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Application of digital science–technology and innovation in developing a sustainable productive force in Thai Nguyen: Achievements, challenges, and prospects to 2030

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Abstract
This paper explores how digital science–technology and innovation are helping to create a sustainable productive force in Thai Nguyen, one of the leading provinces in the Northern Midlands and Mountainous Region of Vietnam. Based on ideas from Marxist–Leninist thought and the Party's policies, the study shows how digital science–technology, such as artificial intelligence (AI), the Internet of Things (IoT), and big data, has transformed productive forces in industry and agriculture. Some major achievements include the digital economy contributing 35.5% to GRDP, applying Industry 4.0 technology in manufacturing, and experimenting with green agriculture models. However, there are still challenges like a lack of skilled workers, weak digital infrastructure, and people being scared of risks. Looking ahead to 2030, Resolution No. 57-NQ/TW is expected to help Thai Nguyen become a regional technology center. There are also specific plans to solve these issues and achieve long-term growth.
Keywords: *Science–technology, digital transformation, innovation, sustainable productive forces, Thai Nguyen, green economy.*

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I. Introduction

In the context of the Fourth Industrial Revolution and rapid digital changes worldwide, digital science–technology and innovation are now the main engines driving the development of sustainable productive forces. Theoretically, sustainable productive forces are not just about increasing production but also about protecting the environment, using resources wisely, and supporting long-term growth in society and the economy. In Vietnam, the Communist Party has recognized the importance of this through major policies and has called digital science–technology a "top strategic breakthrough" to shift the economy from one based on labor and resources to one based on knowledge, high technology, and a green economy. Thai Nguyen, located in the Northern Midlands and Mountainous Region, is becoming an important economic and industrial area.

The province is using digital science–technology to build a more sustainable economy. With its close location to Hanoi and nearby provinces, as well as its rich natural resources like iron, coal, and fertile land for farming, Thai Nguyen is moving strongly towards a digital and high-tech economy.

By 2025, Thai Nguyen has made big achievements because of using digital science and technology. The growth rate of the region's gross domestic product (GRDP) was 6.47% in the first half of the year before the merger, which is better than the national average. In 2024, the digital economy contributed 35.5% to the GRDP, and the total revenue was over 711 trillion VND. The total factor productivity (TFP), mostly from science, technology, and innovation, helped increase GRDP by about 50.4%, showing that digital science and technology are now the main force driving sustainable growth. The Provincial Innovation Index (PII) scored 47.75 points in 2023, placing it in the top 10 nationally and first in the Northern Midlands and Mountainous Region, proving that digital science and technology are being used effectively in both production and governance. These numbers show how the province is moving from a traditional economy to a digital one, with AI, IoT, and big data helping to improve productivity.

This change is supported by national and local policies. Resolution No. 57-NQ/TW from the Politburo on 22 December 2024 focuses on breakthroughs in developing science, technology, innovation, and national digital transformation. It says that science and technology must be the main driver for building modern productive forces, improving production relations, and reforming national governance. It sets seven main tasks like raising awareness, improving systems, increasing investment in digital infrastructure, training high-quality workers, and encouraging technology use in businesses, with the goal of making the digital economy at least 30% of GDP by 2030.

In Thai Nguyen, Resolution No. 01-NQ/TU from the Provincial Party Executive Committee on 31 December 2020 outlines the Digital Transformation Program for 2021–2025, aiming towards 2030. It highlights

digital science and technology as a key factor for restructuring the economy. The target is for the digital economy to contribute 20% of the GRDP by 2025 and over 30% by 2030. According to Provincial People's Committee Report No. 225/BC-UBND dated 22 November 2024, the province attracted 222 foreign direct investment (FDI) projects with a total investment of 11.2 billion USD, including 130 high-tech projects worth 7.3 billion USD, helping to build new productive forces based on digital technology and AI.

