Enhancing the Role of Educational Human Resources in Encouraging Environmentally Friendly Innovation for Sustainable City Transformation in the Industrial Transition Era.

[1]**Krittavit Bhumithavara** (ISIC- Rajamangala University of Technology Krungthep Thailand)
Email: krittavit.b@mail.rmutk.ac.th

[2]**Chatchai Rakthin** (ISIC- Rajamangala University of Technology Krungthep, Thailand)
Email: surachai.t@mail.rmutk.ac.th

[3]**Ada Marie Mascarinas** (ISIC- Rajamangala University of Technology Krungthep, Thailand)
Email: ada.marie@mail.rmutk.ac.th

Keywords: Environmentally, Innovation, Transformation, Industrial, Transition Era.

Received: 15 August 2025
Revised: 5 September 2025
Accepted: 14 Oktober 2025

ABSTRACT

The industrial transition era creates both challenges and opportunities for sustainable urban development, requiring effective integration of environmentally friendly innovations. However, the readiness of educational human resources to adopt and implement such innovations remains uneven, hindering progress. This study aims to assess the readiness of educational human resources in urban settings to encourage environmentally friendly innovation for sustainable city transformation. This quantitative research employed a cross-sectional survey design with 130 purposively sampled respondents, including educators and educational personnel directly involved in innovation adoption. Data collection utilized a validated questionnaire focusing on motivation, technical competence, institutional support, and strategy effectiveness. Sampling targeted the population actively participating in innovation processes within educational institutions. Results indicate a good level of readiness, with 77% of respondents moderately to very ready to adopt eco-innovations. Key internal factors included motivation (mean score 4.2) and environmental awareness (4.1), while institutional support (4.0) and training effectiveness (4.3) significantly enhanced adaptation. Collaboration among stakeholders emerged as a vital enabler for capacity building. The study concludes that developing educational human resources through continuous training and institutional support is crucial for fostering environmentally friendly innovation. Practical implications highlight the need for sustainable capacity-building programs, inter-sectoral collaboration, and policy frameworks to embed green technology into the education system, ultimately contributing to greener and more socially inclusive sustainable city transformation in the industrial transition era.

I. INTRODUCTION

The ongoing industrial transformation globally brings obstacles as well as opportunities for the development of future sustainability-oriented cities. However, the reality is that many cities still face difficulties in optimally integrating environmentally friendly innovations in various development sectors, including education. Several studies show that some human resources are still not fully prepared or able to adopt these innovations effectively (Ullah et al., 2025). Sustainable City Theory explains that sustainable development requires a balance between social, economic, and ecological aspects in urban development in order to be able to support future generations. This is important because resilient and adaptive human resources greatly determine the success of sustainable city development (Gao et al., 2025).

Promoting sustainable cities through eco-friendly innovation plays a crucial role in creating urban environments that are healthy, efficient, and resilient to the impacts of climate change. Environmentally friendly innovations such as the use of green technology, efficient waste management, and the development of green infrastructure help reduce carbon emissions and improve the quality of air, water, and natural resources(Singh et al., 2025). In addition, this innovation also supports the optimization of the use of renewable energy and the development of environmentally friendly transportation systems, thereby reducing dependence on fossil fuels and leading to a reduction in the ecological footprint of cities(*GREEN ENTREPRENEURS CHALLENGES AND INNOVATION : THE STRUGGLES THEY FACE ABSTRACT Article History : Received 30 Dezember 2021 Keywords : Challenges ; Opportunity ; Green in This Context Refers to Environmentally Sensitive Business Practises. According To* , 2022). Thus, this innovation provides a strong foundation for the creation of a city that is not only environmentally sustainable but also supports the social and economic welfare of urban communities(Ho & Lwesya, 2025).

In the context of increasing the readiness of educational human resources, environmentally friendly innovations play a role as a catalyst for learning and capacity building that is relevant to the needs of the times. Educational human resources who are ready to adopt innovation will be able to cultivate a generation that is environmentally aware and proficient in green technology. Another important role is strengthening collaboration between stakeholders and sustainable education, which can accelerate the process of adapting to technological and environmental changes (Al-Doghan et al., 2025). With this approach, educational human resources are not only recipients of innovation but also agents of change who are active in encouraging sustainable cities. Therefore, encouraging the readiness of educational human resources through environmentally friendly innovation also means preparing the foundation for strategic collaboration for greener and more humane urban development in the future(Martín-Díez et al., 2025).

