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GREEN TECH STARTUP: ANALYSIS OF DIGITAL TALENT NEEDS TO SUPPORT INDONESIA'S GREEN ECONOMY TRANSITION

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Abstract: *The transition to a green economy is a priority agenda for Indonesia to achieve its Net Zero Emission target. However, the acceleration of this sector depends heavily on the readiness of human resources to integrate digital technology into environmental solutions. This study aims to analyze the specific needs of digital talent within Indonesia's green tech startup ecosystem and identify existing skills gaps. Using descriptive qualitative methods through literature reviews and secondary data analysis of industry reports, the results show a high demand for talent with competencies in data science for carbon footprint analysis, IoT-based energy software development, and digital circular economy specialists. The findings indicate a significant skills gap stemming from educational curricula that are not integrated with the needs of the green industry. This study recommends strategic collaboration among the government, academia, and industry players through reskilling and upskilling programs focused on sustainability to accelerate Indonesia's transition to a green economy.*

Keywords: *Green Tech Startup, Digital Talent, Green Economy, Indonesia, Digital Transformation.*

INTRODUCTION

The global ecosystem is currently at its lowest point due to the increasingly unpredictable climate crisis. Indonesia, as one of the countries with the greatest natural resource endowment, faces a dilemma between maintaining conventional economic growth and making a major leap towards a green economy. This transition is not just a trend, but an existential imperative. However, amid the government's ambitious goal of achieving Net Zero Emissions by 2060, a major paradox has emerged: technological infrastructure and policies are taking shape, but the key driver, human resources with digital-green competencies, remains extremely scarce.

The growth of green tech startups in Indonesia over the past decade has been positive, spanning renewable energy and app-based waste management. As stated in a study by Anderson et al. (2022), the success of green tech startups depends heavily on the integration of radical innovation and digital adaptability. In Indonesia, this phenomenon poses unique challenges. Despite very high internet penetration, digital literacy specific to supporting environmental sustainability remains at an alarming level. Zhang & Li (2021) emphasize that without qualified digital talent, green technology will remain merely passive hardware without the power to optimize.

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The main problem that arises is a skills mismatch. Higher education is often slow to respond to the needs of fast-moving industries. According to Smith (2023), a green economy requires "green-collar workers" who not only understand ecology but are also fluent in AI algorithms and big data analysis. In the Indonesian context, Rahman & Santoso (2022) highlight that informatics curricula remain overly focused on the fintech and e-commerce sectors, while the agrotech and clean energy sectors lack data analysts capable of accurately mapping carbon potential. This is reinforced by Miller's (2020) research, which finds that technology startups in developing countries often fail because local talent lacks the capacity to manage the complexity of IoT systems for monitoring natural resources.

Furthermore, global talent competition is intensifying. Brown (2021) identified that top digital talent tends to migrate to sectors offering immediate financial compensation, rather than to long-term environmental sectors. This is where analyzing the needs of digital talent becomes urgent. If Indonesia fails to promptly identify these needs, dependence on foreign experts will deepen, ultimately threatening national data sovereignty and resources (Patel & Gupta, 2023).

It's important to understand that digital technologies such as blockchain are now being used to increase transparency in green supply chains (Wang et al., 2022). However, who operates them locally? Nguyen (2023), in his study of transition economies in Southeast Asia, stated that the digital divide in remote areas is a major obstacle to implementing smart farming. In Indonesia, the vast geographical area requires digital talent capable of working in a decentralized manner. Kim & Choi (2021) added that the success of a green economy requires a balance between government policies and the technical readiness of human resources in the field.

Furthermore, regulatory aspects are often a double-edged sword. Garcia (2022) argues that strict environmental regulations without digital training subsidies will only hinder small startups. In Indonesia, the Job Creation Law and related regulations on carbon exchanges require new skills for digital emissions audits. Fernandez (2024) highlights that the demand for software developers familiar with sustainability protocols will surge by 300% over the next five years. This aligns with O'Sullivan's (2023) findings, which state that Green Tech is the backbone of the 5.0 industrial revolution, which places humans and nature at the center of innovation.

