International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 1s, 2025
https://www.theaspd.com/ijes.php

APPROACHING AND APPLYING SCIENCE AND TECHNOLOGY IN AGRICULTURAL PRODUCTION IN THE MIDLAND AND NORTHERN MOUNTAINOUS PROVINCES OF VIETNAM: CURRENT SITUATION AND SOLUTIONS

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Abstract

This paper assesses the current situation and proposes solutions for the application of science and technology (S&T) in agricultural production in the midland and northern mountainous regions of Vietnam, based on a survey of 1,040 farming households. The results show that access to S&T is still limited due to geographical challenges, economic conditions, and farming knowledge. Some technologies have been applied, but unevenly. Proposed solutions include enhancing government support, promoting business–farmer linkages, training skills, transferring appropriate technologies, developing cooperatives, and expanding preferential credit. These measures aim to improve production efficiency and ensure livelihood stability. Among various crops, the proportion of cultivated areas using modern inputs and new production processes ranges from approximately 16% to 58%, with the highest adoption seen in fruit trees and the lowest in forestry crops. The average investment capital for crop production (including new seeds, machinery, etc.) is about VND 55.94 million, with the lowest for forestry crops and the highest for fruit trees.

Keywords: Agriculture, Science and Technology, Household Economy

1. INTRODUCTION

Science and technology (S&T) currently play a pivotal role in enhancing agricultural productivity and quality in Vietnam, especially as the potential for growth from intensifying traditional inputs is being exhausted (Pham Bao Duong et al., 2009). The Midland and Northern Mountainous Region (MNMR) of Vietnam, with its strengths in land resources and diverse climatic conditions, continues to rely heavily on agricultural production for economic development. Although farming households still account for 99.91% of agricultural production (General Statistics Office, 2021), this structure is gradually shifting toward more modern production models. During the 2021–2030 period, the key task of agricultural restructuring in the MNMR is to develop major agricultural production zones with high competitive advantages, such as fruit trees, tea, medicinal herbs, specialty rice, maize, cassava, vegetables, flowers, and livestock including cattle, pigs, chickens, and fish. However, to successfully achieve these objectives, applying advanced scientific and technological innovations in agriculture is essential, particularly in improving product quality and increasing the value of agricultural goods.

Despite significant potential and advantages, the application of S&T in agricultural production in the MNMR still faces many challenges. One major issue is that technology transfer remains fragmented, small-scale, and lacks synchronization. Channels for transferring S&T information have not been truly effective, preventing farmers from fully accessing the latest scientific advancements. Furthermore, the lack of infrastructure, resources, and technical support services hinders the full potential of S&T innovations in local contexts (Hoang Van Phai et al., 2022).

2. RESEARCH METHODOLOGY

The study collected data from 1,040 farming households across 52 communes in the provinces of Lao Cai, Ha Giang, Bac Giang, Thai Nguyen, Son La, and Hoa Binh. Households were randomly selected from local Farmers' Union lists and categorized by production type: crop cultivation (rice, vegetables, fruit trees,

industrial crops, medicinal plants), livestock (cattle, pigs, poultry), aquaculture (fish), and forestry (acacia, eucalyptus). The data were analyzed and compared across groups to assess the application of science and technology and economic efficiency. The results are presented through tables, diagrams, and discussions to provide an objective overview.

Table 1. General Information on Surveyed Households (by Province)

Indicator	Unit	Ha Giang	Lao Cai	Bac Giang	Son La	Hoa Binh	Thai Nguyen	Overall
1. Total surveyed households	households	160	160	200	200	200	120	1,040
2. Production type								
– Household-based	%	98.13	96.88	96.50	98.50	97.50	95.00	97.21
– Farm-based	%	1.88	3.13	3.50	1.50	2.50	5.00	2.79
3. Age of respondent	years	46.08	44.52	42.37	44.91	46.74	48.03	45.25
4. Gender								
– Male	%	63.13	57.50	48.50	58.50	54.00	65.83	57.12
– Female	%	36.88	42.50	51.50	41.50	46.00	34.17	42.88
5. Household size	persons	4.69	4.95	4.51	4.82	4.47	4.76	4.68
6. Family labor	persons	2.89	3.18	2.94	2.90	2.81	2.64	2.90
7. Ethnicity								
– Kinh	%	28.13	31.25	89.50	48.00	55.50	97.50	57.50
– Dao	%	14.38	33.75	3.50	–	–	–	8.08
– Muong	%	–	–	–	–	41.50	–	7.98
– Thai	%	–	–	–	21.50	–	–	4.13
– Hmong	%	–	–	–	26.50	–	–	5.10
– Tay	%	49.38	21.88	2.00	–	–	–	11.35
– Others	%	8.13	13.13	5.00	4.00	3.00	2.50	5.87
8. Household income sources								
– Agriculture	%	75.67	62.28	69.62	78.34	73.47	64.21	70.75
– Non-agriculture & others	%	24.33	37.72	30.38	21.66	26.53	35.79	29.25