Specific factors that hinder the readiness of educational human resources to adopt environmentally friendly innovations, especially in this period of rapid and dynamic industrial transition. Aspects of technical competence, motivation, and institutional environmental support are still lacking in comprehensive studies. Eco-Innovation Theory emphasizes that the adoption of eco-friendly

innovations is influenced by internal factors such as organizational capacity and external factors such as government support. Some literature indicates a significant difference in readiness between human resources in urban and non-urban environments, but there has been no direct research linking this aspect to environmentally friendly innovation in the context of industrial transition. This is in line with the adoption model of source innovation from Rogers in Diffusion of Innovations Theory, explaining that the adoption process goes through the stages of knowledge, persuasion, decision, implementation, and confirmation, which are influenced by the characteristics of innovation and adopters(Fathoni et al., 2025).

Another contradiction is the optimistic claims related to human resource readiness in several national policy reports, while empirical evidence proves that the readiness is uneven and sometimes limited only to certain groups. This indicates that there is a gap (Andriamanantena et al., 2025) between policy perceptions and field realities that is important for further research. Human Capital Theory emphasizes that investment in education, training, and skill development is key to increasing the productivity and adaptability of human resources. Information like this is an important foothold to understand the dynamics of the readiness of educational human resources to face new environmentally oriented innovations in the rapidly changing industrial era. Organizational Learning Theory supports that organizations that are able to learn and adapt will be more successful in implementing sustainable innovation(Agyemang et al., 2025).

Thus, there is still much that is unknown about how the effectiveness of various strategies to strengthen the readiness and adaptation of educational human resources to environmentally friendly innovations can be measured and applied practically. In particular, the role of collaboration between stakeholders, continuous training, and support for facilities and infrastructure in accelerating the innovation adoption process is still minimally explored. The urban context also presents unique conditions that have not been explored in previous research related to human resource readiness in the face of green innovation(Cano & Córcoles, 2025). Theories that are in line with Innovation Readiness and Adoption suggest that readiness is influenced by an understanding of innovation, positive attitudes, technical capabilities, and institutional support. The integration of this theory provides a comprehensive foundation for understanding how educational human resources can play an optimal role in encouraging sustainable cities through the adoption of environmentally friendly innovations.

In addition, it needs to be anticipated is the readiness of educational human resources can optimally be the main agent of change in encouraging sustainable city development through environmentally friendly innovation. In the current conditions, there is no specific and integrated human resource readiness model in the context of industrial transition and urban education comprehensively. The absence of such a model presents a major obstacle to formulating targeted policies and programs. Sustainable City Theory emphasizes that sustainable cities require human resources who can manage resources efficiently and reduce environmental impact through green technology innovations(Ho & Lwesya,

2025). Eco-Innovation Theory explains that eco-innovation is not only technology, but also includes sustainable changes in organizational processes, products, and systems.

The novelty of this research lies in the development of an educational human resource readiness and adaptation model that combines an environmentally friendly innovation approach with a special focus on the industrial transition phase in urban environments. This research will also test the effectiveness of collaborative strategies and continuous training, which have not been studied in depth in the context of human resource readiness in the education sector. Thus, this research makes a new contribution to the literature on the integration of innovation, human resources, and sustainable urban development(Lu et al., 2025). Human Capital Theory supports that human resource capacity development through continuous education and training will improve adaptability to technological and environmental changes. Organizational Learning Theory emphasizes the importance of a culture of learning and collaboration in educational organizations to support the sustainable adoption of innovation(Worakittikul et al., 2025).

The success of encouraging sustainable cities is highly dependent on the readiness of educational human resources to adopt environmentally friendly innovations, so this study will examine the factors that influence such readiness and how certain strategies can increase the adaptive capacity of human resources to ensure the role of human resources as effective agents of change in the sustainable development process(Afolabi, 2025). The purpose of the research is specifically to measure the level of readiness of educational human resources in adopting environmentally friendly innovations during the industrial transition period, identify factors that affect readiness and adaptation, analyze the effectiveness of the strategies used, and evaluate how the implementation of environmentally friendly innovations can encourage the sustainable development of educational human resources in urban environments. The research gap raised is the limitation of previous studies in linking the readiness of academic human resources with the adoption of environmentally friendly innovations, especially in the context of industrial transition and sustainable cities, such as the research of Astuti et al. (2018) entitled "The eco-innovation variables which influence the performance of creative industries center of natural stone crafts" which focuses on the creative industry without exploring the education sector, and Sichoongwe's research (2023) on "Determining Factors of Eco-Innovation Adoption" which is limited to micro and small enterprises without considering the context of human resources, education and sustainable urban development(Nowaczek et al., 2025).