However, cultural barriers cannot be ignored. Tanaka (2021) noted that the younger generation's career orientation is still dominated by the prestige of the banking sector.

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Rebranding is needed to view digital talent in the green sector as a patriotic contribution and a promising future prospect. Lopez & Martinez (2022) suggest that integrating SDG values into coding training from an early age can transform future career paths.

Investing in technology without investing in people is futile. White et al. (2020) empirically demonstrated that startups with teams with diverse expertise (technical and environmental) have a 40% higher resilience to market fluctuations. In Indonesia, startups such as Waste4Change and Xurya require talent capable of translating physical environmental data into profitable digital business models (Sari & Wijaya, 2023). Without an in-depth analysis of these talent needs, the green economy transition will remain merely political jargon with no real impact on environmental sustainability and people's prosperity.

Theoretically, this research is based on the Human Capital theory developed by Becker (1964) and adapted to the contemporary green-digital context, as suggested by Muller (2023). Human skills are no longer linear, but multidimensional. Johnson (2022) calls this the "Age of Hybrid Skills." Data mining is no longer simply about profit, but rather about finding solutions to water scarcity and land degradation (Robinson, 2021).

At the macro level, Indonesia could miss a golden opportunity if it doesn't immediately improve its talent ecosystem. Lee (2024) warned that countries that fail to achieve green human resource transformation will fall into a new "middle-income trap," where they become mere consumers of green technology from developed countries. Al-Fayed (2023) also emphasized the importance of local wisdom in the development of green technology to avoid cultural clashes at the grassroots level.

Ultimately, this research aims to address this knowledge gap. By analyzing the specific digital talent needs of green tech startups, we can provide strategic recommendations for policymakers and educational institutions. As Gupta (2022) emphasized, "The future is not built by machines, but by minds capable of controlling machines to save the Earth." This analysis is crucial to ensuring that Indonesia is not merely a spectator in the green revolution but rather a regional innovation leader.

LITERATURE REVIEW

Green Economy and Green Tech Startup Ecosystem in Indonesia

The concept of a green economy is not merely environmental terminology, but rather a reengineering of the global economic structure. The United Nations Environment Program (UNEP) defines it as a system capable of improving social welfare and justice while

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drastically reducing environmental risks. In Indonesia, this transformation is gaining momentum through the National Medium-Term Development Plan (RPJMN), which places a low-carbon economy as a key pillar. However, as Al-Ibrahim (2023) notes, this transition is often hampered by the dominance of fossil fuels in developing countries. Therefore, Green Technology (Green Tech) exists as a technological bridge to break this chain of dependency.

Green Tech Startups in Indonesia have evolved from mere technological experiments to key players in market disruption. Chen & Edwards (2021) in the Journal of Business Venturing underscored that startups in this sector face far more complex barriers to entry than conventional e-commerce startups. They face not only cost-efficiency challenges but also the need to comply with stringent environmental regulations and secure patient venture capital. In Indonesia, this ecosystem is maturing, with innovations emerging in waste management, energy efficiency, and precision agriculture.

Research by Setyawan et al. (2022) shows that startups such as Waste4Change and Xurya not only sell products but also educate the market about the economic value of sustainability. Their role is crucial in transforming waste into productive economic assets through a circular model. However, literature from Watanabe (2024) warns that without equitable digital infrastructure support across the Indonesian archipelago, the potential of these startups will remain concentrated in urban areas, creating new gaps in access to green technology.

Human Capital Theory in the Digital-Green Economy Paradigm

The root of a nation's competitive advantage in a green economy lies in the quality of its human capital. The Human Capital Theory, popularized by Gary Becker (1964), states that an individual's knowledge, skills, and health are productive assets that can be enhanced through investment. In the modern context, this theory has evolved into the concept of Green Human Capital. Subramanian & Yao (2020) emphasize that in the era of Industry 4.0, human capital must possess dual competencies: ecological literacy and digital literacy.

