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Enhancing land use efficiency for tea cultivation: A case study in Quang Binh District, Ha Giang Province

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Abstract

The study aims to evaluate the efficiency of tea land use in Quang Binh district across three aspects: economic, social, and environmental. The study utilized random survey data from 60 tea-growing households, combined with both quantitative and qualitative analysis. Findings indicated that the total tea cultivation area remained relatively stable between 2020 and 2024; however, economic efficiency sharply declined in 2024 due to disruptions in export markets and a significant drop in tea prices. Tea cultivation continues to be highly accepted by local populations, especially among ethnic minorities, owing to its compatibility with traditional practices and its role in ensuring employment and land tenure stability. Additionally, tea cultivation contributes to increasing land cover, maintaining and protecting soil quality, and reducing land degradation. Nonetheless, the declining wages of daily labor and limited market connectivity threaten the long-term sustainability of economic, social, and environmental aspects of tea cultivation. To enhance effective land use, a comprehensive approach is necessary, which includes rational land planning, adoption of sustainable farming techniques, increased application of organic and biological inputs, and strengthened training and technology transfer. These measures support long-term economic and environmental sustainability in tea-growing regions, while also increasing production and improving soil health.

Keywords: Economy, Efficiency, Environment, Society, Tea.

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Contents

Contribution of this paper to the literature
This study contributes to the existing literature by providing new empirical evidence on tea land use efficiency in Quang Binh. The primary contribution of the paper is the finding that economic, social, and environmental outcomes vary under market and labor challenges. This study documents integrated solutions to improve sustainable land use for tea.

1. Introduction

Tea (Camellia sinensis) is one of the most consumed beverages in the world, with significant economic, cultural, and nutritional value [1-3]. Vietnam has unique natural advantages for tea development, with a total cultivation area of approximately 122.4 thousand hectares, producing over 1.12 million tonnes of fresh tea buds annually [4]. In the North, where the majority of the country's tea regions are concentrated, tea production not only provides hundreds of thousands of households with a substantial source of income, but it also plays a crucial role in developing commodity agriculture and stabilizing livelihoods. Tea also promotes the preservation of indigenous culture, the growth of agricultural tourism, and the export of high-value agricultural products.

Improving the use of agricultural land plays a key role in better organizing farming areas. One way to assess how efficiently land is being used is through comparative analysis. This helps identify which natural conditions are most suitable for different types of agricultural production, such as crop farming or livestock raising [5]. Previous studies also emphasize that land use efficiency is a composite indicator, reflecting the coordination among natural, technical, economic, and social factors in agricultural production [6]. Agricultural land use efficiency can be assessed through various methods, such as output per unit area, output per worker, or the total value of agricultural production. Among these, measuring output per unit area is the simplest and most widely used [7]. The effective use of arable land resources is essential for maintaining social stability and promoting economic development [8]. The economic, social, and environmental aspects of land use efficiency must be considered to produce sustainable agriculture [9].

Economic efficiency in agriculture is demonstrated through both quality and quantity indicators. Solving land use issues today requires accounting for and evaluating the specific conditions of each cultivated plot [5]. Social efficiency is the extent to which agricultural activities contribute to human development, social stability, and improved quality of life in rural areas. Phuong et al. [10] stated that social efficiency was measured by the number and value of working days for each land use type. Since different crops have varying growth stages, the required working days also differ. Environmental efficiency is the extent to which agricultural activities maintain, protect, and improve the quality of the ecological environment, including soil, water, air, biodiversity, and rural ecosystems. Environmental efficiency is the extent to which agricultural activities maintain, protect, and improve the quality of the ecological environment, including soil, water, air, biodiversity, and rural ecosystems.

Quang Binh district, located in the southwest of Ha Giang province, has an area of 780.60 km² and a population of 65,337 people, mainly ethnic minorities such as Ha Giang's Provincial Statistical Office [11]. The primary source of income for the populace is agricultural output, with tea being the main crop and occupying the second-largest area in the province after Bac Quang district. Although Quang Binh's tea area has shown improvement recently, poor product value and weak competition have kept the effectiveness of tea land usage constrained. Tea revenue experienced a significant decline due to a steep decrease in tea prices and challenges in exportation in 2024. Thus, assessing the efficiency of tea cultivation in Quang Binh district is vital for appropriately reorganizing production areas and optimizing land potential in line with the specific natural conditions. Moreover, considering the fluctuations in tea prices and the rising demand for changes in land use, assessing the effectiveness of tea land utilization offers a scientific foundation for strategic planning, enhancing livelihoods, and guaranteeing the sustainability of land resources in Quang Binh.