II. METHODOLOGY

This study employs a quantitative method with a cross-sectional survey design, aiming to measure the readiness of educational human resources to adopt environmentally friendly innovations during the industrial transition period, thereby supporting sustainable urban development(Neuman, 2014). This survey involved 130 respondents, consisting of educators and educational personnel in urban educational environments. The sample was selected purposively to represent the group of human resources who play an active role in the process of adopting innovations in educational institutions. The research instrument was carried out in the form of questionnaires developed from indicators of innovation adoption readiness, influencing factors, and the effectiveness of adaptation strategies. The development of the instrument is carried out by literature study, expert consultation, and validity and reliability tests using statistical analysis, so that the instruments used are valid and reliable(Schoonenboom & Johnson, 2017). The collected data were analyzed using descriptive statistical techniques to map the level of human resource readiness and inferential analyses, such as regression, factor analysis, and correlation tests, to test the relationships between variables.

The research process begins with designing the instrument, then conducting trials on a small number of respondents to ensure the suitability and reliability of the instrument. After validation, the questionnaire was distributed to 130 respondents who met the criteria. The survey data were then processed with statistical software to get a comprehensive picture of the readiness of educational human resources and the factors that contribute to the adoption of environmentally friendly innovations. Conclusions and strategic recommendations are developed based on the results of the analysis to support human resource capacity development in the context of sustainable urban development.GFV

Table 1. Conceptual model

Variable	**Definition**	**Indicators**	**Relationships in Research**
Factors that affect the readiness of educational human resources (Independent Variables)	Internal and external factors that affect the readiness of educational human resources in adopting environmentally friendly innovations	Motivation, Technical Competence, Institutional Support	This variable affects the level of readiness of educational human resources to adopt environmentally friendly innovations
Educational Human Resources Readiness	The level of readiness of educational	Attitudes, Knowledge, Skills,	This variable is the result measured to

Level (Bound Variable)	human resources in facing and implementing environmentally friendly innovations during the industrial transition period	Adaptive Behaviors	assess the readiness of educational human resources in the adoption of innovation.
Effectiveness of Readiness Improvement Strategies (Moderator/Mediator Variables)	Strategies used to improve the readiness and adaptation of educational human resources to environmentally friendly innovations	Training, Collaboration, Policy Support	Training, collaboration, and policy support moderate or mediate the relationship between influencing factors and the readiness level of educational human resources.

Based on the results of Table 1 in this conceptual model it shows that free, bound, and moderator variables interact with each other in the study to illustrate the readiness of educational human resources in adopting environmentally friendly innovations to support the achievement of sustainable cities during the industrial transition period.

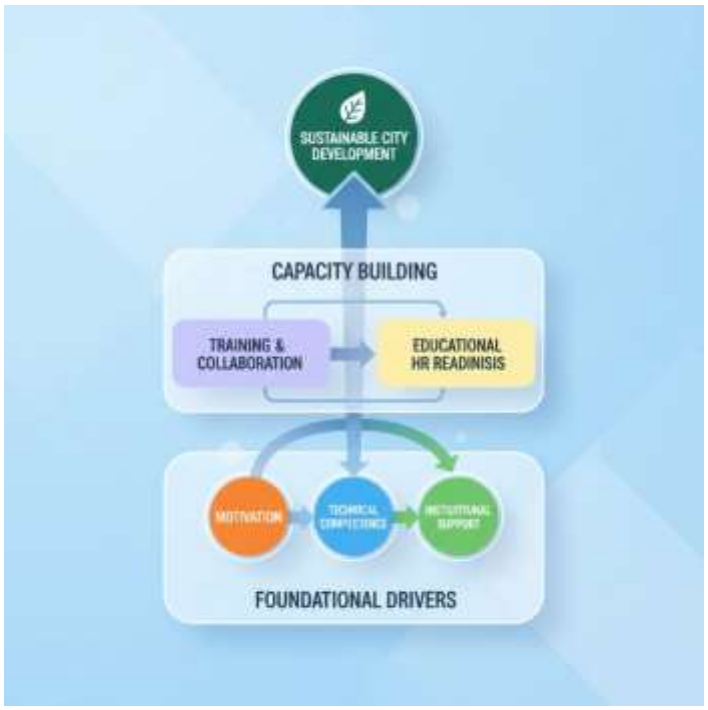
III. RESULTS AND DISCUSSION.