Thai Nguyen is developing eco-friendly and smart industrial zones that attract big companies like Samsung. In 2024, an agreement with Samsung E&A from South Korea to study green economy models created new opportunities to use Industry 4.0 technologies, reduce emissions, and support the circular economy. The Yen Binh Concentrated Information Technology Park, covering 200 hectares, is a major hub for AI and semiconductor research, helping the industry become more digital. This area has seen value-added growth of over 8.5% each year. Digital transformation is helping make a "dual transition" — moving toward both digitalization and greening — which improves production processes and reduces waste.

In agriculture, digital technologies are changing the way farming is done, moving from traditional methods to more advanced and organic practices.

From 2021 to 2024, the province carried out 368 science and technology projects, including growing organic tea and off-season custard apples. This has led to 6,203 hectares of crops that meet VietGAP standards and 85 hectares of organic farming. Places like Thien Phuc Cooperative use by-products to make organic fertilizer, which reduces chemical use and increases product value, supporting greener farming. The "AI for Everyone" program and 2,255 local technology teams have trained nearly 15,000 people, helping farmers use the internet of things for better land management.

Training high-quality human resources is a top priority, with Thai Nguyen University leading in AI and semiconductor education. In the 2024–2025 academic year, the university has accepted nearly 130 students in high-tech fields, working with Viettel and international partners. By 2030, the province wants to be a research center for chips and electronic devices, as stated in Resolution No. 57-NQ/TW.

However, there are still problems, such as small farms, a lack of skilled workers, and uneven digital infrastructure. This paper looks at the achievements, challenges, and future of digital science and technology in Thai Nguyen, and suggests ways to achieve sustainable growth by 2030. It is based on official documents such as the 2013 Law on Science and Technology (amended in 2022) and Party resolutions.

II. Theoretical basis for the role of digital science–technology and innovation

According to Marxist-Leninist theory, productive forces are the main drivers of social development, including human labor and production tools like machines and materials. Karl Marx said that once science reaches a certain level, it becomes a direct productive force, changing knowledge into a force that helps production. Vladimir Lenin added that science should be seen as a key part of improving productivity and helping society move forward.

In today's digital world, science and technology such as AI, IoT, and big data, along with innovation, are changing how we create value. These tools not only make production more efficient but also help protect the environment and society by using resources wisely.

In Vietnam, the 2013 Science and Technology Law, updated in Document No. 13/VBHN-VPQH (2022), describes science and technology as a system of knowledge that helps us understand how things work. It plays an important role in improving production and daily life. The law encourages innovation and supports digital transformation. It also shows how science and technology can create new productive forces by supporting research, sharing knowledge, and encouraging business investments.

Resolution No. 57-NQ/TW (22 December 2024) by the Politburo states that digital science and technology are key areas of focus. It highlights seven main areas, including improving systems, investing in digital infrastructure, and training skilled workers. The goal is to have science and technology contribute more than 55% to overall economic growth by 2030. The resolution also shows how science and technology can improve production, increase value, and help build a green and circular economy.

In Thai Nguyen, Resolution No. 01-NQ/TU (2020) says digital science and technology are important in changing the economy from one based on labor to one using high-tech methods. The digital economy is expected to make up 20% of the region's GRDP by 2025. Reports from the Provincial People's Committee show that science and technology are already helping grow the local economy by 50%, which matches Marx's idea that science directly affects productive forces.

In industry, digital science and technology help make production more efficient. For example, AI can manage the supply chain, which reduces waste and boosts productivity by 15–20%. In agriculture, biotechnology and IoT help increase productivity and reduce environmental damage, showing how productive forces can grow in a sustainable way.

The theory also focuses on the role of people in productive forces. As Marx said, highly skilled workers are essential to this process. In Thai Nguyen, training programs at Thai Nguyen University are improving human

resources, which supports the goals in Resolution No. 57-NQ/TW about developing talent. Overall, the theoretical basis shows that digital science and technology and innovation are crucial for Thai Nguyen to build sustainable productive forces and integrate into the global economy.

III. Achievements in applying digital science–technology and innovation in Thai Nguyen

Thai Nguyen has made major progress in using digital science, technology, and innovation to support sustainable growth. Thai Nguyen, being the top province in the Northern Midlands and Mountainous Region, has used digital tools to change its economy from depending on natural resources to one that focuses on knowledge and high-tech industries.

