ISRG JOURNAL OF ECONOMICS AND FINANCE (ISRGJEF)

ISRG PUBLISHERS

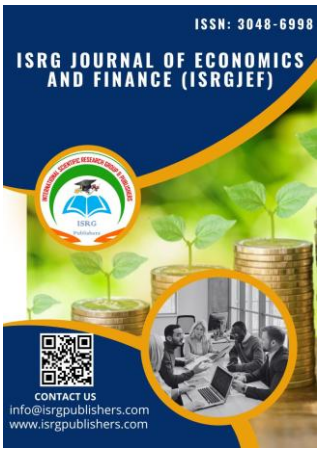
Abbreviated Key Title: ISRG J Econ Fin.

ISSN: 3048-6998 (Online)

Journal homepage: https://isrgpublishers.com/isrgjef-2/

Volume – 2 Issue -3 (May-June) 2025

Frequency: Bimonthly



Application of science and technology in crop production of farm households in some provinces of the Northern midlands and mountainous areas of Vietnam.

Mai Thi Huyen

Bac Giang Agriculture and Forestry University, Vietnam

| **Received:** 18.05.2025 | **Accepted:** 24.05.2025 | **Published:** 29.05.2025

***Corresponding author:** Mai Thi Huyen

Bac Giang Agriculture and Forestry University, Vietnam

Abstract

Applying science and technology (S&T) in agriculture is paramount for enhancing productivity, improving product quality and value, and ultimately increasing farm household income, particularly in challenging terrains like Vietnam's Northern Midlands and Mountainous Provinces (NMMP). This region, crucial for its diverse agricultural outputs, faces unique hurdles in modernizing its farming practices. This study aims to comprehensively assess the current status of S&T application in crop production among farm households in this region and to identify key factors influencing technology adoption. Furthermore, it seeks to propose actionable solutions to promote broader and more effective S&T utilization in agricultural production. Employing a quantitative approach, the research utilized survey data from 1,040 farm households across 52 communes in six strategically selected provinces within the NMMP, focusing on key agricultural products including rice, tea, vegetables, and fruit trees. Descriptive statistics and comparative analysis were the primary methods for data evaluation. The findings reveal a varied landscape of S&T adoption. Key technological applications observed include mechanization, predominantly for land tillage; the use of new and improved crop varieties, especially for rice and tea; the adoption of water-saving irrigation systems, notably for vegetables and tea; the implementation of Good Agricultural Practices (GAPs) such as VietGAP and organic farming principles; and the application of biological inputs, including organic fertilizers and bio-pesticides. A significant gap was identified in applying S&T solutions for post-harvest preservation and processing of agricultural products, which remains minimal among the surveyed households. The study further identifies several critical factors that significantly affect farmers' decisions and the extent of S&T application. These include the existing policy environment and support mechanisms, the availability and adequacy of farm households' production resources (such as capital, land, and labor), prevailing market conditions for agricultural inputs and outputs, and the state of essential production and market infrastructure. Based on these findings, the study offers several recommendations for fostering greater S&T adoption. These encompass strategic policy adjustments to enhance accessibility and support, initiatives for land consolidation,

innovation in agricultural extension services to improve knowledge transfer, strengthening market linkages for S&T-derived products, focused training programs, particularly for younger farmers, and continued investment in rural infrastructure development. Addressing these areas is crucial for unlocking the full potential of S&T to drive sustainable agricultural growth and improve livelihoods in the NMMP region.

Key Words: *Science and technology, agriculture, northern midland and mountainous area*

INTRODUCTION

The Northern Midlands and Mountainous Provinces (NMMP) region of Vietnam encompasses 14 provinces with a total area of over 95,000 km². It is characterized by predominantly hilly and fragmented terrain, diverse ethnic groups, and rich cultures. Agricultural production continues to play a crucial role for households in this region. In crop and forestry production, the main plants in the region include vegetables, fruit trees, medicinal plants, rice, and forestry trees (Huyen, 2015). In recent years, facing demands for more efficient use of existing resources and to meet market needs, farmers in the NMMP region have increasingly applied science and technology (S&T) in agricultural production. The application of S&T in production is also a key objective of the "Program to support the application and transfer of scientific and technological advances to promote socio-economic development in rural, mountainous, and ethnic minority areas for the period 2016-2025," according to Decision No. 1747/QD-TTg issued by the Prime Minister on October 13, 2015. However, applying and transferring techniques and high technology for agricultural and rural development still face many difficulties, especially in mountainous rural areas and ethnic minority regions (Dinh, 2023). To date, there has been a significant lack of practical research on the current status of S&T application in agricultural production by farm households, specifically in the NMMP region. This study aims to assess the current situation of S&T application in the crop production of some major crops in the NMMP region. Based on these findings, it will propose solutions to encourage farm households to apply S&T to increase value and income, thereby contributing to the local socio-economic development of the region in the coming time. This research is limited to S&T solutions applied in the production phase, mainly including mechanization, machinery, and good agricultural practices.

LITERATURE REVIEW

Agriculture is a fundamental pillar of Vietnam's economy and the primary source of livelihood in rural areas, especially within diverse geographical contexts like the Northern Midlands and Mountainous Provinces (NMMP). The pressing need to bolster agricultural productivity, enhance product quality, secure national food supplies, and elevate farmers' incomes amidst challenges such as climate change, resource constraints, and dynamic market demands has brought the critical role of science and technology (S&T) to the forefront (VnEconomy, 2025). The Vietnamese government has consistently underscored S&T as a pivotal driver for agricultural transformation. This commitment is reflected in foundational policies including the Law on High Technology (National Assembly, 2008), the National Program for High Technology Development until 2020 (Prime Minister, 2010), and the extensive "Program to support the application and transfer of scientific and technological advances to promote socio-economic development in rural, mountainous, and ethnic minority areas for the period 2016 – 2025" (Prime Minister, 2015). These strategic frameworks are designed to cultivate an enabling environment for technological innovation and the widespread adoption of advanced farming methodologies nationwide. Reports such as "Technological change in Vietnam" by CSIRO (2025) further illuminate the ongoing efforts and the overarching landscape of S&T integration within the country. Concurrently, the advent of digital agriculture is opening new avenues for enhancing efficiency and improving value chains within the sector (Food and Agriculture Organization of the United Nations [FAO], 2021).