The level of readiness of educational human resources in environmentally friendly innovation during the industrial transition period is in a fairly positive category. The respondents, consisting of educators and education staff in urban education environments, showed a proactive attitude and readiness to learn and implement innovations that support environmental sustainability(Carral et al., 2025). This is in line with the theory of Diffusion of Innovations by Rogers, which states that the readiness to adopt innovation is greatly influenced by the attitude and readiness of individuals to new changes. This study found that most of the education human resources already have basic knowledge about the importance of environmentally friendly innovation and are starting to show adaptive behavior in the use of green technology and environment-based learning methods(Martín-Díez et al., 2025).

Factors that affect the readiness and adaptation of educational human resources can be classified into internal and external factors. Internal factors include personal motivation, technical competence, and awareness of the urgency of sustainability. Motivation is the main driving force that encourages

educational human resources to actively seek new information and experiences related to environmentally friendly innovations. Technical competence, especially the ability to use green technology tools and efficient methods, is a crucial aspect that determines the success of innovation adaptation. Influential external factors include institutional support in the form of pro-innovation policies, ongoing training, and the provision of appropriate facilities and resources. This condition aligns with Human Capital Theory, which emphasizes the importance of human resource capacity development as the primary foundation for sustainable development. Such institutional support significantly facilitates the transition process and reduces barriers to implementing environmentally friendly innovations in educational institutions.

Figure 1. Sustainable City Development



Capacity building refers to the continuous process of developing and strengthening the knowledge, skills, resources, and organizational structures that individuals, institutions, and communities need in order to effectively address current and future challenges. In the context of sustainable development, capacity building is a crucial element that enables societies to implement eco-friendly innovations and sustainable practices successfully. It equips stakeholders, including educational human resources, with the necessary competencies to adopt new technologies and adapt to changes, thereby facilitating sustainable growth and resilience. This process encompasses a wide range of activities, such as training programs, knowledge-sharing initiatives, policy development, and fostering collaboration among various stakeholders like governments, educational institutions, and the private sector. Capacity building promotes an enabling environment where innovation can be effectively integrated into daily practices, ensuring that sustainability goals are met. It also supports the enhancement of institutional frameworks and the creation of

partnerships that accelerate learning and action toward sustainable urban development. Therefore, capacity building not only improves individual skills but also strengthens organizational and system-wide capabilities, supporting long-term sustainable transformation in education and beyond.

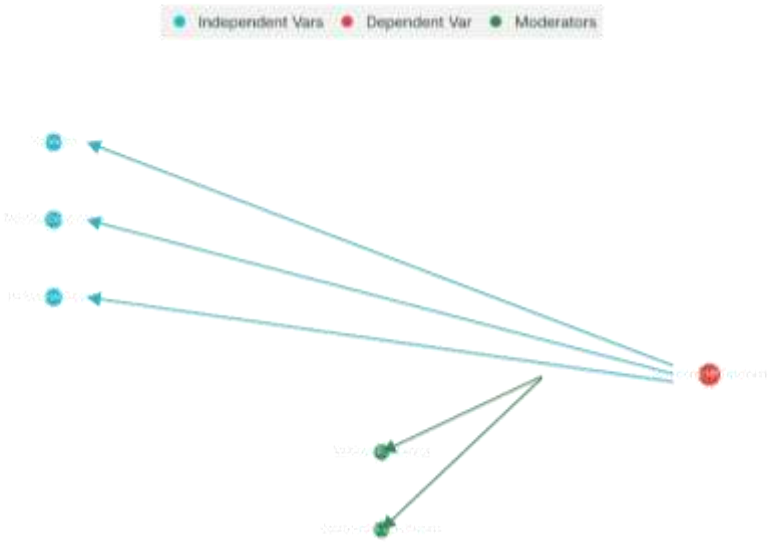


Figure 2. Educational HR Readiness Model

Analysis of the effectiveness of strategies used to improve the readiness and adaptation of educational human resources shows that continuous training, collaboration between stakeholders, and the provision of supporting infrastructure are important elements. Regular and structured training not only increases knowledge but also builds the confidence of educational human resources in practically implementing environmentally friendly innovations. Collaboration between educational institutions, government, and the private sector opens up space for dialogue and sharing of resources and best practices that accelerate the learning process and the application of green technology. Additionally, adequate access to innovative facilities and equipment supports the integration of innovations into daily teaching and learning activities. This overall strategy reflects the principles of Organizational Learning, which emphasizes collective learning as the primary capital for continuous adaptation and innovation.