2. Methods

Data survey: Secondary data on the current status of tea production was collected from the Statistical Office of Ha Giang Province and the Statistical Office of Quang Binh District. Primary data on the current status of tea production (yield, selling price, costs, etc.) was collected from a random survey of 60 tea-growing households in Quang Binh District using a prepared questionnaire.

Data processing: Collected data is examined, cleaned, and imported into Excel in accordance with each survey indicator system, including cost, workforce size, and productivity. It is then processed according to standards for assessing the efficiency of the economy, society, and environment. Economic efficiency is related to Gross Output (GO), Intermediate Cost (IC), Added Value (VA), and Capital Efficiency (CE) [10]. Gross Output is the total economic value of tea production in an accounting period and a unit area (GO = total products × product value); Intermediate Cost is the total cost used to pay for materials and services during tea production; Added Value is the difference between Gross Output and Intermediate Cost or the profit of a crop (VA = GO - IC). Capital Efficiency is the profitability of capital (CE = VA/IC). Social efficiency is evaluated through indicators such as employment opportunities, working-day value [10], people's acceptance [12, 13], and security of land use rights [9]. Environmental efficiency is evaluated through indicators such as increased land cover, maintenance and protection of soil, and reduction of land degradation [13].

3. Empirical Results

3.1. Current Status of Tea Production in Quang Binh District

Table 1 illustrates that the tea cultivation area in Quang Binh District remained relatively stable during the 2020-2024 period. According to the Ha Giang's Provincial Statistical Office [11], the district's total tea-growing area in 2024 reached 33,286.7 hectares, with cultivation concentrated mainly in the communes of Tien Nguyen, Xuan Minh, and Tan Trinh (accounting for approximately 56% of the total tea cultivation area of the entire district). In contrast, Vị Thường recorded the smallest tea area, with only around 2 hectares under cultivation [14]. During this period, the area of tea under productive harvest showed a consistent upward trend, increasing from 2,701.7 hectares in 2020 to 3,145.7 hectares in 2024, an approximate growth of 16.4%. While the total area remained largely unchanged, the proportion of productive tea area to total tea area rose markedly, from 83.0% to 95.7% [11]. This indicates a significant improvement in land use efficiency and reflects the accelerated conversion of immature

plantations to commercial tea production. However, the rate of expansion began to decelerate after 2022, suggesting that the district may be approaching a relatively saturated stage regarding exploitable tea land. This trend signals a necessary strategic shift from land expansion to the enhancement of yield and product quality. Although the growth in productive tea area has contributed to improved output and farmer income, it also presents challenges, requiring a focus on deeper investment, particularly in improved cultivars, intensive farming techniques, and market connectivity to secure sustainable growth.

Table 1. Current status of tea production in Quang Binh district.

Indicators	2020	2021	2022	2023	2024
Tea cultivation area (ha)	3.256,50	3.234,2	3.268,0	3.293,60	3.286,7
Productive tea area (ha)	2701.7	2.861,1	2.997,5	3.085,90	3.145.7
Output (tons)	11.036,5	14.897,1	16.780,5	16.972,5	17.301.2

Source: Ha Giang's Provincial Statistical Office [11].