Source: Calculated from 2022 survey data

Out of the total 1,040 households surveyed, 97.2% were household-based producers, and nearly 3% were farm-based. The average age of respondents was 45.3 years, and over half (57%) were male. About 57.5% of respondents were of Kinh ethnicity, while the rest belonged to minority groups such as Dao, Tay, Hmong, and Muong. Thai Nguyen and Bac Giang had the fewest minority respondents.

Regarding household income, over 70% of surveyed households reported agriculture as their main income source, with the remainder coming from non-agricultural activities and wage labor. This indicates that agriculture remains the primary livelihood for most households. On average, each household had 4.7 members and nearly 3 laborers.

Regarding farms: According to data from the General Statistics Office's farm survey, farm owners were nearly 50 years old on average, and nearly 90% were male. In Son La, however, about one-third of farm owners were

female. On average, each farm employed about 4 workers, but only about one-quarter were trained (with the lowest training rates in Ha Giang and Son La). More than half of the farms relied solely on family labor, while the remainder hired additional workers—averaging 4 laborers per farm.

3. Research Findings and Discussion

3.1. Current Status of Access to and Application of Science and Technology in Agricultural Production in the Midland and Northern Mountainous Provinces

In Son La province, the area applying good agricultural practices (GAP) reached 5,041 hectares. Specifically, coffee areas certified under 4C and UTZ standards covered 16,542.9 hectares, involving 14,148 households. The total area of fruit tree grafting and renovation in the province was 13,109 hectares, mainly involving longan, mango, avocado, orange, pomelo, and peach. In aquaculture, fish production following VietGAP standards reached approximately 3,098 tons per year. In forestry, all 12 districts and cities had applied GIS technology for forest management and protection.

Table 2. Scale of Application of Production Processes in Crop Cultivation

Indicator	Rice	Vegetables	Fruit Trees	Timber Trees	Medicinal Plants	Tea	Overall
Total surveyed households (households)	120	120	120	120	80	80	640
Total investment in production using technological processes (million VND)	48.25	61.42	104.00	26.03	33.31	54.63	55.94
Total crop area using new processes (m^2)	886.42	1,031.16	4,066.17	1,446.98	1,040.75	1,794.75	1,747.70
Total crop area (m^2)	3,572.75	2,899.42	7,062.43	8,789.92	3,118.25	4,329.88	5,116.86
Application rate of standard processes or techniques (%)	24.81	35.56	57.57	16.46	33.38	41.45	34.16

Source: Calculated from 2022 survey data

In Thai Nguyen, by 2021, the area of tea certified under VietGAP reached 750.6 hectares, contributing to a total of 3,839.6 hectares of VietGAP-certified agriculture in the province. The province also had 171 hectares of tea under organic standards and 122 hectares under conversion. Livestock farming has shifted towards a farm-based model, with 738 farms applying high technology and value chain production. Intensive and semi-intensive aquaculture covered 2,600 hectares, incorporating high-tech methods in fish farming and breeding.

In Bac Giang, the vegetable cultivation area reached about 23,000 hectares in 2022, with 80% of this area mechanized and 10% of pesticide spraying conducted using drones. The area under VietGAP-certified vegetables was 8,000 hectares, and organic vegetables covered 30 hectares. Rice grown under VietGAP practices reached 65,000 hectares, with nearly 50% applying the System of Rice Intensification (SRI). Fruit tree cultivation covered about 52,000 hectares, with a mechanization rate of 87%. Regarding lychee production, 555.5 hectares met GlobalGAP standards in 2022, mainly for export to the U.S. and Japan.

In Hoa Binh, fruit tree areas exceeded 10,000 hectares in 2022, with 7,400 hectares in commercial production. Citrus varieties made up 45% of the total area, including oranges, tangerines, and pomelos. From 2018–2020, the province consolidated 2,057 hectares of farmland, forming concentrated production zones

equipped with water-saving irrigation systems. In 2021, a total of 4,086 hectares were certified as VietGAP or organic, mainly involving citrus fruits and safe vegetables. Notable models included small-scale production of tomatoes and melons. Livestock farming shifted to closed-loop farms using high technology. Aquaculture included 2,700 hectares of ponds and lakes, and 4,900 fish cages. The province also implemented supportive measures for production and product promotion.