The extent to which the implementation of environmentally friendly innovations encourages the development of sustainable educational human resources is also the main focus of this study. Data shows that the implementation of innovation not only increases the technical capacity of educational human resources but also strengthens pro-environmental attitudes and values that are essential for long-term sustainability. Real experience in implementing learning methods and green technology can increase commitment to environmental issues while expanding insight into the important role of human resources in supporting sustainable urban development. These findings are in line with the concept of Sustainable City Theory, which emphasizes the involvement of all elements of society, including the education sector, as the main

pillar in creating an environmentally friendly and sustainable city. In addition to technical and policy aspects, this research also highlights the importance of organizational culture in educational institutions that supports innovation and continuous learning. A culture that opens up space for experimentation, reflection, and appreciation for the success of innovation has been proven to increase the motivation and readiness of human resources to continue to adapt to technological and environmental changes. This refers to Organizational Learning Theory, which states that a conducive organizational culture is a determining factor in the success of innovation and organizational transformation. The implementation of environmentally friendly innovations supported by a positive organizational culture is able to produce a wider impact on sustainable human resource development.

This study also identifies that the obstacles still faced by educational human resources in adopting environmentally friendly innovations are mainly related to the limitations of physical resources and adequate budgets(Chioatto, 2025). Despite the readiness and strong desire to adopt innovation, some educational institutions still face difficulties in accessing the latest technology and adequate training. Therefore, increased investment and policy attention from the government and other stakeholders are crucial in ensuring that all education human resources get equal opportunities in this adaptation process. This approach is consistent with Human Capital theory, which emphasizes human resource investment as the key to productivity and innovation(Carral et al., 2025).

Based on the results obtained, it shows that encouraging the readiness of educational human resources through environmentally friendly innovations is an effective strategy in supporting sustainable city development in the industrial transition period(Mallari et al., 2025). Human resource capacity building is not only technical, but also involves aspects of motivation, institutional support, and organizational culture that are responsive to change. The synergy between these components forms a strong foundation for integrating eco-friendly innovations in the city's education system, so that it can contribute to urban development that is sustainable, inclusive, and adaptive to global change. The practical implication is that education policy needs to be directed at the development of innovative training, strengthening multi-stakeholder collaboration, and facilitating facilities that support the sustainable implementation of green technology. This is expected to serve as a reference for policymakers and program implementers in the education and urban development sectors in designing targeted interventions to accelerate the transition to greener and more competitive sustainable cities.