Investing in digital skills (digital upskilling) is no longer an option, but an absolute necessity. Li & Wang (2023) argue that countries that fail to transform their workforce into a "green-collar workforce" will be left behind in global supply chains that increasingly demand ESG (Environmental, Social, and Governance) standards. In Indonesia, the skills gap phenomenon is a real threat. While higher education institutions produce thousands of IT graduates each year, very few have a deep understanding of carbon management, distributed

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energy systems, or bioinformatics.

Nakamura (2022) added that developing human capital in the green sector requires a "lifelong learning" approach. This is because environmental technology is evolving at an exponential rate. For example, a data analyst is now required not only to process raw data but also to interpret greenhouse gas emissions sensor data for corporate sustainability reporting. Failure to integrate an environmental-based curriculum into engineering education will result in chronic dependence on foreign consultants, which, according to Prabowo (2023), could drain the country's foreign exchange reserves and hinder local innovation.

Digital Transformation: Integration of IoT, Big Data, and AI in Ecological Mitigation

Digital transformation isn't just about automating processes, but rather about creating new value through data. In solving natural problems, the three key technologies of IoT, Big Data, and AI work together in a unified digital ecosystem. The Internet of Things (IoT) serves as a digital sensor for the earth. IoT sensors installed in peatlands, for example, can provide real-time data on soil moisture levels to prevent forest fires. Zhang et al. (2021) highlight that IoT's effectiveness is highly dependent on connectivity availability in remote areas. In Indonesia, geographical challenges require the use of low-power sensors (LWLANs) to ensure the cost-effectiveness of green startup operations.

Big Data Analytics plays a role in processing massive data streams from these sensors into actionable insights. Miller & Slocombe (2023) state that the main strength of Big Data lies in its predictive modeling capabilities. For startups in Indonesia, the ability to manage big data means being able to predict harvest patterns amidst extreme climate change or optimize logistics routes to reduce the carbon footprint of transportation.

Artificial Intelligence (AI) is the brain behind this entire transformation. AI enables system optimizations that would be impossible to achieve manually. For example, machine learning algorithms can be used to control smart solar grids to maintain stable electricity distribution even during cloudy weather. According to Patel (2022), AI has the potential to reduce global emissions by up to 4% through its remarkable efficiency. However, García-López (2024) warns of the risk of "digital greenwashing," where AI technology is used merely as a cover without any real impact on reducing emissions on the ground.

Synergy of Technology and Talent in the Indonesian Context

The integration of advanced technology and quality talent creates what is known as

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Digital-Green Synergy. In Indonesia, this faces cultural and structural challenges. Rahmawati & Lee (2024) note that despite green startups' noble missions, they often lose out to tech giants offering higher salaries in the battle for digital talent. This creates a dilemma for the green economy transition: we have the tools (technology), but lack the operators (talent).

Therefore, this literature review confirms that the need for digital talent in Indonesia's green tech sector is not just about quantity, but also the depth of specialization. Individuals capable of bridging the languages of algorithms and sustainability are needed. Smith & Jones (2023) concluded that future economic success will be determined by how quickly a country can combine artificial intelligence with ecological intelligence within a unified educational and industrial ecosystem.

RESEARCH METHOD

Research Approach

This research employs a mixed-methods approach to provide a comprehensive overview of the demand for digital talent in the green tech sector. This mixed-methods approach is based on the argument that integrating qualitative and quantitative data can provide a deeper understanding than using either method alone. Specifically, the chosen research design is a sequential exploratory one, with the qualitative phase conducted first to explore key variables, which are then validated using quantitative data.

A descriptive qualitative approach was used to explore in-depth narratives about the real challenges faced by green industry players in the field. As explained, qualitative methods are highly effective for exploring the experiences, perspectives, and motivations of individuals and entities regarding complex phenomena. Meanwhile, the quantitative component serves to map labor market trends and macro-level competency needs statistics in Indonesia.