Despite robust policy initiatives, translating S&T advancements from research institutions to practical, widespread farm-level application encounters significant obstacles, particularly in complex regions like the NMMP (Dinh, 2023). These regions are often characterized by highly fragmented landholdings, challenging topography, a rich tapestry of ethnic minority groups with diverse traditional farming practices, and often limited access to essential resources and timely information, all of which can act as impediments to the effective dissemination and adoption of new technologies (Yen et al., 2013). Hung (2024) highlights explicitly that while the sustainable development of the NMMP is intrinsically linked to S&T, substantial hurdles persist. The existence of academic publications like the Vietnam Journal of Agricultural Sciences indicates continuous scholarly engagement in addressing these agricultural challenges. However, there appears to be a discernible gap in the literature concerning a comprehensive, contemporary assessment of the actual application status and the multifaceted factors that influence S&T adoption by farm households across diverse cropping systems within the unique context of the NMMP.

Key science and technology applications in crop production in Vietnam

Application of mechanization: The application of machinery in agriculture, particularly for labor-intensive tasks such as land preparation (tillage), is widely recognized as a cornerstone of modernization efforts aimed at increasing labor productivity and ensuring operational timeliness (MARD, 2015). Studies on the evolution of agricultural mechanization in Vietnam show a complex trajectory influenced by policy, economic reforms, and regional specificities (Takeshima et al., 2018). While national statistics might indicate high mechanization rates in certain rice production stages (B-Company, 2024), adopting various crops across diverse terrains, especially mountainous regions, can be uneven. Literature suggests that small farm sizes, high investment costs for machinery, and access to maintenance services often limit broader uptake (B-Company, 2024; Matsubara et al., 2020).

Application of water-saving and innovative irrigation systems: With increasing water scarcity and the impacts of climate change, adopting water-saving and innovative irrigation systems (e.g., drip, sprinkler) is identified in the literature as crucial for sustainable crop production, especially for vegetables and tea. These technologies not only conserve water but can also improve the

application efficiency of fertilizers and reduce labor (World Bank, 2018). Studies often point to the economic benefits and improved yields from such systems. However, adoption rates can be influenced by initial costs, technical knowledge requirements, and water source availability.

Use of uncrewed aerial vehicles (UAVs)/drones: Unmanned Aerial Vehicles, or drones, represent an emerging technology in global agriculture with documented applications in precision crop monitoring, mapping, and the targeted application of inputs. Literature suggests a growing interest in UAVs for their potential to improve efficiency and reduce chemical use, particularly in large-scale farming or for high-value crops. However, factors such as cost, regulatory frameworks, technical expertise, and suitability for small, diverse plots in mountainous regions are discussed as potential influences on their adoption rate among smallholders (FAO, 2021).

Use of machinery in harvesting: Like land preparation, mechanizing harvesting operations can significantly reduce labor costs, shorten harvesting times, and minimize post-harvest losses. While combine harvesters are noted as more prevalent in rice production in certain regions (Matsubara et al., 2020), their application for diverse crops (vegetables, fruits, tea) in challenging terrains likely faces hurdles. Literature points to issues such as the unsuitability of generic harvesters for specific crops requiring delicate handling, the scale of individual farms, and the cost of specialized machinery as common barriers.

Application of good agricultural practices (GAPs): Good Agricultural Practices, encompassing standards like VietGAP, GlobalG.A.P., organic farming, Integrated Pest Management (IPM), and System of Rice Intensification (SRI), are widely promoted in literature as central to producing safe, high-quality food and ensuring environmental sustainability (JICA, 2016; Khoa et al., 2015). Research in Northern Vietnam has validated the positive effects of VietGAP on crop quality (Ha, 2014). Organic farming, often supported by Participatory Guarantee Systems (PGS), is also gaining traction, though literature indicates it comes with specific challenges related to conversion, labor, certification, and market access (Thuy & Niem, 2025; Cuong et al., 2024). Adopting these comprehensive systems often requires significant changes in farmer practices, record-keeping, and sometimes collective action.

Application of S&T solutions in crop care and pest management: This area includes using treated organic fertilizers, biological pesticides, microbial fertilizers, and improved soil treatment methods. The literature indicates a shift towards these inputs driven by the need to reduce reliance on synthetic chemicals, improve soil health, and enhance product safety. Integrated Pest Management (IPM) strategies, often incorporating biological controls, are a key component of sustainable agriculture discussed in numerous studies. Adoption of these solutions is often influenced by the availability and cost of these inputs, farmer' knowledge, and their perceived effectiveness compared to conventional methods.

Application of new varieties: Adopting new crop varieties that offer higher yields, better quality, resistance to pests and diseases, or tolerance to abiotic stresses is a fundamental S&T application for enhancing agricultural productivity, as documented extensively in agricultural research (CGIAR, 2025). National and international agricultural research institutions continuously work to develop and disseminate such varieties. Farmer adoption, however, is influenced by factors such as access to reliable seed sources, information about the variety's performance under local conditions, cost of seeds, and compatibility with existing farming systems and market preferences (Le et al., 2020; Yen et al., 2013).

Application of preservation and processing technology: Literature frequently highlights the critical importance of appropriate post-harvest technologies (e.g., improved storage, drying, cooling, primary processing) to reduce substantial losses in quantity and quality of agricultural produce, add value, and extend shelf life, thereby improving farmers' income. The low adoption of such technologies at the farm-household level in many developing regions is often attributed to a lack of access, high investment costs, a lack of technical knowledge, or insufficient market incentives for processed or better-preserved products.

Application of crop production management software: Digital agriculture, including farm management software and mobile applications for various farm operations and information access, holds considerable promise for improving decision-making and efficiency in farming (FAO, 2021). However, smallholders' adoption, particularly in less developed or mountainous regions, can be constrained by factors such as digital literacy, internet connectivity, the cost of devices and software, and the perceived relevance or complexity of these tools for small-scale operations.

