AI for Sustainable Agriculture and Renewable Energy in Indonesia

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ABSTRACT

In today's era, data is widely considered the "new oil" that powers the overall global economy and many industries. Artificial Intelligence (AI) possesses an essential role in data processing, prediction, and automation, especially in Indonesia, as its digital economy is still developing at a slower pace compared to global trends. As Indonesia has many natural resources, it faces unique challenges with digital transformation and sustainability. Digital technology, AI, and IoT devices (cloud-connected sensor systems that capture, analyze, and send data in real-time and leverage AI for autonomous systems) used communication technology for optimizing and environment friendly crop production. This progression to a more sustainable future is however compromised by significant climate vulnerabilities such as droughts and *El Niño* events, which threaten local agriculture and livelihoods.

On this basis, modern digital technologies hold significant potential to drive Indonesia's sustainable development, especially across both the agriculture and energy sectors. Smart farming, for example, is a data-based practice that employs AI and sensors, and other automated systems to improve the performance of crops through efficient planting, irrigation, and fertilization, along with monitoring crops as they grow. Smart farming also supports the farmers to preserve the current state of soil health and intensively farmable land, since it would provide real-time data on nutrient levels and moisture conditions through the continuous monitoring of soil properties. With precision in irrigation, Smart farming reduces water waste and ensures it is delivered where it is most impactful; an important aspect in a potentially unpredictable environment confronting inconsistent rain and temperature conditions. AI-based crop disease risk is able to detect infectious diseases and insect threats early and limit the potential yield losses and dependence on the irrigation of chemical pesticides. Each of these benefits increase productivity, decrease water and fertilizer consumption, ultimately improving Indonesia's crop harvest rates and food security.

Parallel to agricultural modernization, the integration of digital technologies is also a major necessity for energy transition in Indonesia. Though the country has an abundance of renewable energy sources, implementation of clean energy in a full-scale transition remains a difficult task—particularly in rural and developing regions. In this case, using AI and a combined system of advanced digital sensors increases system reliability if they can predict solar and wind energy generation under uncertainty. For example, smart grid infrastructure and demand forecasting practices improves operational efficiency by minimizing energy waste and managing energy distribution and loss ensuring they operate within the threshold of supporting guidance to renewable energy sources, and reduces. The technologies reinforce the overall resilience and flexibility of the energy system and hypothetically reduce operating costs.

Over time, these approaches could substantially reduce the country's extensive dependence on fossil fuels and its greenhouse gas emissions, thus reinforcing Indonesia's broader trajectory toward a green transition and sustainable development. Enhancements in agricultural efficiency alleviated environmental pressure and assured the safety and quality of harvested crops; but expanding and diversifying Indonesia's energy sector speeds up a slow-moving transition away from fossil-fuel dependence. This approach would ultimately contribute to building the cornerstones of a resilient society sustained by low-carbon economies and increased technology integration; and would help reduce dependency on human labor. AI, they believe would lead to an incredibly important role as a link between the digital economy (development) and sustainability; providing data-driven estimates for decision-making and helping create a more gradual link between economic modernization and environmental sustainability.

Despite these opportunities, it cannot be understated that Indonesia's path toward sustainable digital transformation is already fraught with challenges. Unequal access to technology between rural and urban regions threatens to expand socioeconomic disparities, while limited digital literacy and shortages of skilled professionals hinder the country's ability to fully utilize advanced systems which primarily include AI and IoT. Infrastructural limitations, especially with respect to electricity reliability and internet coverage, also hamper the diffusion of complex technological devices beyond large urban settlements. Additionally, legislation has generally not been able to catch up to the pace of technological development, thus creating uncertainty in the area of data protection and management and supervision. Moreover, great financial costs of implementing renewable energy systems and transitioning from regular fossil fuel usage remain a significant obstacle for both the government and local communities whose livelihoods still highly depend on coal, oil and natural gas.

Ultimately, the most current digital technologies allow Indonesia to have the potential to achieve balance between sustainability and economic growth, especially in the energy and agriculture industries. As Indonesia attempts to overcome a number of barriers to implement a range of green initiatives, it can begin to create structural barriers, build out digital services, and put foundational policy frameworks in place. With the reduction of reliance on non-renewable energy and the climate crises risk, a smooth transition can help Indonesia create the basis of resilience and low carbon emissions in the future.

Keywords: *artificial intelligence, internet of things, sustainable development, smart farming, energy transition*

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