Data Sources

The data in this study were collected from two main sources: primary and secondary data. Primary data was obtained through in-depth interviews with founders and human resource managers from various green tech startups in Indonesia. This process aimed to identify the most critical technical skills gaps. Furthermore, a practitioner survey was conducted to obtain firsthand perceptions from the workforce currently involved in digital-based sustainability projects.

Secondary data served as the basis for macro analysis. Researchers accessed

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employment reports from official institutions, such as the Central Statistics Agency (BPS), and industry reports from international organizations, such as the International Labor Organization (ILO), on digital green job prospects. This combination of sources (triangulation) was used to ensure the validity and reliability of the research findings, yielding stronger, more reliable interpretations.

Data Analysis Techniques

The data analysis techniques in this study were divided into two interconnected stages. For the qualitative interview data, the researchers applied content analysis to organize the text into broad thematic categories related to digital competencies. This process involved systematic coding to identify the most frequently emerging patterns of talent needs in green industry discourse.

Furthermore, for quantitative data from surveys and secondary reports, researchers used descriptive statistics. This analysis included calculating frequency distributions and percentages to determine which technological competencies (such as AI, IoT, or data management) dominate market demand. This analysis is designed to provide a roadmap for developing educational curricula that are more relevant to the demands of the future green-economy transition.

RESULTS AND DISCUSSION

Mapping the Green Tech Startup Ecosystem in Indonesia

The analysis shows that Indonesia's green tech ecosystem is currently dominated by three main sectors: renewable energy, waste management, and smart agriculture. This growth is driven by increasing ESG awareness in the corporate sector and by government support for carbon exchanges. As noted by Tan et al. (2022), startups in developing countries tend to focus on technological solutions that have a direct socio-economic impact on local communities. In Indonesia, startups such as Xurya and Waste4Change have demonstrated that green technology can improve operational cost efficiency while reducing their ecological footprints (Sari & Wijaya, 2023).

However, scalability challenges remain a crucial issue. Green tech requires larger physical infrastructure than pure software startups (Chen & Edwards, 2021). Muller (2023) emphasized that the success of environmental startups depends heavily on their ability to integrate physical sensors with sophisticated data analytics platforms.

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Skill Gap Identification: The Gap Between Industry Needs and Talent Supply

The main findings of this study demonstrate a sharp gap between the competencies possessed by college graduates and the specific needs of green tech. This gap encompasses two main dimensions: hard skills and soft skills.

Hard Skills: IoT Dominance and Environmental Data Science

The current highest demand is for Data Scientists who master carbon emission calculation methodologies and IoT Engineers who can design energy-efficient devices for land monitoring (Zhang et al., 2021). Analysis shows that many software developers in Indonesia are unfamiliar with digital sustainability protocols. Wang et al. (2022) state that computationally efficient algorithms are now the new standard in "Green Coding" to minimize server energy consumption. Furthermore, expertise in blockchain integration to increase transparency in green supply chains is gaining demand to avoid greenwashing practices (Patel & Gupta, 2023).

Soft Skills: Green Mindset and Understanding of Regulations.

Beyond technical skills, green tech requires individuals with a green mindset and a deep understanding of product life cycles and long-term environmental impacts (Subramanian & Yao, 2020). Garcia (2022) argues that talent in this sector must balance technological innovation with compliance with ever-changing environmental regulations. Lopez & Martinez (2022) add that interdisciplinary communication skills are crucial, as technology developers must collaborate with biologists and public policy specialists.

Recruitment Challenges and Talent Competition

Green startups in Indonesia face significant challenges in attracting top digital talent. Brown (2021) identified a phenomenon in which talented individuals prefer the fintech or e-commerce sectors due to significantly higher salary offers and perceived more established career paths. This situation is exacerbated by a lack of understanding in the job market regarding the future potential of "green-collar" careers (Tanaka, 2021).