In Lao Cai, the area of high-tech agricultural production reached 3,360 hectares by the end of 2021. In 2022, vegetable farming exceeded 12,000 hectares, including 200 hectares of greenhouses and 173 hectares using water-saving irrigation systems. The province had 10 high-tech livestock facilities. Many enterprises and households were certified under organic and VietGAP standards, including 685 hectares of tea and 3,503 hectares of cinnamon. However, the application of science and technology still faced financial and policy-related challenges.

Table 3. Application of Science and Technology in Pig Farming in Lao Cai Province (2020–2022)

Indicators (Pigs)	2020	2021	2022
1. Total pig herd	302,515	367,994	374,200
2. Percentage of exotic pig breeds (%)	80	80	80
3. Total number of pig farms	110	91	94
4. Farms applying closed-loop farming	110	91	94
5. Farms applying VietGAHP standards	0	2	2
6. Farms applying disease safety protocols	110	89	108
7. Farms applying organic pig farming	0	0	0
8. Farms using automation (feed/water systems)	–	–	–
9. Farms applying other technologies (bio-bedding)	0	2	2

Source: Department of Agriculture and Rural Development of Lao Cai Province (2023)

Aquaculture Sector

Cold-water aquaculture: There are currently 10 organizations and individuals in the province applying high-tech methods in cold-water aquaculture, covering an area of 10,341 m^2. Farmed species include salmon and sturgeon, mainly using intensive farming methods in Sa Pa, Bat Xat, and Bac Ha districts.

Forestry Sector

Initial steps have been taken to apply remote sensing technology for forest resource investigation and management. A forest fire warning software has been integrated and can be used on computers or smartphones with internet access. It provides daily fire alerts for specific areas and displays forest fire risk maps quickly, accurately, and in a timely manner.

Table 4. Application of Science and Technology in Aquaculture in Lao Cai Province (2020–2022)

Indicators (Aquaculture)	2020	2021	2022
1. Total aquaculture area (ha)	2,168	2,185	2,275
2. % of intensive production area (%)	40	40	40

3. % of area applying biotechnology	–	–	–
4. % of area applying VietGAHP	15	15	15
5. Number of aquaculture farms	5	4	4
6. Farms applying smart/automated technologies	–	–	–
7. Farms using high-quality breeds	2	2	2

Source: Department of Agriculture and Rural Development of Lao Cai Province (2023)

By 2021, a number of enterprises and households have been certified organic, including: Bac Ha Development Investment Company Limited with 685 hectares of tea in Ban Lien commune, Bac Ha district; Cao Son Tea Joint Stock Company certified 30 hectares of tea in Ta Thanh commune, Muong Khuong district; Hoa Loi Trading Co., Ltd. certified 05 hectares of vegetables in Y Ty commune, Bat Xat district; International organic certification for 3,503 hectares of cinnamon (Van Ban district: 1,255 hectares for 742 households; Bac Ha district: 2,248 hectares for 683 households).

VietGAP certification: there have been 10 hectares of pineapples in Nam So and Nam Sui villages, Ban Phiet commune, Bao Thang district; THT in Muong Khuong and Hoang Bang One Member Co., Ltd. in Bat Xat district: 200 hectares of bananas; Phuc Yen Company, Lao Cai city: 15 hectares of bananas; Dai Hung Tea Company in Bao Yen district: 100 hectares of tea; THT in Muong Khuong district: 212 hectares of tangerines; Cooperative enterprises in Sa Pa, Bac Ha, Bat Xat: over 100 hectares of vegetables. Regarding medicinal plants, GACP-WHO certification (for medicinal plants): There are 140.2 hectares/11 species of medicinal plants meeting GACP-WHO standards in the province.