By 2025, the province had made 130 documents to support science, technology, innovation, and digital transformation. They also held many hybrid conferences and seminars to share knowledge and encourage the use of these technologies. These efforts helped the province reach a PII score of 47.75 in 2023, placing it in the top 10 nationally. Technology and innovation helped grow the GRDP by 50.4%. In 2024, the digital economy made up 35.5% of GRDP, with revenues over VND 711 trillion. This shows that digital science and technology are important for long-term growth. Innovation models have been used widely, helping different areas develop and expand in the region.

3.1. In Industry

In the industrial sector, the use of digital science and technology has worked very well, helping Thai Nguyen become a modern industrial center.

The province attracted 222 foreign investment projects worth USD 11.2 billion, including 130 high-tech projects worth USD 7.3 billion. This was possible because of policies that support innovation and digital transformation. The Yen Binh Concentrated Information Technology Park (200 hectares) was approved, becoming a key center for AI, semiconductors, and digital technology research. It attracted over 50 projects and created many high-quality jobs. Big companies like Samsung used Industry 4.0 technologies, such as IoT and AI, to automate production lines, cut carbon emissions by 20%, and increase labor productivity by 15–20%.

In 2025, the province introduced integrated data platforms, connecting administrative agencies and businesses smoothly. All public services were fully digitized. The textile and food processing industries also benefited from technology, using big data to predict market trends and improve supply chains, helping exports reach over USD 5 billion in 2024.

The rate of updating technology and equipment averaged 20% per year from 2021 to 2025, and the value of the technology market rose by 10% annually. Thai Nguyen University of Information and Communication Technology (ICTU) showed excellent products at events, such as automated beverage machines and disinfection robots, helping with real-world research.

Directive No. 07/CT-UBND (2025) focused on building secure digital infrastructure, supporting industrial growth of 8.5% per year and increasing labor productivity by 7.5% per year.

3.2 In green agriculture

The province honored 10 scientists and companies for making great science and technology products in 2024. These achievements encouraged new ideas in industry. These successes helped make products better and helped industries move toward greener and more sustainable ways. In green agriculture, using digital technology has made big progress. From 2021 to 2024, the province used 368 science and technology models. These included 218 trials of new farming methods, like 65 hectares of organic tea and 3 hectares of off-season custard apple. There were also 40 models that helped connect different parts of the product chain.

By 2025, Thai Nguyen had 6,203 hectares of crops with VietGAP certification and 85 hectares of organic farms. This was made possible through biotechnology and smart systems for managing land. These helped cut the use of chemicals by 40% and increase production by 10 to 15%. The “AI for Everyone” program from 2024 to 2025 helped 5,000 farmers use AI to predict weather and analyze data, which reduced greenhouse gas emissions from rice farming by 30%.

The Thien Phuc Cooperative uses farm waste to make organic fertilizer. This increases the value of products by 25% and helps promote agricultural tourism. The province also improved online sales of agricultural goods through the “Thai Nguyen OCOP Market 2025” on digital platforms, showing its leadership in using technology in agriculture.

The value of agricultural production grew by VND 2,529 billion each year, helping to develop better rural areas. Thai Nguyen University of Sciences has strong research groups that have published 80 papers in international indexes, got two patents, and led projects on biotechnology for farming. The agriculture innovation startup scene has grown. By 2025, there were 858 science and technology companies and 45 high-tech businesses. These achievements have made green agriculture a key part of Thai Nguyen’s sustainable and circular economy.

IV. Challenges, prospects, and solutions to 2030

Despite these successes, using digital technology and innovation in Thai Nguyen still faces several challenges that need full solutions. The biggest problem is that most farms are small-scale, with over 70% of small businesses and farming families not having full access to digital tools. This is because they don't have enough money and there is poor infrastructure. The tea and livestock industries also struggle to make more value from their products and their operations are not well connected. Feed costs for livestock make up 65 to 70% of total expenses.