Factors influencing technology adoption by farm households in the NMMP area

Policies: Government policies provide the overarching framework that can either stimulate or hinder technology adoption. These include national strategies for agricultural development and S&T (National Assembly, 2008; Prime Minister, 2010; Prime Minister, 2015), specific programs offering financial support (subsidies, credit), technical assistance, agricultural extension services, land use policies (Prime Minister, 2014), and market regulations. Literature suggests that the clarity, consistency, and accessibility of these policies to farmers, particularly smallholders in remote areas, are crucial for their effectiveness (Dinh & Dung, 2023). Effective policies can reduce the risks of adopting new technologies and create positive incentives.

Farm Households' Production Resources: The resources available to a farm household are fundamental to its capacity to adopt new technologies. This broad category includes:

Human Capital encompasses the education level, farming experience, technical knowledge, and skills of household members. A higher level of human capital generally correlates with an increased ability to seek, evaluate, and implement new or complex technologies (Bui & Nguyen, 2022; Nhuong & Truong, 2024). Farmers' age and health also affect their ability and willingness to undertake new farming ventures.

Financial Capital: This involves the household's savings, income levels, and access to formal and informal credit sources. Many agricultural technologies require upfront investment for equipment, inputs, or infrastructure, making financial capacity a critical determinant of adoption (Nhuong & Truong, 2024).

Land Resources: Farm size, the number of plots (fragmentation), soil fertility, and land tenure security are key physical resources. Small, fragmented landholdings, common in mountainous regions, can make certain technologies (e.g., large machinery) impractical or uneconomical (Yen et al., 2013). Secure land tenure gives

farmers the confidence to make long-term investments in their land.

Labor Availability: The amount and type of family labor available can influence the choice of technology, as some innovations may be labor-saving. In contrast, others might require more intensive labor, at least initially.

Markets:
Input Markets are the availability, accessibility, and affordability of necessary inputs like high-quality seeds for new varieties, appropriate fertilizers (including biological ones), machinery, and irrigation equipment. Well-functioning input markets ensure farmers can acquire the components needed to utilize new technologies.

Output Markets: The existence of stable, accessible, and profitable markets for agricultural products derived from new technologies is a primary incentive for adoption. If farmers perceive that a technology will lead to increased yields or higher quality produce that can be sold at a premium or with greater ease, they are more likely to adopt it. Conversely, lack of market access or price volatility can be a significant disincentive (Phuong, 2021). The structure of the value chain, including the role of traders, cooperatives, and direct linkages to businesses, also impacts the benefits that accrue to farmers from technological upgrading.

Production Infrastructure: The level and quality of rural infrastructure significantly enable or constrain the adoption and effective use of agricultural technologies. Key infrastructural elements include:

Irrigation and Water Management Systems: Reliable irrigation infrastructure is crucial for many crop production technologies, especially improved varieties and intensive cultivation practices.

Transportation Networks: Roads, bridges, and other transport facilities are essential for farmers to access input suppliers and to bring their agricultural produce to markets efficiently and cost-effectively. Poor transport infrastructure increases costs and can lead to post-harvest losses.

Electricity Supply: Reliable electricity is often necessary for operating irrigation pumps, post-harvest equipment, and other farm machinery.

Communication Infrastructure: Access to information via mobile phones, the Internet, and extension services relies on the underlying communication infrastructure. This infrastructure is vital for farmers to learn about new technologies, market prices, and weather information (FAO, 2021).

Storage and Processing Facilities: Availability of local storage and primary processing facilities can reduce post-harvest losses and enable farmers to add value to their products, which can, in turn, make technology investments more attractive.

METHODS AND MATERIALS

Data were collected through a survey of 1,040 farm households across 52 communes in 6 provinces of the Northern Midlands and Mountainous Provinces (NMMP) region, including Lao Cai, Ha Giang, Bac Giang, Thai Nguyen, Son La, and Hoa Binh provinces. Households were randomly selected based on lists provided by the communes' Farmers' Associations, focusing on those producing vegetables, fruit trees (lychee and orange), rice, and tea. The data analysis method employed descriptive statistics and comparison.

RESULTS

Current status of science and technology application in crop production by farm households

The total number of surveyed households was 1,040. The average age of the interviewees (mainly the primary agricultural laborers and/or household heads) was 45 years. Over 40% of the interviewees were female. Approximately 43% of the interviewees belonged to ethnic minority groups (Hmong, Dao, Thai, Tay, Nung, etc.), with the highest proportions in Ha Giang and Lao Cai provinces. This is also a characteristic feature of the NMMP region. Agriculture contributes significantly to household income, accounting for an average of about 70% of the total household income (Table 1).

Table 1. General information about surveyed households

Indicator	Unit	Ha Giang (n=160)	Lao Cai (n=160)	Bac Giang (n=200)	Son La (n=200)	Hoa Binh (n=200)	Thai Nguyen (n=120)	Total (n=1040)
1. Age of interviewee	years	46,08	44,52	42,37	44,91	46,74	48,03	45,25
2. Female interviewee	%	36,87	42,5	51,5	41,5	46	34,17	42,88
3. Number of household members	persons	4,69	4,95	4,51	4,82	4,47	4,76	4,68
4. Ethnic minorities	%	71,87	68,75	10,5	52	44,5	2,5	42,5
5. Contribution of agriculture to household income	%	75,67	62,28	69,62	78,34	73,47	64,21	70,75
6. Total agricultural land area	m^2	5435,7	6128,2	6977,6	7076,2	6880,2	2825,0	6130,8

Source: Calculated from survey data (2022)

Application of mechanization: Mechanization is one of the S&T application solutions encouraged by all localities to increase labor productivity and ensure crop seasonality. The proportion of vegetable cultivation area prepared by machinery is about 57%, with the main types of machinery being handheld soil cultivators, plows, harrows, and grass cutters. Mini soil cultivators are ordinary, imported from China (multi-functional mini tillers), machinery from Japan, and joint ventures. In general, households with small vegetable plots often use manual labor instead of machinery, or lack the finances to invest in these machines; sometimes they also borrow from each other (Bac Giang, Son La). Mechanization in land preparation is most common for rice (over 70% apply machinery), mainly plows and harrows, and is used in areas with flat terrain. In some districts, such as Kim Boi, Cao

Phong, and Da Bac, households cultivating rice on terraced fields, small plots, or with difficult road access cannot use machinery and still rely on buffalo-drawn plows and manual labor. Sowing and planting methods depend heavily on local customs, such as direct seeding or transplanting rice seedlings. In some areas, farmers have effectively used transplanting machines, saving labor. Machine seeding offers the advantage of more even seed distribution, and the rental cost is not too high, for example, only 50,000 VND/sao (1 sao = 360m²) in Yen Dung district, Bac Giang province. Drones for pesticide spraying have been implemented in some models, for instance, in Bac Giang province; however, farmers are not enthusiastic about widespread application.