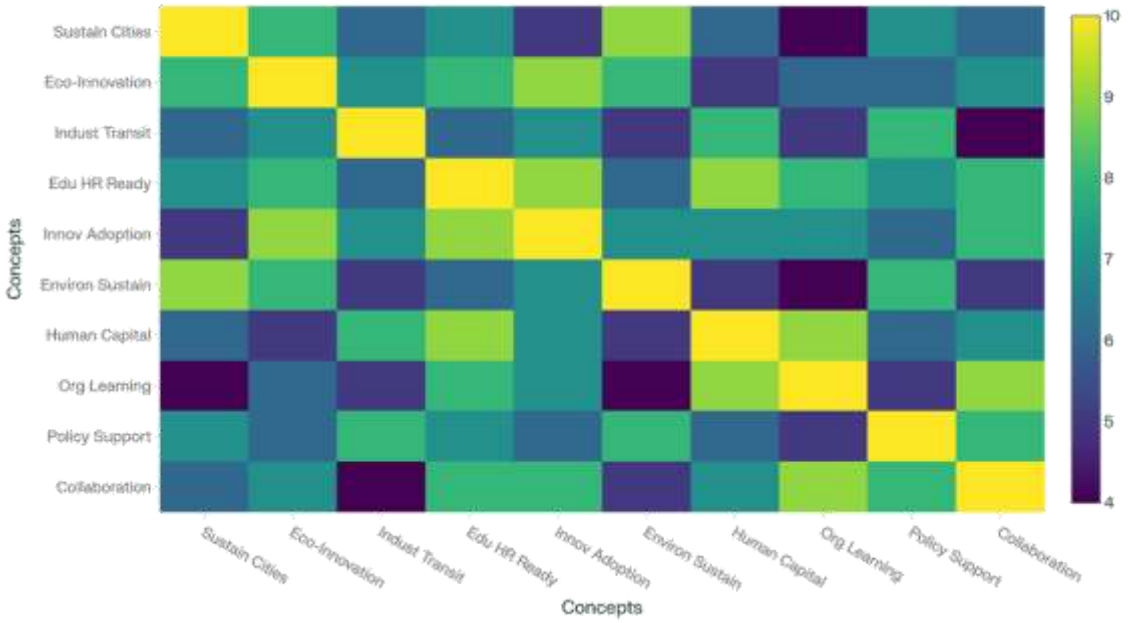


Figure 3. Co-occurrence Matrix Eco-Innovation

Table 2. Distribution of Education HR Readiness Level

Readiness Level	Percentage
Highly Ready	32
Moderately Ready	45
Somewhat Ready	18
Not Ready	5

The Distribution Table of the Readiness Level of Education Human Resources shows that the majority of education human resources are in the category of moderate to high readiness in adopting environmentally friendly innovations. 45% of respondents were in the "Moderately Ready" category and 32% in the "Highly Ready" category, indicating a positive tendency to embrace change and innovation. A relatively small percentage (5%) in the "Not Ready" category indicates that a small percentage of HR still needs special attention to improve readiness. This data reflects the importance of continuous efforts in providing

training and support so that all education personnel can achieve optimal readiness in the context of green innovation.

Table 3. Factors Affecting the Readiness of Educational Human Resources

Factor	Average Score (1-5)
Motivation	4.2
Technical Competence	3.8
Institutional Support	4.0
Policy Support	3.7
Environmental Awareness	4.1

Table 3 above shows the presence of factors that affect the readiness of educational human resources, revealing the highest average scores on motivation (4.2 on a scale of 1-5) and environmental awareness (4.1), indicating that enthusiasm and ecological awareness are the main drivers of individual readiness. Technical competence, although relatively lower (3.8), remains a crucial component, while institutional and policy support received close scores of 4.0 and 3.7. These results are consistent with the discussion, which shows that investment in human resources, according to Human Capital Theory, is very important to support the readiness of human resources to face new technological innovations and environmental barriers.

Table 4. The Effectiveness of Strategies to Increase the Readiness of Educational Human Resources

Strategy	Effectiveness Score (1-5)
Training	4.3
Collaboration	4.0
Policy Support	3.9
Resource Availability	3.7

In Table 4 above, the effectiveness of the Readiness Improvement Strategy indicates that training (4.3) and collaboration (4.0) are the most effective strategies in strengthening the capabilities and readiness of educational human resources. Policy support (3.9) and resource availability (3.7) also play significant roles but require further improvement for the implementation of innovation to run effectively. These findings strengthen the theory of Organizational Learning, which emphasizes the importance of continuous learning and inter-institutional

cooperation as the main factors in the successful adoption of environmentally friendly innovations in the educational environment.

This research is also supported by Human Capital Theory, popularized by Becker (1993), which emphasizes the importance of human resource development through education, training, and competency development as a strategic investment to increase productivity and adaptation to environmental and technological changes. The authors Astuti et al. (2018) in their research entitled "The eco-innovation variables which influence the performance of creative industries center of natural stone crafts," explored that investment in the development of technical capabilities and environmental knowledge increases readiness to adopt environmentally friendly innovations in the context of the creative industry. These findings are in line with the results of research that emphasizes the importance of improving technical competence and environmental awareness among educational human resources in the face of industrial transition.

Sustainable City (Wardhani et al., 2024) is a conceptual framework that directs this research to understand how environmentally friendly innovations can change urban development patterns to be more sustainable. Research by Wardhani et al. (2024) entitled "Sustainable Urban Development through Green Innovation" shows that the integration of green technology innovation with the active involvement of human resources in various sectors, including education, significantly improves the quality of the urban environment. The results of this study support that the readiness of educational human resources to adopt and implement environmentally friendly innovations will have a broad positive impact on the development of sustainable cities with a strong ecological and socially inclusive basis.