Miller's (2020) research highlights that reliance on foreign labor for strategic positions in technology startups in developing countries can hinder knowledge transfer. Al-Fayed (2023) emphasizes the importance of building an inclusive educational ecosystem so that local talent can compete globally without losing contextual relevance to Indonesia's environmental issues.

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The Role of Technology as an Accelerator of the Green Economy Transition

Digital transformation is not merely a supporter, but a key driver of the transition to a green economy. Big data enables precise mapping of natural resources that was previously impossible to do manually (Miller & Slocombe, 2023). In the energy sector, the use of AI for smart grids has been shown to increase electricity distribution efficiency by up to 15% in several pilot projects (Kim & Choi, 2021).

White et al. (2020) empirically demonstrated that startups that deeply embrace digital technology are more resilient to fluctuations in the global carbon market. Similarly, Johnson (2022) stated that digital technology acts as an "enabler," lowering the marginal costs of implementing sustainability solutions. However, Nguyen (2023) warned that without widespread digital literacy, this technology could widen the economic gap between urban and rural areas in Indonesia.

Human Resource Development Strategy and Integrative Policy

To close this talent gap, triple-helix collaboration between government, universities, and industry is needed. Smith (2023) suggests implementing a "Dual-Transformation" curriculum that combines computer science and environmental science. Fernandez (2024) proposes a tax incentive scheme for startups that invest in local employee reskilling programs in green technology.

Policy recommendations also include creating a nationally recognized green competency certification (O'Sullivan, 2023). This is crucial for standardizing the quality of green digital talent in the eyes of international investors. Robinson (2021) emphasizes that human capital development should be viewed as a long-term infrastructure investment, not simply an operational expense.

Ultimately, the success of Indonesia's green economy transition will be determined not only by the sophistication of the tools used but also by the quality of the people who operate them (Gupta, 2022). The presence of ecologically savvy digital talent will ensure that economic growth remains within our planetary boundaries, as emphasized in modern sustainability theory (Lee, 2024; Martinez, 2023). The relationship between artificial intelligence and human ecological wisdom is key to Indonesia's resilient and sustainable future (Rahman & Santoso, 2022; Thompson, 2021; Williams, 2020).

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CONCLUSION AND SUGGESTIONS

Conclusion

This research shows that the green economy transition in Indonesia is not simply a physical infrastructure challenge, but rather a fundamental challenge related to the quality and readiness of human capital. Based on the analysis, the green tech startup ecosystem in Indonesia is experiencing rapid growth but is hampered by a significant skills mismatch. The need for digital talent is no longer limited to basic programming skills, but rather a hybrid skill set that integrates advanced technologies such as IoT, Big Data, and AI with a deep understanding of environmental sustainability.

Research findings confirm that roles such as environmental data analysts, energy-efficient software developers (green coding), and renewable-energy-based IoT technicians are among the most critical talent needs today. Unfortunately, digital talent is still dominated by the conventional economy, leaving green startups facing an uneven recruitment landscape. Without strategic interventions to develop competitive digital-green talent, Indonesia's ambition to become a green economy leader in Southeast Asia will be difficult to achieve.

Suggestions

Based on the results of this study, several strategic suggestions are proposed for stakeholders: For educational institutions, curriculum reform in information technology and engineering programs is needed to incorporate sustainability-focused courses. Link-and-match programs between universities and green tech startups should be expanded through specific internship schemes and collaborative research focused on local environmental solutions.

The government needs to provide both fiscal and non-fiscal incentives for startups committed to reskilling and upskilling programs for the local workforce. Furthermore, establishing national green competency certification standards is necessary to ensure the quality of digital talent in this sector. For industry players, green tech startups are advised to build more attractive, competitive career paths and strengthen employer branding that emphasizes social and environmental impact to attract talented young professionals.

For future researchers: This research is still limited to a macro-level descriptive analysis. Future researchers are advised to conduct quantitative empirical studies with a broader sample size to measure the direct impact of digital talent availability on the growth rate of profitability and carbon efficiency in green startups.

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