Table 2. Application of mechanization in land preparation for cultivation (% of households)

Indicator	Rice	Vegetables	Fruit trees	Tea	Total
1. Total surveyed households	120	120	120	80	640
2. % of households applying soil machinery	70,8	86,7	68,0	42,5	23,6
3. % of households applying manual methods	29,2	9,2	10,8	21,3	31,6
4. Others	0	4,1	21,2	36,2	44,8

Source: Calculated from survey data (2022)

Nearly 70% of households used machinery to prepare land for fruit trees. Standard equipment includes plows, harrows, and fuel-powered grass cutters. Land preparation mechanization is more prevalent in Bac Giang and Son La provinces than in other provinces like Ha Giang and Lao Cai.

Applying mechanization in land preparation for tea cultivation depends on the households' production stage. Most households with newly planted areas use machinery for land preparation, such as multi-functional tillers and compact handheld soil cultivators powered by gasoline/oil. For established tea plantations in the commercial stage, manual care is more common than machinery use. Older tea gardens were primarily prepared manually in the past. However, with the current availability and variety of agricultural machinery and labor shortages, many tea-growing households have invested in machinery or borrowed from each other for land preparation. There is no complete statistical data for all provinces; according to 2022 statistics, Lao Cai province had 5,038 ha of tea, but the level of mechanization in land preparation was very low, accounting for only 7%. In general, mechanization in crop production aligns with the trends set out in the plan by the Ministry of Agriculture and Rural Development (2015)."

Application of water-saving and innovative irrigation systems: The application of drip irrigation and automatic sprinkler systems is still uncommon, with about 10% of vegetable-growing households applying water-saving irrigation systems, and 34% using sprinklers to irrigate vegetables (Table 3). The advantages of these irrigation systems are water, time, and labor savings. No households in the survey sample applied automatic irrigation systems. When water-saving irrigation systems are applied to vegetable production, households also use these systems for fertigation. Combined irrigation and fertilization is uncommon among many families, mainly due to system investment costs and frequent issues like blockages and damaged irrigation pipes. No households applied machinery for vegetable harvesting.

Table 3. Application of net houses and irrigation systems in vegetable production among surveyed household groups

(Note: A household may apply multiple vegetable production models.)

Indicator	Bac Giang	Lao Cai	Son La	Total
1. Total surveyed households	40	40	40	120
2. % of households applying net houses/screens	12,50	7,50	2,50	7,50
3. % of households with models built to technical standards	17,50	12,50	10,00	13,33
4. % of households use sprinklers for vegetable irrigation	42,5	35,0	25,0	34,2
5. % of households use water-saving irrigation systems	17,5	7,5	7,5	10,8

Source: Calculated from survey data (2022)

Water-saving irrigation systems are applied to fruit trees such as oranges and custard apples, but their adoption is not widespread. Common machinery for tea production includes weeders, water-saving sprinkler irrigation systems, pesticide sprayers, pruning machines, and tea plucking machines. Sprinkler systems for irrigation are becoming increasingly popular due to their utility on sloping land, labor savings, and increased tea productivity. The area of tea under water-saving irrigation in Lao Cai province is still modest, about 33 ha, accounting for less than 1% of the total tea area in the province.

Use of uncrewed aerial vehicles (UAVs)/drones: Pesticide spraying by UAVs for lychee has been demonstrated in some VietGAP and organic lychee production models. However, it has not been widely adopted for various economic and technical reasons. No households used machinery for harvesting fruit tree products. In Bac Giang province, the tea area in 2022 reached 421 ha, of which a small portion (about 2%) applied UAVs for pesticide spraying, and 40% of the area applied water-saving irrigation. The application of UAVs in tea production has mainly been implemented in pilot models and is rarely used on a large scale. Besides, the use of tea plucking machines for harvesting is primarily limited to areas producing raw tea for processing into black or medium-quality green tea.

Use of machinery in harvesting: No households in the sample used harvesting machinery for vegetables, rice, or fruit trees. Tea plucking machines are hardly used due to the different tea bud

DOI: 10.5281/zenodo.15541881

grade requirements for processing various types of tea. Tea plucking machines are only suitable for processing black tea, not for branded green teas from cooperatives and enterprises, especially in Thai Nguyen. Water-saving irrigation systems are only standard in Thai Nguyen and Bac Giang, while they are very limited in Lao Cai and Ha Giang.

Application of good agricultural practices (GAPs): In crop production, farm households apply various disseminated and trained practices, including VietGAP, safe production, GlobalGAP, organic farming, IPM (Integrated Pest Management), and SRI (System of Rice Intensification - specifically for rice). VietGAP is the most common standard applied across all crop types (excluding medicinal plants and timber trees). Over a quarter of households apply VietGAP in cultivation, with the highest rates for vegetables and fruit trees. Safe production processes are used by nearly a quarter of vegetable-producing households and 10% of tea-producing households. VietGAP is a process for which training is provided annually, and its application is encouraged in all localities.

Table 4. Application of production practices in rice, vegetable, fruit, and tea production (% of households)

Production Practice	Rice	Vegetables	Fruit Trees	Tea	Total
- VietGAP	19,17	54,17	57,50	13,75	26,25
- Safe Production	0,00	24,17	0,00	10,00	5,78
- Global GAP	0,00	0,00	11,67	0,00	2,19
- Organic	0,00	10,83	0,00	8,75	3,13
- IPM/ICM	15,00	0,00	0,00	0,00	2,81
- SRI	28,33	0,00	0,00	0,00	5,31
- Traditional	37,50	10,83	30,83	67,50	40,16
- Others	0,00	0,00	0,00	0,00	14,38

Source: Calculated from survey data (2022)

Considering vegetable growers separately, the proportion of surveyed households applying practices such as VietGAP and organic farming exceeds 50% (note that this does not necessarily mean certified), and they have been using these practices for an average of about 5 years. Among these, farmers in Bac Giang adopted these practices slightly earlier than those in the other two provinces.