The Organizational Learning Theory described by Argyris and Schön (1978) also provides a solid theoretical foundation to explain the importance of a culture of learning and collaboration in educational institutions. Sichoongwe's (2023) research on "Determining Factors of Eco-Innovation Adoption" proves that organizations that are able to maintain an adaptive and collaborative learning culture will adopt sustainable innovation faster. This study confirms that training, knowledge exchange, and institutional support are the keys to the successful adaptation of educational human resources to environmentally friendly innovations. The alignment of these findings with the results of the research proves that strengthening the learning culture and collaboration is an important aspect in supporting the readiness of educational human resources during the industrial transition period. The results of the research that combines the readiness of educational human resources, human resource investment, environmentally friendly innovation, sustainable urban development, and organizational learning make a significant contribution to understanding how human resources can become agents of strategic change in the era of industrial transition. This theoretical reference strengthens the validity of the findings while opening up opportunities for the application of these principles more widely in the education and urban development sectors in the future.

IV. CONCLUSION AND RECOMMENDATIONS

It can be concluded that the level of readiness of educational human resources to adopt environmentally friendly innovations is in the good category, with most respondents showing a positive attitude and openness to the adaptation of green technology in the urban education environment. The main factors affecting this readiness include motivation, technical competence, and institutional support, all of which are significant drivers in the innovation adoption process. In addition, Continuous training and collaboration among stakeholders have proven to be effective strategies for strengthening the adaptation of educational human resources to changes in environmentally friendly innovations. The implementation of this innovation is also able to encourage sustainable development of educational human resources, which will later contribute to the development of sustainable cities more broadly.

The practical implications of this study emphasize the need to strengthen educational human resource capacity development programs sustainably, especially in terms of improving technical skills and instilling awareness of the importance of environmentally friendly innovation. Educational institutions and policymakers should provide systematic training and facilitate cross-sector collaboration to support the adaptation process of these innovations. Furthermore, consistent policy support and the provision of adequate infrastructure facilities are important keys so that environmentally friendly innovations can be effectively integrated into curricula and daily activities. Thus, educational human resources are not only technically ready but also have a strong commitment to sustainability that can strengthen the foundation of green and inclusive city development in the future.

Theoretically, these findings reinforce the view of Human Capital Theory that investment in human resource development is the main foundation for achieving sustainable development goals. In addition, these results also support the principle of Diffusion of Innovations, which emphasizes the importance of the readiness of individuals and organizations to absorb and implement innovations to succeed in technological transformation. Cultural readiness and Organizational Learning Theory are also strengthened by the finding that adaptive learning culture and collaboration between institutions are important factors in responding to changes and maximizing the use of environmentally friendly innovations in the education system.

REFERENCES

Afolabi, J. A. (2025). Advancing the circular economy in Europe: The role of eco-innovation, economic complexity, and digitalization. *Technology in Society*, *83*. https://doi.org/10.1016/j.techsoc.2025.103027

Agyemang, A., Osei, A., & Kongkuah, M. (2025). Exploring the ESG-Circular

Economy Nexus in Emerging Markets: A Systems Perspective on Governance, Innovation, and Sustainable Business Models. *Business Strategy and the Environment*, *34*(5), 5901–5924. https://doi.org/10.1002/bse.4278

Al-Doghan, M. A., Soomro, F. A., Abdelwahed, N. A. A., & Soomro, B. A. (2025). Driving circular economy progress through eco-innovations and greener enablers: a potent mechanism for environmental management and sustainability. *Management of Environmental Quality*. https://doi.org/10.1108/MEQ-09-2024-0392

Andriamanantena, A. N., Yana Mbena, J., Viala, C., & Durst, S. (2025). Enabling circular economy transitions in ports: The role of innovation ecosystems in North Sea Port. *Journal of Environmental Management*, *392*. https://doi.org/10.1016/j.jenvman.2025.126816

Cano, A., & Córcoles, D. (2025). Leveraging eco-innovation and market knowledge for a circular economy transition: Insights from Spanish manufacturing firms. *Technological Forecasting and Social Change*, *216*. https://doi.org/10.1016/j.techfore.2025.124152

Carral, L., Lamas-Galdo, M. I., Buenhombre, J. L. M., Cartelle Barros, J. J. C., Álvarez-Feal, C., & Tarrío-Saavedra, J. (2025). Valorisation of gourmet shellfish waste for sustainable artificial reef construction. *International Journal of Gastronomy and Food Science*, *41*. https://doi.org/10.1016/j.ijgfs.2025.101258