There is also a lack of skilled workers, as only 20% of the people have digital skills, causing a brain drain and making it hard to use AI and IoT. People and businesses are not willing to take risks, which stops them from investing in new technology, especially in rural areas. The internet is not equally available everywhere, with only 80% of rural areas having 5G, which affects how IoT can be used. Cyberattacks have increased by 15% in 2025, putting smart production systems at risk. Climate issues like floods and droughts make it harder to use green technologies. These problems need a new way of thinking about digital tools and more investment to stay competitive.

Prospects

Thai Nguyen, as the economic and industrial center of the Northern Midlands and Mountainous Region, is positioned to become one of the top provinces in using digital science and technology (STI) and innovation to develop sustainable industries.

By 2030, Thai Nguyen aims for an average GRDP growth of 10.5% each year, with the digital economy making up 50% of the GRDP. It is expected to become a regional technology center, especially in semiconductors, artificial intelligence (AI), and green industries. According to the Thai Nguyen Provincial Master Plan for 2021–2030, the province will focus on three main areas: high-tech industry, green agriculture, and digital services, aiming to become a modern industrial economic center connected to the capital region. This plan is supported by Resolution No. 57-NQ/TW (2024), which highlights the importance of digital STI in supporting sustainable growth and international connections. Starting in 2025, the province will carry out six key digital technology projects and 20 STI application models, focusing on e-commerce (EC), the green economy, and the circular economy. These models will help Thai Nguyen achieve annual labor productivity growth of 7.5% and industrial value-added growth over 8.5%, create around 200,000 good jobs, and reduce poverty in a sustainable way. In agriculture, the goal by 2030 is to increase organic farming to 200 hectares and VietGAP-certified farming to 10,000 hectares, with agricultural production value growing by 4–5% each year through the use of biotechnology, IoT, and AI. Circular-economy models, such as those in the Thien Phuc Cooperative, will be copied and combined with agritourism to increase value-added by 30%. In industry, the province aims to become a research and manufacturing center for chips and electronic devices, with the Yen Binh Information Technology Park aiming to attract an extra USD 10 billion in foreign investment and create 50,000 high-quality jobs. The innovation startup ecosystem will develop strongly, targeting 1,000 science-and-technology enterprises and 60 high-tech enterprises by 2030, supported by policies under Resolution No. 01-NQ/TU (2020).

Digital science, technology, and innovation are very important for Thai Nguyen to handle challenges and reach its sustainability goals. However, these efforts need to work together across education, policy, and international partnerships. If problems like a lack of skilled workers and uneven digital infrastructure aren't fixed, the province might fall behind, with its GDP growth 2–3% lower than it could be, according to World Bank economic models. But Thai Nguyen has good geographic advantages and strong support from the central government, which can help it make big progress, especially in areas like Industry 4.0 and green farming.

Solutions

Boosting high-quality training for skilled workers: Thai Nguyen should grow the "AI for Everyone" program and work more closely with local universities and big companies like Samsung and Viettel to train 10,000 digital workers every year, focusing on AI, semiconductors, and green tech.

By 2030, 40% of workers should have digital skills, up from 20%. Training costs are expected to be about VND 500 billion yearly, but the economic benefits could be 3–4 times higher due to a 20% boost in work efficiency, as shown by studies on education returns in Vietnam. For instance, training 500 semiconductor experts each year could cover half the need for Yen Binh Park and reduce talent loss to other provinces. Working with businesses can help create learning programs that mix classroom knowledge with real-world experience, like the internship plans at Samsung. Also, offering free online courses on AI and IoT to farmers and small businesses can improve tech access in rural areas.

Enhancing policies and financial support: The province should offer a 50% tax cut for five years to companies using green technologies and create a VND 200 billion fund to help small businesses manage risks.

According to the Ministry of Planning and Investment, tax breaks could bring an extra USD 5 billion in foreign investment by 2030, raising the use of high-tech solutions by SMEs from 30% to 80%. The risk fund

would help reduce hesitation in areas like organic farming and the semiconductor industry, where initial costs are high. For example, giving VND 50 million per company for IoT projects could push 500 SMEs to use digital tools, leading to wider benefits. These policies must also be supported by clear tracking systems to prevent misuse of funds.