A key point for fruit trees is the prevalence of safe production practices like VietGAP and organic farming. Specifically for VietGAP and organic lychee production, farmers in Bac Giang receive regular training and support from programs such as the New Rural Program and Resolution 47 of the Provincial People's Committee, through which producers are supported with pesticides, traceability stamps, and quality inspection for export. The Chinese market is not excessively demanding but requires cultivation area codes and VietGAP compliance, prioritizing good appearance. In contrast, markets like Japan, Australia, and the USA have high food safety quality requirements, so households with cultivation area codes for export to these markets must strictly manage their orchards to ensure products are flawless. For rice-growing households, the average rice area is 3,572 m², of which about 886 m² (just over three sao) applies safe or advanced production practices (VietGAP, organic, SRI, etc.), accounting for about 25% of the total area (Survey data, 2022). Generally, households' application of these practices depends on whether their rice area is within a planned safe/VietGAP production zone. Although land fragmentation has been addressed in the past, the scattering of production plots remains common, thus limiting the application of these practices.

S&T application in tea cultivation mainly involves production according to VietGAP or organic standards, with about 14% of farm households applying these. Traditional production households are small-scale and not yet part of value chains linked with companies or enterprises. In Ha Giang province, the tea area certified under GAP standards in 2022 was 10,398 ha (VietGAP area: 3,700.2 ha; organic: 6,698 ha), accounting for 50.91% of the total provincial tea area and 54.65% of the harvested area. In Thai Nguyen province, about 3,000 ha of tea were VietGAP certified by 2022. Organic agriculture is encouraged by provinces through production support and farmer training; however, its prevalence and application remain limited due to stricter requirements for production conversion and market potential. In Bac Giang, the VietGAP tea area is about 100 ha, accounting for nearly 2% of the provincial tea area. However, the organic tea area is almost 700 ha, over 10% of the total provincial tea area.

Application of S&T solutions in crop care and pest management: 100% of vegetable-growing households used treated organic fertilizers. Over 90% of households used biological pesticides, especially for production in net houses and greenhouses for safe vegetables. Over 80% of households used microbial fertilizers. Households also applied soil treatment measures using biological products. Due to the short-term nature of vegetable crops, which can be cultivated for multiple seasons per year (e.g., cabbage, water spinach), soil treatment is necessary to prevent degradation and soil-borne diseases. Using biological products is a good measure to improve soil quality and eliminate pathogens. Every day, biological products used by farmers include lime powder and soil amendment products (Table 5).

Table 5. Application of S&T in care and pest management for vegetables (% of households)

S&T Solution	Bac Giang	Lao Cai	Son La	Total
- Organic fertilizers	100,00	100,00	100,00	100,00

- Use of biological pesticides	100,00	92,50	92,50	95,00
- Use of microbial fertilizers	90,00	85,00	77,50	84,17
- Soil treatment with biological products	80,00	65,00	62,50	69,17

Source: Calculated from survey data (2022)

Nearly 40% of households used biological pesticides, almost 25% used organic fertilizers for rice production, and one-third used microbial fertilizers for rice. About half of the households applied "VietGAP-oriented" or "organic-oriented" production processes. VietGAP or organic rice production received little attention among the surveyed households.

Table 6. Application of new varieties and biological inputs in rice production

Indicator	**Lao Cai (n=40)**	**Ha Giang (n=40)**	**Hoa Binh (n=40)**	**Total**
1. Use of high-quality rice varieties	100,00	100,00	100,00	100,00
2. Use of organic fertilizers	20,00	22,50	30,00	24,17
3. Use of biological pesticides	37,50	35,00	45,00	39,17
4. Use of microbial fertilizers	32,50	30,00	37,50	33,33

Source: Calculated from survey data (2022)

Fruit tree farmers have become more aware of the long-term impacts of chemical inputs (especially fertilizers) on their soil, and the effects on future yield and product quality. Therefore, farmers tend to utilize more organic fertilizers for fruit trees and increase the use of biological inputs. According to the survey, 100% of households used organic fertilizers for fruit trees, with an increasing trend in recent years. However, there are some difficulties accessing organic fertilizer sources due to the decline in livestock (buffalo, cattle, pigs, poultry) in recent years. In addition, biological inputs (fertilizers, pesticides) are more expensive than conventional inputs.

Over 80% of tea-growing households applied biotechnology in pest management, for example, using biological products to control green leafhoppers and tea mosquito bugs; and BT products to control tea leaf rollers, slug caterpillars, and red spiders. Herbal and biological products (such as Sukopi, SH01, Xanh Green, Song Lam 333, Deris, Rotox, etc.) and mineral oil pesticides control major pests on tea plants.

Table 7. Application of some S&T solutions in tea production (% of households)

	Thai Nguyen (n = 40)	**Hoa Binh (n=40)**	**Total (n=80)**
- VietGAP, organic	20,00	7,50	13,75
- Biotechnology in crop pest management	90,00	80,00	85,00
- Use of machinery in preliminary processing and tea processing	100,00	42,50	71,25

Source: Calculated from survey data (2022)

Application of new varieties: Regarding fruit tree varieties, off-season orange varieties (early and late ripening) and off-season cultivation techniques for oranges and lychees are common in many localities (lychee is specific to Bac Giang). Among the surveyed households, only five orange-growing households were experimenting with new early-ripening orange varieties. For the technique of adjusting lychee vụ (cropping season), most households applied it, but with varying degrees of success, mainly depending on the household's labor experience and interest in diversifying and converting to new tea varieties, cooperatives in tea production, as their primary market focus is domestic green tea. New varieties such as Kim Tuyen, O Long, and Ngoc Thuy have been adopted by households, but the number of adopters is still small, depending on processing and product branding. According to survey data, rice farmers in Lao Cai, Ha Giang, and Hoa Binh provinces have applied new, high-yield, or high-quality rice varieties such as Dai Thom 8, VNR20, Ha Phat 3, TH8, Nep Thom 86, Nep DT52, and local specialty rice varieties like Seng Cu, Khau Nam Xit (Lao Cai); Viet lai 20 new generation, HKT99, TH3-3, GS55, Lai Thom 6; Thai Xuyen 111, Te nuong Ha Giang (Ha Giang), Thien Uu 8, Dong A1, TBR97, and hybrid rice varieties Thai Xuyen 111, QL 301, VNR 20, Thuy Huong 308 (Hoa Binh).