During the 2020-2024 period, tea output in Quang Binh district increased steadily from 11,036.5 tons in 2020 to 17,301.2 tons in 2024, representing a growth of approximately 56.8%. The most significant increase occurred between 2020 and 2021, with a rise of over 35%, followed by moderate and stable growth in subsequent years. This upward trend reflected improvements in production efficiency, primarily driven by the expansion of the productive tea area (Table 1). According to survey results, Quang Binh's tea yield steadily increased and surpassed the provincial average. As illustrated in Figure 1, the district's yield consistently rose and remained higher than the Ha Giang provincial average throughout most of the period. In 2020, Quang Binh's yield was 4.09 tons/ha, lower than the provincial average of 4.78 tons/ha. However, from 2021 to 2024, Quang Binh exceeded the provincial level and maintained this lead. Quang Binh district's tea yield in 2024 was 5.50 tons/ha, which is 17.34% higher than the province's total yield (Ha Giang province's yield in 2024 was 4.6 tons/ha). Nevertheless, compared to other significant tea-producing regions, especially Thai Nguyen province, the yields of tea in Quang Binh district and Ha Giang province as a whole remain considerably lower. According to Statistical Office of Quang Binh District [14], the average tea yield in Thai Nguyen province in 2024 reached approximately 12.5 tons/ha [15]. In comparison, the lower yield in Quang Binh district is primarily attributed to insufficient intensive farming practices that do not meet technical standards, the aging condition of many tea plantations, and suboptimal planting density.

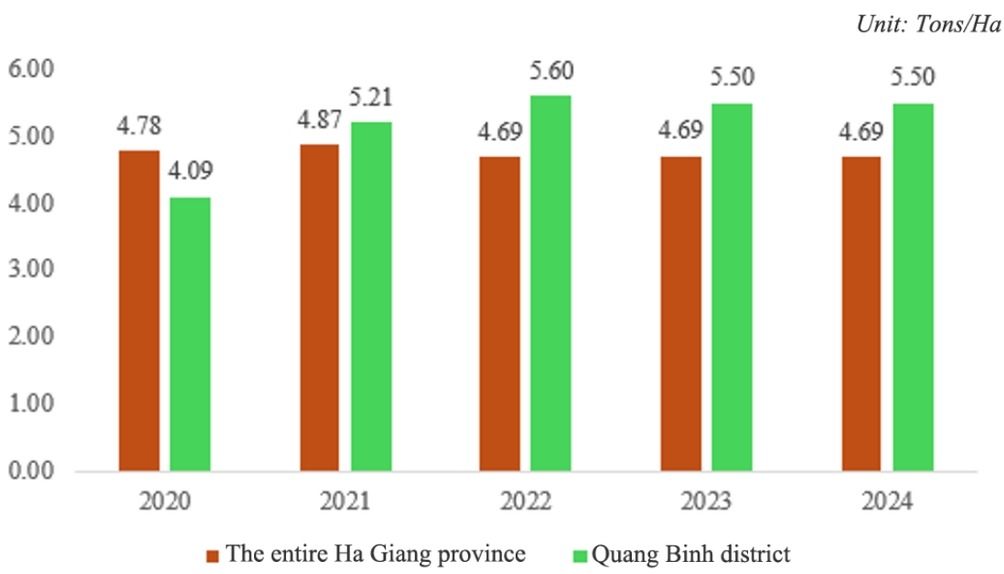

Figure 1. Tea yield in Ha Giang province and Quang Binh district.
Source: Ha Giang's Provincial Statistical Office [11].

Tea cultivation in Quang Binh district primarily focuses on industrial Shan tea, which is suitable for the cool, humid climate of the highlands. According to custom, tea trees are occasionally planted on slopes or in garden plots adjacent to residential areas. It is not technically ensured that tea will be planted, pruned, fertilized, and pest-controlled; many tea estates do not utilize organic fertilizers. The application of fertilizers is mainly empirical, lacking balance among nutrients, while pest control measures still rely on chemicals, with little attention paid to biological methods and organic farming. Additionally, the harvesting and preservation of raw materials are not conducted at the right time and using proper techniques, which also affects the quality of finished tea. These limitations not only reduce the productivity and quality of tea but also negatively impact the development of sustainable agriculture.

3.2. Land Use Efficiency for Tea Cultivation

3.2.1. Economic Efficiency

Economic efficiency refers to the evaluation of the outcomes achieved from an economic activity [16]. Economic efficiency is a multifaceted concept that represents the beneficial outcome of an economic activity in relation to the required expenditures or effort needed for its implementation [17]. The economic efficiency of tea cultivation serves as a key indicator, reflecting not only the productive capacity of the land but also integrating various natural and socio-economic factors. It thus helps assess the suitability of natural conditions for tea planting and production. Research findings indicated a marked decline in the economic efficiency of tea in Quang Binh district during the 2022-2024 period, with a particularly sharp drop in 2024. As shown in Table 2, added value reached 47,139,524 VND in 2022, decreased to 46,173,333 VND in 2023, and fell significantly to 17,573,690 VND in 2024. This decline was not primarily due to production costs, as total expenditures in 2024 (22,738,810 VND) were even lower than in the previous two years. The primary cause was disruptions in the market for consumption, specifically the temporary suspension of tea imports by China, which is Ha Giang province's main export market. This disruption resulted in a