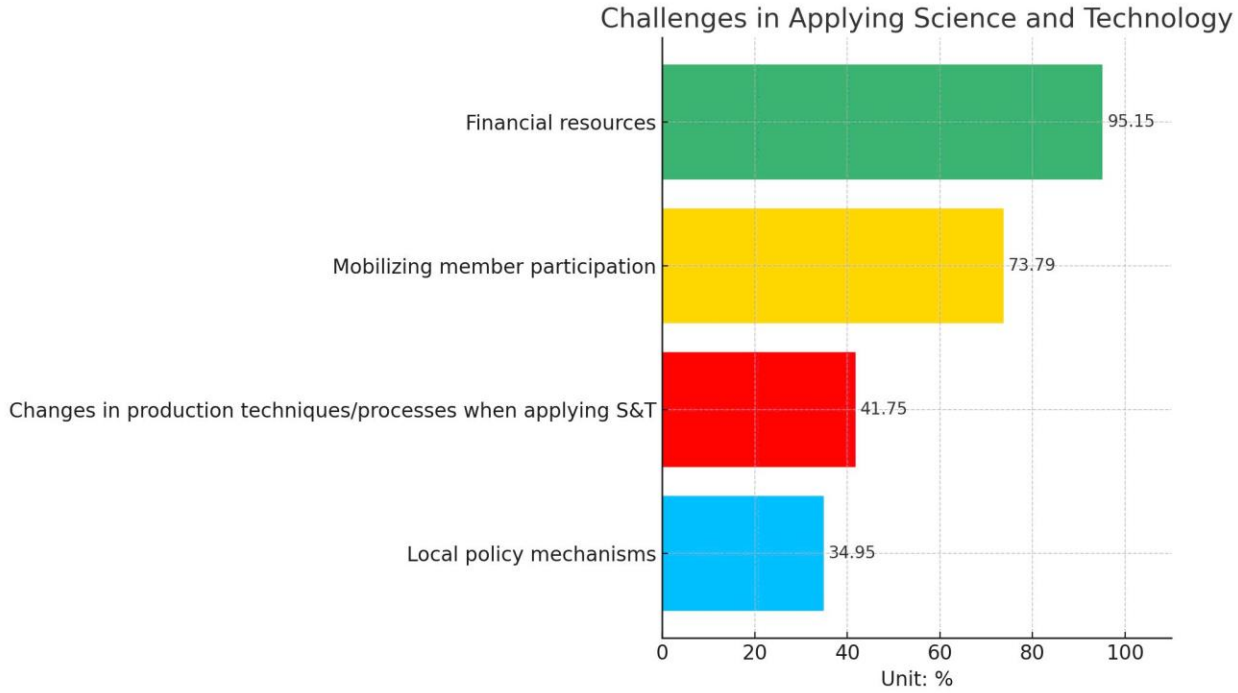

Figure 1. Evaluation of cooperatives on the difficulties of members when approaching and applying science and technology to agricultural production

Source: Summary of survey results (2023)

According to the results of a survey of cooperatives and enterprises in the field of agriculture in the provinces, currently, the access and application of science and technology in agricultural production still faces many difficulties, hindering farmer households. Most cooperatives believe that the difficulty when their members apply science and technology to agricultural production is from financial resources, the mobilization of members, when applying science and technology to production, will have to change the technical process when producing and partly from local mechanisms and policies.

3.1.4. Assessment of the economic efficiency of some high-tech application models in agricultural production of households in TD & MNPB provinces

Calculating the yield per 1 pole, the revenue of high-tech vegetable production households reached more than 800 kg, significantly higher than that of ordinary production households. Efficient calculations show that vegetable production High-tech households have to invest more in advanced equipment, machinery or input materials, so the depreciation cost is higher and the total cost is higher in general. Although the productivity is higher, the percentage of products sold at higher prices is only partial, so the total revenue as well as total income are not significantly different from traditional production.

Table 5. Comparison of Economic Outcomes and Efficiency of Key Vegetable Crops Between Traditional and High-Tech Producers

(*Average per 360 m²/sào per production season*)

Indicator	Unit	High-Tech Producers	Traditional Producers
Key Output Indicators			
– Gross Output (GO)	1000 VND	11.01	8.8
– Intermediate Costs (IC)	1000 VND	4.6	3.8
– Value Added (VA)	1000 VND	6.41	5
– Total Production Costs (TC)	1000 VND	6.05	4.3
– Mixed Income (MI)	1000 VND	4.96	4.5
Efficiency Indicators			
– GO/IC	Times	2.39	2.32
– VA/IC	Times	1.39	1.32
– MI/IC	Times	1.08	1.18

Source: Survey summary (2023)

Pig Farming

In the livestock sector, based on the average production of 1,000 kg of live pigs, a comparison between high-tech and conventional producers shows that high-tech households had higher production costs—5,240 thousand VND, compared to 4,890 thousand VND for traditional households (per 100 kg of live weight).

Table 6. Economic Results and Efficiency of High-Tech vs. Conventional Pig Farming Households

(*Average per 1,000 kg of live pigs*)

Indicator	Unit	High-Tech Farming	Traditional Farming
1. Production Costs	'000 VND	5,240	4,890
2. Production Results			
a. Gross Output (GO)	'000 VND	6,140	5,640
b. Value Added (VA)	'000 VND	1,100	990

c. Mixed Income (MI)	'000 VND	890	840
3. Production Efficiency			
– GO/IC	Times	1.3	1.2
– VA/IC	Times	0.3	0.2
– MI/IC	Times	0.3	0.2

Source: Survey summary (2023)

High-tech farming households earned 6,140 thousand VND per 100 kg of live pigs, slightly more than traditional producers. Efficiency indicators suggest that every 1 VND spent on intermediate inputs generated: 1.3 VND in output value, 0.3 VND in value added, compared to 1.2 VND and 0.2 VND, respectively, for conventional households. However, the differences between the two groups are not substantial, indicating room for improvement in high-tech efficiency or the need for broader scaling and support.