Application of preservation and processing technology: No fruit-growing households in the survey sample applied preservation or processing technology for their fruit products; the same was true for rice and vegetables. All products were sold fresh immediately after harvest. Approximately 70% of households used machinery for the preliminary processing and processing of tea.

Application of crop production management software: Although some farmers had invested in net houses, greenhouses, and irrigation systems for vegetables, no households in the survey sample used crop management software. The surveyed farm households were also unaware of such software; they were generally not interested due to their small production scale and perceived lack of capacity to operate and use these applications.

Factors affecting the application of S&T in crop production by farm households in the NMMP region

Policies: Policies supporting and promoting S&T application in agricultural production in general, and crop production in particular, play a decisive role in the decision-making and level of

S&T application in production. These policies can be divided into three groups: orientation policies, support policies, and risk mitigation policies. In recent years, the Government, ministries, sectors, and local authorities have issued many orientation policies for S&T application, the most comprehensive being the Law on High Technology (2008), which outlined seven important tasks for high-tech application. Support policies include land policies (e.g., Decree No. 46/2014/ND-CP dated May 15, 2014, regulating land and water surface rental fees), credit (e.g., Decision No. 2475/QD-TTg in 2010 approving the National Program for High-Tech Development until 2020), infrastructure development, promotion of research and technology transfer, support for S&T application in agricultural production (e.g., Decree No. 98/2018/ND-CP dated July 5, 2018, on policies to encourage cooperation and linkage in farm production and product consumption), agricultural extension policies, and human resource development (Decree No. 83/2018/ND-CP on agrarian extension). The group of policies helping households prevent risks in S&T application includes agricultural insurance (Decree No. 58/2018/ND-CP dated April 18, 2018), and debt rescheduling and freezing for farm households (Decree No. 55/2015/ND-CP dated June 9, 2015, and Decree No. 116/2018/ND-CP dated September 7, 2018). In the provinces, central government policies are concretized into programs, projects, and schemes for S&T application in agricultural production. The policies are generally quite comprehensive; however, people's access to these policies is still limited, mainly to training-related policies. The number of households receiving support is also primarily through training (nearly 60%) and agricultural inputs (mostly new varieties, fertilizers, biological pesticides, and vaccines for livestock) (Figure 1).

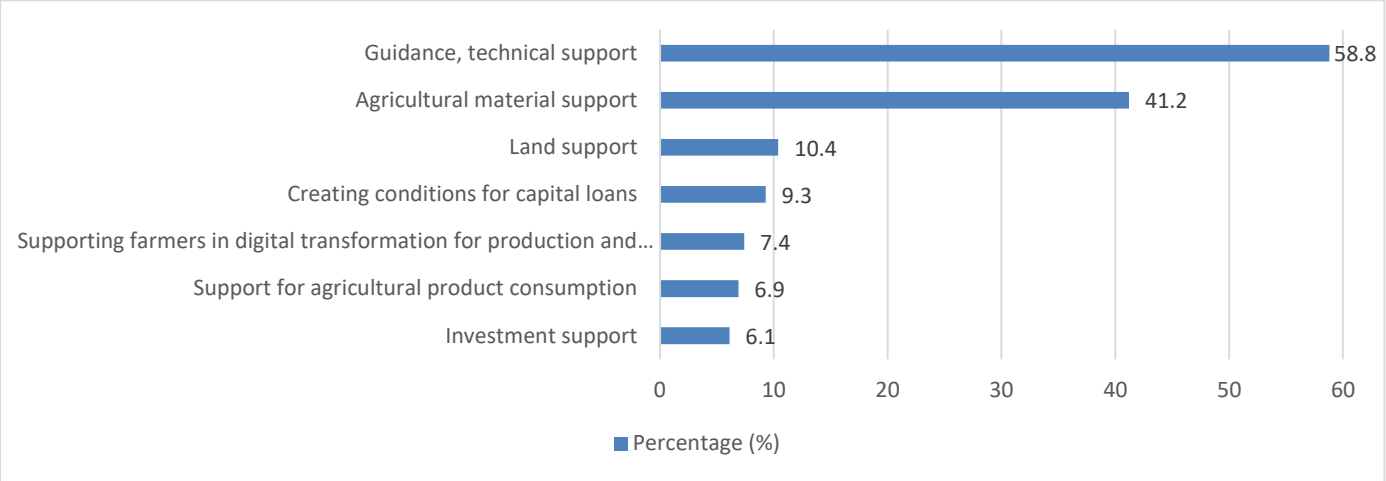


Figure 1. Percentage of households accessing S&T application support policies in agricultural production (% of households)

Household production resources: Although the average production land area per household is over 6000m² (Table 1) – including forestry land – the fragmentation of this land makes it challenging to apply S&T, such as machinery for remote, sloping upland fields, or VietGAP for a large consolidated area involving multiple households. Organizing production according to VietGAP or organic standards requires a sufficiently large area, whereas farmers' plots are small and interspersed, making it difficult to unify and implement the process. In addition, the educational and professional levels of agricultural labor are still low; according to survey data, nearly 85% of interviewees had not received any training. This is also an issue identified by Hung (2024). Furthermore, the age of farmers is a concern. As analyzed above, "aging" in agriculture and rural areas is a long-term issue affecting overall agricultural productivity and efficiency, particularly S&T application in agriculture. Most rural youth pursue education or work in industrial zones rather than engaging in farming at home, leaving parents, grandparents, and even children in the care of grandparents. Thus, the main agricultural workforce is aging but shoulders multiple responsibilities: agricultural labor, housework, childcare, etc. With small, scattered production areas, many households engage in agrarian production mainly for self-consumption (especially rice, poultry, and pig raising in highland regions). The actual need and capacity for S&T applications in agricultural production are limited. Moreover, older farmers also pose challenges for the transfer of S&T to production households.