sharp decline in tea prices and limited market access, leading to significant reductions in both total gross output and added value. These changes highlighted how susceptible tea production is to market uncertainties and emphasized the urgent need for market diversification and added value techniques to lessen dependence on exports. According to field surveys conducted in the research region, many households in Quang Binh district neglected or abandoned their tea gardens as a result of the low income from tea cultivation.

Table 2. Economic efficiency of tea cultivation in Quang Binh district.

Years	GO	IC	VA	CE
2022	70,330,000	23,190,476	47,139,524	2.03
2023	70,070,000	23,896,667	46,173,333	1.93
2024	40,312,500	22,738,810	17,573,690	0.08

The data presented in Table 2 indicated that capital efficiency was expected to significantly decline from 2.03 in 2022 to 1.93 in 2023, eventually reaching a mere 0.08 in 2024. This change revealed a sharp decline in the returns on capital spent on tea, especially in 2024, indicating that these expenditures produced little value. The sharp decline in tea prices, difficulties in exporting, growing input costs, and hard-to-market goods were the main causes noted. This situation affected tea farmers' profits, but it also demonstrated the urgency of reorganizing production to increase value, reduce costs, diversify products, and enhance the efficiency of government investments in the tea sector.

3.2.2. Social Efficiency

Data in Table 3 showed that the labor cost for growing one hectare of tea is between 140 and 145 workers. The cost of labor is significantly lower for mass tea cultivation than in many other tea-growing regions. Research by Nam [12] showed that tea cultivation in Dinh Hoa district, Thai Nguyen province attracts 450 laborers, two times higher than tea cultivation in Quang Binh district. Another study by Duc [18] in Huong Son district, Ha Tinh province, also indicated that tea cultivation attracted 348.7 laborers per hectare per year [18]. In tea farming, the process of picking tea requires the most labor. Survey findings indicated that a worker can harvest 60 to 70 kg of tea. Therefore, if 5 tonnes of tea are produced per hectare each year, 70 to 80 workers are needed for tea harvesting. Table 3 showed that the value of labor days in tea cultivation in Quang Binh district decreased sharply over the period from 2022 to 2024, from 325,100.17 VND to only 125,526.35 VND, representing a decrease of more than 61%. The income and livelihoods of local workers were strongly impacted by this phenomenon, indicating a significant decline in the socioeconomic efficiency of tea. The purchase price of tea at the garden dropped from VND 13,000 per kg to roughly VND 8,000 per kg in the first months of 2024 and barely VND 6,000 per kg by the end of 2024, mainly due to the steep drop in raw tea prices caused by a significant loss in the export market to China. This situation makes it imperative to diversify the market, enhance the value of the production chain, and promote consumption links to ensure revenue and stabilize the livelihoods of highland tea growers.

Table 3. Social efficiency of tea cultivation in Quang Binh district.

Years	Number of working days	Working-day value	Local people's acceptance	Security of land use rights
2022	145	325,100.17	Good	Good
2023	143	322,890.44	Good	Good
2024	140	125,526.36	Good	Good

The evaluation results in Table 3 showed that people's acceptance of tea was "Good." This was a crucial sign of the social efficacy of tea development for a mountainous district like Quang Binh. People's positive attitudes and attachment to tea demonstrated that the crop is appropriate for local livelihood demands, growing methods, and production conditions. In regions with a large number of ethnic minorities, such as the Mong, Dao, and Tay, tea not only helps provide steady jobs but also boosts income and reduces poverty, fostering social stability. Simultaneously, the decades-long acceptance showed how satisfied and confident people are in tea as a vital crop for family economic growth. This is particularly important for sustainable rural development programs, especially in upland areas, where community and social acceptance play a key role in ensuring policy effectiveness and diffusion.

