (2022) discovered that the institutional coordination of West African economies restricts the scalability of eco-innovations and prevents the green entrepreneurs to get financing, research support, or go through the regulatory processes. Conversely, the rates of green entrepreneurial success are greater in the countries where policy ecosystems are integrated, i.e., South Africa, Kenya, and Morocco because of consistent sustainability policies, environmental rules, and knowledge networks (Makhura & Sebola, 2021).

The argument, which states that there is green entrepreneurial activity when there is strong environmental regulation, is supported by evidence of China. Zhang and Tian (2023) demonstrated that the pressure of environmental regulation drives firms to use cleaner technologies and stimulates the appearance of green startups in the industries with a significant pollution with the help of the dataset of 1,200 firms. This is in line with the policy-push aspect of ecological innovation theory. On the contrary, in economies with the presence of inconsistent enforcement of environmental laws, green entrepreneurs receive disincentives, and sustainable innovations are not easily diffused (Roy and Jha, 2022).

In addition, empirical research emphasizes the role of innovation systems which are universities, incubators and R&D centers and cluster networks in improving green entrepreneurial performance. To illustrate, Mendonca (2021) determined that companies were ingrained in sustainability-based innovation network in Brazil demonstrated greater eco-innovation performance compared to isolated companies. These clusters offered common infrastructure, platforms of exchange of knowledge and joint R&D opportunities that contributed to a faster commercialization of green technologies. The same evidence has been noted in Kenya, which indicates that the green technology hubs including the renewable energy labs and sustainable agriculture incubators increase the innovation capacity of green entrepreneurs significantly (Omondi & Wekesa, 2023).

Monetary and Investment Processes, Green Business, and Enterprise.

One of the most frequent empirical observations drawn by a variety of studies is that the success of the sustainable entrepreneurial ventures is directly dependent on the access to the green financing. Chen, Lin, and Wang (2023) proved, with a structural equation modeling, that green finance instruments (sustainability bonds, green microcredit, and concessional loans) are

important to increase eco-innovation intensity in SMEs. Impact investors who bring long-term capital and advice also come to avail the presence of green investment structures.

Financing gap is still a significant barrier in emerging economies. Research in Sub-Saharan Africa has shown that the challenge with the start-up capital lies in the fact that most green entrepreneurs perceive the risk of making their venture long-term as high. Nevertheless, Essel and Frempong (2022) demonstrate that in case governments offer green credit warranties or sustainability-oriented investment initiatives, eco-innovative startups have a higher growth rate, increased employment levels, and better environmental impacts. They prove that the financial mechanisms are the inseparable parts of the greater sustainable innovation system.

Empirical Insights in a Nutshell.

Empirical evidence in the world, over various economic backgrounds, continuously indicates that:

Green entrepreneurship provokes ecological change and sustainable innovation.

Eco-innovations can be used to improve climate resilience by ensuring that environmental risks are minimized and that resources can be used in a sustainable manner.

Green entrepreneurial success is highly dependent on institutional quality, regulatory systems, and innovation systems.

The availability of green finance is an essential factor of sustainability in entrepreneurial development.

These empirical results support the main thesis that green entrepreneurship may be one of the driving forces to build climate-resistant economies, especially in the emerging countries where environmental frailties are severe.

The Gaps in Methodology and Implications of the research.

Research gaps include:

There is a shortage of longitudinal research on the effects of green innovation.

Poor research on green entrepreneurship in Africa.

Also lack of sufficient research on the relationship between green entrepreneurship and measurable climate-resilience indicators.

Poor incorporation of digital sustainability to green entrepreneurship research.

Macro-micro integrated studies, ecosystems, and mixed methods should be embraced in future studies.

Conclusion and Recommendations

To develop climate-resilient economies, green entrepreneurship is necessary. It fosters sustainable innovation, mitigates environmental risks, amplifies adaptive capacity and makes green economic change. In order to enhance the green entrepreneurship:

Governments need to increase green financing, impose environmental policies, and promote innovation systems.

Circular and frugal innovation strategies should be embraced by the entrepreneurs.

Empirical research of the effects of green innovation needs to be furthered by academic researchers.

Climate finance access in the developing countries should be increased by international organizations.

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