Capital: Farm households generally lack the capital to invest in S&T applications to purchase new equipment, varieties, and quality inputs. Currently, borrowing from the Bank for Agriculture and Rural Development and some other banks is not overly complex in terms of procedures, especially for larger-scale farming households. Smaller households can also borrow, but the loan scale is quite limited. However, many families fear production risks and unstable product markets, so they dare not borrow capital and invest in S&T applications.

Market for products and inputs: One of the most important reasons is that the value of products from S&T applications is not adequately compensated. Most products produced according to VietGAP standards are sold in the open market without price differentiation from conventional products. According to survey data, the main buyers of agricultural products (rice, vegetables, fruit trees) are traders; only tea is sold to cooperatives and enterprises due to its characteristics as a raw material for processing. This reduces the motivation of farm households to produce according to safe and environmentally friendly processes. In addition, converting to organic production also faces difficulties as it requires leaving the land fallow for a specific period; for example, organic rice and vegetables need at least 12 months, when the harvested products are not considered organic. This also makes households hesitant to convert to organic farming. Besides, the prices of biological inputs such as fertilizers and pesticides are often higher than chemical inputs, and their effectiveness is often lower and slower. The product quality is not valued correctly, which makes farmers reluctant to use it. Market issues affecting S&T application in agricultural production have also been analyzed by Phuong (2021) and Dinh & Dung (2023).

Production infrastructure: Difficulties with on-farm transportation and irrigation in some vegetable and fruit tree areas remain significant, especially in mountainous provinces such as Son La, Lao Cai, and Hoa Binh, where agricultural production is

DOI: 10.5281/zenodo.15541881

mainly on sloping hilly land. This complicates transporting inputs and products, increasing product losses and production costs. In some tea-growing areas, access roads are narrow, posing challenges for collection and transportation. The NMMP region has difficulties in all aspects, such as transportation and irrigation, affecting S&T application in agricultural production (Hung, 2024).

CONCLUSION

Agriculture remains the primary livelihood source for farm households in the NMMP region. In the current context of declining productivity growth and market demands, applying S&T is a key solution to increase the value of agricultural products, enhance competitiveness, and raise income for farmers. The research results show that S&T applications in agricultural production by farm households in the NMMP region range from inputs (new varieties, fertilizers, safe pesticides), good farming practices (VietGAP, organic, etc.), to mechanization. The application of high technology, such as net houses and greenhouses, in vegetable production is still limited. Mechanization is mainly applied in land preparation and water-saving irrigation systems, while in product harvesting, it is almost exclusively found in rice production. Products are sold fresh (except for tea as a raw material for processing), with no technology applied in product processing and preservation. Some factors affecting S&T application in crop production by farm households in the NMMP region include policies, access to policies, household resources, input and output markets, and production and consumption infrastructure.

Some recommended solutions to promote S&T application by farm households in agricultural production in the NMMP region include: Firstly, relevant agencies and local authorities need to review solutions and policies, and disseminate information to production households so they can more easily access support policies. Secondly, continue to promote land consolidation and accumulation to create a foundation for S&T application. Thirdly, continue to innovate the content and methods of agricultural extension by building and replicating good models, and organizing farm households for visits and learning. This solution aims to improve the operational efficiency of community agricultural extension groups and use agricultural cooperatives to implement agricultural extension activities, S&T transfer, market information, production linkages, support for digital transformation, and sustainable agricultural production. Fourthly, communicate with consumers and support the establishment of linkages between production households and enterprises to consume VietGAP, organic, and safe products. Fifthly, it is necessary to develop policies to support training and skill enhancement for young pioneering laborers who are at the forefront of S&T application in agricultural production, and to attract university graduates to start agricultural businesses in their households, playing a core role in promoting S&T application in agricultural production among local households. Sixthly, continue to balance resources or engage in public-private partnerships to build and improve infrastructure for agricultural production.

REFERENCES

1. B-Company. (2024). *Agricultural machinery in Vietnam: Opportunities and challenges*. B-Company. Retrieved from https://docs.wpcodebox.com/snippet_doesnt_run accessed 08 January 2025
2. Bui, T. D., & Nguyen, D. M. (2022). Sustainable land managements in Vietnam: adoption determinants and income effects at farm household level. *Environment, Development and Sustainability*, *24*(7), 9687-9703.
3. CGIAR. (2025). *Major study reveals widespread adoption of CGIAR agricultural innovations in Vietnam, impacting millions of rural households*. CGIAR News. Retrieved from https://www.cgiar.org/news-events/news/major-study-reveals-widespread-adoption-of-cgiar-agricultural-innovations-in-vietnam-impacting-millions-of-rural-households/ accessed 04 April 2025
4. CSIRO. (2025). *Technological change in Vietnam | Summary*. CSIRO Research. Retrieved from https://research.csiro.au/aus4innovation/wp-content/uploads/sites/578/2025/04/1.-VietnamTechnologicalChangeSummary-ENG.pdf accessed 04 April 2025
5. Dinh, L. T. (2023). Vietnam's agriculture: Some achievements in the period 2010-2022, orientations and development solutions for the coming time. *Journal of Economics and Forecasting*, (28). Retrieved from https://kinhtevadubao.vn/nong-nghiep-viet-nam-mot-so-ket-qua-dat-duoc-trong-giai-doan-2010-2022-dinh-huong-va-giai-phap-phat-trien-thoi-gian-toi-28546.html accessed 08 January 2025
6. Dinh, N. X., & Dung, N. M. (2023). Factors affecting the application of high technology in vegetable production of farm households in Hanoi city. *Vietnam Journal of Agricultural Sciences*, *21*(6), 739-747. Retrieved from https://tapchi.vnua.edu.vn/wp-content/uploads/2023/06/tap-chi-so-6.7.pdf accessed 08 January 2025
7. Dung, N. M. (2022). Factors Affecting Farmers' Adoption of Sustainable Land Management Practices in Vietnam. *Vietnam Journal of Agricultural Sciences*, *5*(3), 1586-1597.
8. Food and Agriculture Organization of the United Nations (FAO). (2021, May). *Digital agriculture profile – Viet Nam*. FAO. Retrieved from https://openknowledge.fao.org/server/api/core/bitstreams/732bdbcf-4fa0-4d10-a659-0b9d29e0fb76/content accessed 08 January 2025
9. Ha, T. M. (2014). Effectiveness of the Vietnamese Good Agricultural Practice (VietGAP) on plant growth and quality of Choy Sum (Brassica rapa var. parachinensis) in Northern Vietnam. *Aceh International Journal of Science and Technology*, *3*(3), 80-87.
10. Hung, V. (2024). The Northern Midlands and Mountains Region: Rapid and sustainable development based mainly on science, technology, and innovation. *Vietnam Journal of Science and Technology*, (11). Retrieved from https://vjst.vn/vn/tin-tuc/11061/vung-trung-du-va-mien-nui-phia-bac--phat-trien-nhanh-va-ben-vung-dua-chu-yeu-vao-khoa-hoc--cong-nghe-va-doi-moi-sang-tao.aspx accessed 08 January 2025
11. Huyen, T. T. (2015). Green economic development - a sustainable direction in the midland and mountainous regions of northern Vietnam. In *Proceedings of the Scientific Conference on Vietnamese Studies - Proceedings of the 4th*