The widespread acceptance of tea by the populace is intimately linked to maintaining long-term land use rights and also demonstrates societal efficiency. People are more likely to stabilize output and remain on the cultivated land rather than move or leave it when they can clearly see the socioeconomic benefits of tea planting. In reality, the degree of acceptance of tea among Quang Binh district residents encourages them to preserve their land use rights as a sustainable source of income while having no plans to relocate. The acceptance of tea cultivation by the people of Quang Binh district has led them to maintain land use rights as a sustainable livelihood asset, with no intention of transferring or selling their land. In the context of land being an important resource increasingly pressured by competition for use, this helps limit the fragmentation of agricultural land, protect the land fund for production, and establish a stable foundation for policies that support the development of highland areas. Additionally, land used for growing tea is frequently linked to traditional agricultural methods and the lives of mountain people; hence, the mindset of preserving land and sustaining output persists, particularly in instances where the State still guarantees land use rights. Even though the research findings indicated a temporary economic downturn, tea trees will remain a "livelihood pillar" in the area, and people do not prioritize surrendering land use rights in the current situation. According to Nguyen et al. [19], Thailand's land tenure security benefits from higher agricultural investment [19]. Thailand's land tenure security benefits from higher agricultural investment [20, 21]. Therefore, tea is not only a good choice for cultivation but also helps to ensure that people in Quang Binh district, Ha Giang province, have stable and long-term land use rights.

3.2.3. Environmental Efficiency

Reports from agricultural households indicate that growing tea helps conserve the environment while providing locals with a reliable source of income from February to November. The broad canopy and high coverage density of tea trees, which are biological traits, allow them to reduce soil erosion and runoff, particularly in steep hilly regions. Shan tea varies greatly in height and canopy growth throughout a season; in the first harvest, the trees grow to a

height of roughly 80-100 cm, and in the final harvests of the season, they can reach 120-130 cm. In addition to increasing productivity, the gradual rise in biomass also enhances soil cover efficiency, helps retain moisture, and slows soil deterioration.

Table 4. Environmental efficiency of tea cultivation in Quang Binh district.

Assessment	Increased land cover	Maintenance and protection of soil	Reduction of land degradation
Good	93.33	83.34	76.66
Average	6.67	13.33	16.67
Low	0.00	3.33	6.67

The results in Table 4 show how important tea trees are for preventing land degradation and safeguarding soil. The maintenance and protection of soil from tea trees were graded as "Good" by up to 83.34% of the assessors, "Average" by 13.33%, and "Low" by 3.33%. Similarly, 76.66% of survey respondents gave it a "Good" rating, 16.67% an "Average" rating, and just 6.67% a "Low" rating for the reduction of land degradation. These figures clearly reflect the positive ecological effects of tea trees, especially in the context of agricultural production in mountainous areas such as Quang Binh District. Tea trees' broad canopy and consistent growth throughout the seasons have made a substantial contribution to preserving vegetation cover, lowering erosion, retaining moisture, and safeguarding the structure of farmed soil.

3.3. Some Solutions to Enhance the Efficiency of Tea Land Use

Reasonable planning and improvement of tea-growing land: The efficiency of tea land use depends largely on the organization of production space. The tea-growing area must therefore be replanned in accordance with the slope, geography, and soil characteristics to ensure the proper planting density. Replanting is required to maintain consistent coverage and maximize the amount of farmed land in tea gardens with improper planting density, such as too few trees or when many tea trees are dead or stunted. Replanting is best done between February and March, planting during cold, moderate rain or after heavy rain. Repairing the tea canopy twice a year, in April after the conclusion of the spring crop and again in July, is also crucial. Replanting improves the ability to develop evenly among tree batches, increases soil coverage, reduces weeds, and prevents erosion in addition to stabilizing tree density according to technical criteria. Furthermore, tea gardens with reasonable density also help increase the efficiency of fertilizer management, irrigation water, and care, thereby improving the productivity and quality of tea buds in a sustainable direction.