Chioatto, E. (2025). What do circular innovator firms look like in Emilia-Romagna? A cluster analysis of firms innovating in the circular economy. *Economia Politica*, *42*(2), 405–440. https://doi.org/10.1007/s40888-025-00367-0

Fathoni, F., Kesidou, E., Rifansha, M. M., & Tiftazani, A. (2025). Drivers and barriers of eco-innovation in electric vehicle diffusion: Evidence from Indonesia. *Journal of Environmental Management*, *389*. https://doi.org/10.1016/j.jenvman.2025.126021

Gao, J., Wang, L., & Li, K. (2025). A Bibliometric Review on Eco-Innovation in SMEs: Current Status, Development, and Future Directions. *Polish Journal of Environmental Studies*, *34*(2), 1083–1107. https://doi.org/10.15244/pjoes/187125

GREEN ENTREPRENEURS CHALLENGES AND INNOVATION : THE STRUGGLES THEY FACE ABSTRACT Article history : Received 30 December 2021 Keywords : Challenges ; Opportunity ; Green in this context refers to environmentally sensitive business practices. According to. (2022). 1–21.

Ho, Y.-S., & Lwesya, F. (2025). Sustainable tech's global ascent: An analysis of emerging eco-friendly innovations. *Development and Sustainability in Economics and Finance*, *7*. https://doi.org/10.1016/j.dsef.2025.100091

Lu, X., Brennan, M. A., & Brennan, C. S. (2025). Harnessing the multifaceted potential of mushrooms: Sustainable development, health promotion, and industrial innovation. *International Journal of Food Science and Technology*, *60*(2). https://doi.org/10.1093/ijfood/vvaf159

Mallari, C. B., San Juan, J. L., & Li, R. (2025). Policy design for the circular economy rebound: A system dynamics approach to green transitions in

product life extension models. *Journal of Cleaner Production*, *521*. https://doi.org/10.1016/j.jclepro.2025.146165

Martín-Díez, R., Saiz-Santos, M. Y Torralba, N. (2025). Circular Economy and Environmental Performance: Strategies and Challenges for SMEs in the Basque Machinery and Equipment Industry. *International and Multidisciplinary Journal of Social Sciences*, *14*(2), 134–157. https://doi.org/10.17583/rimcis.15688

Neuman, W. L. (2014). Pearson New International Edition Social research methods: Qualitative and Quantitative approaches. In *Pearson*. https://www.amazon.co.uk/Social-Research-Methods-Quantitative/dp/0205786839/ref=sr_1_5?s=books&ie=UTF8&qid=1461496914&sr=1-5&keywords=social+research+methods+qualitative+and+quantitative+approaches

Nowaczek, A., Kowalski, Z., Kulczycka, J., & Makara, A. (2025). Ecological Innovations Supporting Sustainable Development: The Case of the Polish Tire Industry. *Sustainability (Switzerland)*, *17*(16). https://doi.org/10.3390/su17167210

Schoonenboom, J., & Johnson, R. B. (2017). Wie man ein Mixed-Methods-Forschungs-Design konstruiert. *Kölner Zeitschrift Für Soziologie Und Sozialpsychologie*, *69*, 107–131. https://doi.org/10.1007/s11577-017-0454-1

Singh, A. K., Garg, V., & Kaushik, P. (2025). Darkside of Climate Neutrality and Smart Eco Innovations in Developed and Developing Countries. In *Climate Change Management: Vol. Part F106* (pp. 299–316). Springer Science and Business Media Deutschland GmbH. https://doi.org/10.1007/978-3-031-83250-5_18

Ullah, A., Treiblmaier, H., & Rejeb, A. (2025). Empowering circular economy transformation through immersive digital open innovation. *Journal of Innovation and Knowledge*, *10*(6). https://doi.org/10.1016/j.jik.2025.100812

Worakittikul, W., Srisathan, W. A., Rattanpon, K., Kulkaew, A., Groves, J., Pontun, P., & Naruetharadhol, P. (2025). Cultivating sustainability: Harnessing open innovation and circular economy practices for eco-innovation in agricultural SMEs. *Journal of Open Innovation: Technology, Market, and Complexity*, *11*(1). https://doi.org/10.1016/j.joitmc.2025.100494