Investing in digital infrastructure: Spend VND 1,000 billion to improve 5G coverage in rural areas to 95% and make cybersecurity stronger so that smart production systems run smoothly. According to the International Labour Organization (ILO), every 10% increase in 5G coverage can improve labor productivity by 5 to 7%. A strong 5G network will support IoT applications in farming, such as smart irrigation, and in industry, like supply chain management, especially in Yen Binh Park. Investing in cybersecurity can lower the risk of cyberattacks by 15%, which has risen in 2025, helping to protect business and government data. Priority should be given to areas like Phu Binh and Dai Tu, where green agriculture is growing fast, to ensure reliable internet access.

Working with international partners on climate-adaptive technologies: Collaborate with South Korea, Japan, and the EU to bring in technologies for weather forecasting, waste management, and renewable energy.

Climate change, with more frequent floods and droughts in Thai Nguyen—up by 20%—is affecting farming and industry. Weather-forecasting technology from South Korea can reduce crop losses by 30% and increase farming output by 10 to 15%. Waste management technology from Japan can cut industrial emissions by 25%, helping achieve green economy goals. These activities should include knowledge-sharing programs and research funding, with a total budget of VND 300 billion by 2030.

Improving research and technology transfer connections: Create innovation centers at Yen Binh Park that connect universities, research labs, and companies to work on 500 science and technology projects each year.

This will help bring research into real-world use more effectively, reaching an 85% success rate. For example, Thai Nguyen University can partner with Samsung to develop semiconductors, producing 10 new products every year. In farming, research teams can help farmers use biotechnology, such as genetically modified crops, to increase harvests by 20%. Spending VND 200 billion each year on these innovation centers will help export more agricultural and high-tech products, leading to a 30% increase in added value.

Developing e-commerce and the science-technology market: Expand e-commerce platforms like the "Thai Nguyen OCOP Market" and set up technology trade floors to connect science and technology products with the market. E-commerce has already helped increase agricultural income by 20%, as seen with organic tea in 2024. These technology trade floors can help 100 companies each year bring their science and technology products to the market, increasing the value of the science and technology market by 10% every year. Invest VND 100 billion to improve e-commerce systems and hold annual technology fairs to attract foreign investors. Raising awareness about science and technology: Increase public awareness through campaigns, short training sessions, and workshops to change how people and businesses think about taking risks. Avoiding risks reduces the use of new technologies in rural areas by 30%. Using the C-Thai Nguyen app and local media for awareness campaigns can raise awareness by 50%, leading to 5,000 farming families using IoT and AI. An annual budget of VND 50 billion for these programs will provide long-term benefits for the economy and society, especially for green agriculture.

If these solutions are implemented together, Thai Nguyen will be able to solve current challenges, fully use the potential of digital science and technology, and create a sustainable development model that balances economic, social, and environmental goals.

This will help achieve the national goals for industrialization and modernization.

V. Conclusion

Digital science and technology have played a big role in developing sustainable productive forces in Thai Nguyen, helping the province move from a resource-based economy to a knowledge-based and green economy. Some key successes include the digital economy making up 35.5% of GRDP, attracting USD 11.2 billion in high-tech foreign direct investment, and 368 science and technology applications in green agriculture. These applications have led to 6,203 hectares of VietGAP-certified crops and 85 hectares of organic farming. These developments have helped increase labor productivity, support a circular economy, reduce emissions, and improve product value. However, challenges like small-scale production, lack of skilled workers, uneven digital infrastructure, and risk-averse attitudes still exist, and need coordinated efforts.

By 2030, Thai Nguyen aims to become a regional technology hub, with the digital economy making up 50% of GRDP and growing at 10.5% a year. This will be achieved through Resolution No. 57-NQ/TW and through solutions related to human resource development, policy incentives, infrastructure investment, and international cooperation. In short, digital science and technology are crucial for Thai Nguyen to achieve sustainable development and integrate into the global economy. Continued investment and effective policy implementation will help the province overcome challenges, create modern productive forces, and contribute to the country's industrialization and modernization goals.

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