Applying sustainable farming techniques and developing value chain production linkage models: Transitioning from traditional farming practices to sustainable techniques is an essential solution for effective and long-term land utilization. One significant way to enhance the effectiveness of tea land use is to encourage a shift in perspective from solely agricultural production to agricultural economic growth. Constructing value chains emphasizes elements such as cooperative ties, product quality, consumption markets, and branding. To maximize added value on the same unit of land area, this transformation requires support from agricultural extension policies, technology transfer, and, especially, the development of cooperative economic models or connections between farmers and tea processing and consuming firms. Specifically, to produce safe, high-quality tea products that are competitive in the market and generate high added value per unit area, a strong production link between the "4 houses: Farmers - Scientists - Entrepreneurs - Managers" must be established. Additionally, tea gardens require regular cleaning and weeding. Young branches are susceptible to disease, so avoid pruning too early. To prevent the spread of disease, tea buds and diseased leaves should be burned and pruned as soon as symptoms appear. Provide tea plants with balanced water and fertilizer applications. The optimal time and method for pruning tea are from mid-December to the end of January the following year. To ensure higher productivity, tea should also be harvested using the correct method. Leave a sufficient number of buds (three to four leaves for the spring harvest and one to two leaves for the summer-autumn crop) after selecting suitable buds. It is advisable to harvest buds near the fresh leaves at the top of the main stem and branch axis.

Increasing the use of organic fertilizers and biological products: To improve soil quality in areas where hilly soil is susceptible to erosion and degradation, chemical fertilizers for tea plants must be replaced with organic or microbial fertilizers. Organic fertilizers help improve humus content and soil structure, while biological products, particularly nitrogen-fixing or phosphorus bacteria, enhance nutrient absorption for plants. Indeed, various microbes can convert insoluble phosphorus compounds into forms that plants can easily absorb and utilize [22]. Substantial amounts of phosphorus are stored in biomass for plant use, and phosphorus-solubilizing bacteria in the soil are crucial for solubilizing inorganic phosphorus minerals. Nitrogen-fixing microbes can employ biological nitrogen fixation to convert atmospheric molecular nitrogen (N_2) into ammonia (NH_3). Plants absorb this ammonia as an accessible form of nitrogen, enhancing soil fertility and sustainability, improving plant health, and increasing productivity [23]. Phosphorus-solubilizing microorganisms in the soil are essential for decomposing inorganic phosphorus minerals and storing a sizable amount of phosphorus in biomass for plant uptake.

Enhancing training and technology transfer: The efficiency of tea land use is closely linked to the cultivation level and awareness of the producer. Tea productivity and quality will remain low even with favorable site potential if producers lack the necessary knowledge and skills to manage soil, water, fertilizer, and pests. Consequently, enhancing farmers' capacity through consistent coaching and training programs must go hand in hand with increasing land use efficiency. Advanced agricultural practices suitable for the region should be the main focus of training materials. These should include balanced nutrient management, fertilization based on the developmental needs of tea plants, the use of organic fertilizers, and soil cultivation methods that prevent erosion and preserve fertility. Simultaneously, encouraging the implementation of integrated pest management (IPM) strategies, prioritizing biological pesticides and safe pest control methods, will help reduce adverse effects on the soil environment and safeguard the agricultural ecosystem. To increase land use efficiency in a stable and long-term manner, it is also vital to emphasize the role of agricultural extension agents, cooperatives, and businesses in facilitating connections, sharing technologies, and assisting individuals in engaging in sustainable tea production.

4. Conclusion

Tea cultivation plays an essential role not only in generating household income but also in contributing to

broader economic, social, and environmental objectives in Quang Binh district. The overall area used for tea production remained relatively stable between 2020 and 2024; however, in 2024, economic efficiency fell precipitously due to disruptions in export markets and a sharp decline in tea prices, underscoring the susceptibility of local life to market swings. Tea cultivation continues to be highly accepted by people, especially among ethnic minorities, due to its compatibility with traditional practices and its role in ensuring employment and land tenure stability. Additionally, tea cultivation contributes to increasing land cover, maintaining and protecting the soil, and reducing land degradation. However, the declining value of daily labor wages and limited market connectivity threaten the long-term economic, social, and environmental sustainability of tea cultivation. To improve effective land use, it is necessary to focus on a comprehensive approach that combines rational land planning, the adoption of sustainable farming techniques, increased application of organic and biological inputs, and strengthened training and technology transfer. These integrated solutions support long-term economic and environmental sustainability in tea-growing regions, in addition to increasing production and soil health.

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