International Conference: Vietnam on the Path of Integration and Sustainable Development.

12. JICA. (2016). *Basic GAP manual for safe vegetable production in Vietnam*. Japan International Cooperation Agency. Retrieved from https://www.jica.go.jp/Resource/vietnam/office/others/pamphlet/ku57pq0000221kma-att/Basic_GAP_Manual_e.pdf accessed 08 January 2025
13. Khoa, D. B., Ngan, H. T., Huy, N. B., Nhung, N. T., & Liem, N. V. (2015). Development of Good Agricultural Practices (GAPs) models for tea, rice and vegetables in Vietnam. *FFTC Agricultural Policy Platform*. Retrieved from https://ap.fftc.org.tw/article/991 accessed 08 January 2025
14. Le, T. Q. A., Shimamura, Y., & Yamada, H. (2020). Information acquisition and the adoption of a new rice variety towards the development of sustainable agriculture in rural villages in Central Vietnam. *World Development Perspectives*, *20*, 100262.
15. Linh, T. T., Huyen, N. T. T., Quynh, N. N., & Doanh, N. K. (2025). Impacts of self-efficacy and herd behavior on farmers' intention to adopt digital payment in the mountainous regions of Northern Vietnam. *Journal of Agribusiness in Developing and Emerging Economies*.
16. Matsubara, T., Truong, C. T., Le, C. D., Kitaya, Y., & Maeda, Y. (2020). Transition of agricultural mechanization, agricultural economy, government policy and environmental movement related to rice production in the Mekong Delta, Vietnam after 2010. *AgriEngineering*, *2*(4).
17. Ministry of Agriculture and Rural Development (MARD). (2015). *Decision No. 3642/QD-BNN-CB: Approving the project to promote mechanization in agricultural production to create impetus for agricultural restructuring*.
18. National Assembly. (2008). *Law on High Technology*.
19. Nhuong, B. H., & Truong, D. D. (2024). Factors affecting the adoption of high technology in vegetable production in Hanoi, Vietnam. *Frontiers in Sustainable Food Systems*, *8*, 1345598.
20. Phuong, N. T. T. (2021). *Research proposing policies and solutions to promote agricultural cooperatives applying high technology in production, processing, and consumption of agricultural products*. Ministerial-level scientific research project. Ministry of Agriculture and Rural Development.
21. Prime Minister. (2010). *Decision No. 2457/QD-TTg: Approving the National Program for High Technology Development until 2020*.
22. Prime Minister. (2014). *Decree No. 46/2014/ND-CP: Regulating the collection of land and water surface rents*.
23. Prime Minister. (2015). *Decision No. 1747/QD-TTg: Approving the Program to support the application and transfer of scientific and technological advances to promote socio-economic development in rural, mountainous, and ethnic minority areas for the period 2016 – 2025*.
24. Takeshima, H., Liu, Y., Nguyen, C. V., & Masias, I. (2018). *Evolution of agricultural mechanization in Vietnam: Insights from a literature review and multiple rounds of a farm household survey* (IFPRI Discussion Paper 1724). International Food Policy Research Institute (IFPRI). https://hdl.handle.net/10568/146904
25. Thuy, P.T., & Niem, L. D. (2025). Organic Farming Based on Participatory Guarantee Systems: Exploring Economic Performance of Farmers in the Northern Delta Provinces of Vietnam. *Journal of Global Innovations in Agricultural Sciences*, *13*(1), 149-156.
26. Van Cuong, P., Linh, D. M. T., Nhung, B. H., Van, D. T. M., & Hanh, T. T. (2024). Development of organic rice production for agricultural environment conservation in Northern Vietnam. *J. ISSAAS*, *30*(1), 207-215.
27. VnEconomy. (2025). *To develop a smart and sustainable agriculture*. Vietnam Economic Times. Retrieved from https://en.vneconomy.vn/to-develop-a-smart-and-sustainable-agriculture.htm accessed 04 April 2025
28. World Bank. (2018). *Climate-smart agriculture in Viet Nam*. World Bank Group. Retrieved from https://climateknowledgeportal.worldbank.org/sites/default/files/2019-06/CSA_Profile_Vietnam2.2.pdf accessed 08 January 2025
29. World Bank. (2021). *Firm-level technology adoption in Vietnam*. World Bank Group. Retrieved from https://documents1.worldbank.org/curated/en/498501615216149075/pdf/Firm-Level-Technology-Adoption-in-Vietnam.pdf accessed 08 January 2025
30. Yen, B. T., Visser, S. M., Hoanh, C. T., & Stroosnijder, L. (2013). Constraints on agricultural production in the northern uplands of Vietnam. *Mountain Research and Development*, *33*(4), 404-415.