Beef Cattle Farming

Currently, there is almost no application of high technology in beef cattle farming. Only a few households have adopted hybrid breeds such as Shin cattle or 3B cattle. However, income differences remain insignificant, mainly because the price of 3B cattle is similar to that of local breeds. In recent years, due to China's halt in importing live cattle, the price of live beef has dropped sharply—from around 100,000 VND/kg to approximately 70,000 VND/kg.

Table 8. Economic Results and Efficiency of Beef Cattle Farming by Breed

(*Average per animal*)

Indicator	**3B Cattle Households**	**Local Cattle Households**
Gross Output (GO)	34.5	18.18
Total Costs (IC)	21.75	8.40
– Breeding stock	15.2	5.32
– Feed	5.5	2.86
– Veterinary services	1.0	0.13
– Other costs	0.05	0.09
Value Added (VA)	12.75	9.78
Mixed Income (MI)	12.25	9.58
Efficiency Ratios		
– GO/IC	1.59	2.16
– VA/IC	0.59	1.16
– MI/IC	0.56	1.14

Source: Survey summary (2023)

In fisheries: Comparing the economic results between the group of households applying high technology and the group of households not applying high technology in shrimp farming, calculating the turnover per 1 hectare of fish shows that: Households applying high technology invest more in fish farming, the total cost for 1 hectare of intensive fish farming is over 900 million VND, Meanwhile, this figure in the group of households without high-tech application is 850 million VND.

Table 9. Economic Results and Efficiency of High-Tech vs. Traditional Fish Farming

(*Average per 1 hectare*)

Indicator	Unit	Intensive & VietGAP	Conventional
1. Production Costs	'000 VND	910,000	850,000
a. Intermediate Costs (IC)	'000 VND	890,000	750,000
b. Depreciation	'000 VND	20,000	5,000
2. Production Results			
a. Gross Output (GO)	'000 VND	1,120,000	850,000
b. Value Added (VA)	'000 VND	230,000	100,000
c. Mixed Income (MI)	'000 VND	210,000	95,000
3. Efficiency Indicators			
– GO/IC	Times	1.26	1.13
– VA/IC	Times	0.26	0.13
– MI/IC	Times	0.24	0.13

Source: Survey summary (2023)

The results and economic efficiency in cultivation, animal husbandry and aquaculture of the group of households applying high technology are higher than those of the group without applying high technology, but the difference is not high. This result also shows the benefits of the application of high technology in agricultural production from an economic perspective.

Solutions to strengthen the application of science and technology to agricultural production

In order to improve the efficiency of the application of science and technology to agricultural production in the TD & MNPB region, it is necessary to implement a number of main solutions:

Strengthening the technology transfer system: Building and consolidating effective science and technology transfer channels, thereby helping farmers access and apply new scientific advances. Forms of transfer may include seminars, training classes, face-to-face training, and transfer programs through agricultural extension organizations, cooperatives, and affiliated enterprises.

Application of information technology in science and technology transfer: Using information technology platforms such as websites, mobile applications, and social networks to convey information about new production techniques, superior crop varieties, livestock, and sustainable farming methods. This will help reduce the gap between experts and farmers in remote areas sticky rice.

Financial and infrastructure support: Provide concessional loans, financial support for farmers when applying new technologies, and upgrade infrastructure, especially local irrigation, warehousing and processing systems.

Building point models: Creating point models for the application of science and technology to agricultural production in communes and districts to replicate the model, helping farmers clearly see the effectiveness and applicability in practice.

Development of specialty agricultural products: Supporting farmers to apply science and technology to develop high-value agricultural products, especially local specialty agricultural products such as tea, specialty rice, clean fruits and vegetables, and medicinal products.

CONCLUSION

The application of science and technology to agricultural production in the Northern Midlands and Mountainous provinces is a key factor to improve productivity, product quality and sustainable growth. However, to achieve this result, it is necessary to have a synchronous and effective science and technology transfer system, along with strong financial and infrastructure support. The above solutions will help promote agricultural development in this area, towards the goal of improving farmers' lives and developing the rural economy.

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