

Forecasting the Change in Organic Agricultural Output in the Northern Midland and Mountainous Provinces of Vietnam Based on Artificial Neural Network Model

Huy Quang Doan

*TNU-University of Economics and Business Administration, Vietnam
doanquanghuytm@gmail.com*

ABSTRACT

This study presents a method to forecast the change in organic agricultural output in the northern midland and mountainous provinces of Vietnam by using an artificial neural network model, the inputs include the change in the area of organic agricultural farming, the capital invested in the sector, the percentage of labour, and the organic agriculture output by year. Forecasts conducted for the stage of 2021-2025 show that when the area of organic agricultural production increases from 1.5% to 2% per year, according to the approved scheme of the Government of Vietnam, the organic agricultural output increases by an average of 12-13% respectively.

JEL Classification: M2, Q1, R1

Keywords: Organic Vegetables, Neural Network, Mountainous Areas, Northern Vietnam

I. INTRODUCTION

High levels of pesticides and chemical fertilizers inside agricultural products always pose numerous risks to the Vietnamese population. According to studies, the usage of pesticides in agriculture has increased from 100 tons per year in the 1950s to 35.000 tons in 2002 and about 105.000 tons in 2012 (Ha et al., 2019). Unsafe foods increase the risk of malignant growth for citizens. The incidence of cancer in Vietnam currently ranks 16th in Asia. In 2020, Vietnam ranked 91/185 globally, with a cancer occurrence rate of 151.4 per 100,000 population (Le et al., 2019; Kim, 2019). After two years, from 2018 to 2020, Vietnam rose seven places on the world cancer ranking scale (GSO, 2020). One of the three primary causes of cancer in Vietnamese is the eating habits such as eating raw, grilled, salads, innutritious along with mould foods which contain preservatives as well as stimulants, becoming alarming and one of the causes of instability in people's lives and health (Nguyen et al., 2019; My et al., 2021). Being aware of the nutriment importance, in the early years of the twenty-first century, food safety has become a social issue that receives due attention from the government in Vietnam (Pham and Turner, 2020). In 2010, the National Assembly passed the Law on Food Safety, thanks to which the country began to apply modern management principles.

Organic agricultural products are considered with relatively higher nutritional value since they are produced more naturally, without using pesticides, fertilizers or harmful chemicals, instead of applying microbial fertilizers which do not harm human health. In addition, both caring and irrigation processes use clean water. Therefore, organic products contain more antioxidants, nutrients, vitamins and minerals, which contributes to creating a healthier immune system than other common vegetables, helping to reduce the risk of cardiovascular diseases, cancer, and high blood pressure. Thus, the demand for organic agricultural products is increasing worldwide (Bazaluk et al., 2020; Bhattarai, 2019; Opoku et al., 2020; Tandon et al., 2020; Tandon et al., 2021). The largest organic product consumption market is the US (over 45%), followed by Germany and France. In recent years, the increasing distribution of organic products in the provinces and cities of Vietnam indicates that Vietnamese consumers are increasingly interested in protecting their health by using organic foods.

Organic agricultural production requires a strict and synchronous process, including seed selection, caring and harvesting. Even the land for growing organic products needs to be planned into a separate area, along with the clean irrigation system with no impurities as well as GMOs in the entire production process (Bonelli et al., 2017; Han et al., 2017; Iocola et al., 2018). Organic agriculture is a trend, with a farming area of 43 million hectares, which creates a market value of about 80 billion USD. However, it only accounts for 5.7% of the mainstream agricultural market. The area for organic farming worldwide is still increasing over the years, especially in Oceania, accounting for nearly 40% of the world's organic agricultural land, while Australia alone contributes 22.7 million hectares. While Asia has 4.0 million hectares, Vietnam has its advantages in production spends only about 240 thousand hectares on organic agriculture (Liu and Nguyen, 2020; Kim, 2019). Being aware of organic agriculture importance for people's health, along with the desire to develop agriculture, in 2020, for the first time, the project on organic agriculture development for the period 2020 - 2030 was approved by the Government of Vietnam, showing the determination to develop safe agricultural products towards domestic consumption and export (Vietnam Government, 2020). The project

original is from the practice, methods and general orientation of the agriculture restructuring project towards enhancing added value and sustainable development. The project contributes to implementing national target programs along with promoting the potential strengths of organic agriculture of regions and localities. Moreover, it enhances the brand name of Vietnamese agricultural products on the world agriculture map, making Vietnam become a country with a level of organic production on par with advanced countries in the world. In this project, the Government has planned and considered the Northern midland and mountainous area as a key for organic agricultural production in the country, especially organic vegetables.

The northern midland and mountainous region of Vietnam is one of the six socio-economic regions in the country, including 14 provinces: Ha Giang, Cao Bang, Lao Cai, Bac Kan, Lang Son, Tuyen Quang, Yen Bai, Thai Nguyen, Phu Tho, Bac Giang, Lai Chau, Dien Bien, Son La, Hoa Binh; with a total area of about 100,965 km², accounting for 28.6% of the country; the total population of 13,853,190 people making up to approximately one-seventh of the country's population. The region also needs to ensure ecological environment security and water security since it is the headwaters of many rivers in Vietnam, ensuring irrigation for the vast Red River Delta (GSO, 2020).

The model with inputs combines some changeable factors over the years, such as the area of land for organic farming, the capital invested in the agricultural sector, the proportion of employees in the field of organic agriculture and Organic agricultural output collected from the national database and the database on agriculture in Vietnam.

The next part of this study is structured as follows: Section 2 introduces the standards of organic agricultural production in Vietnam, section 3 presents the background of the Northern Midlands and Mountainous Areas area including geographical conditions, analysis of advantages and disadvantages when developing organic agriculture in the region, section 4 presents the forecast research model, and the results will be presented in section 5, finally is discussion and conclusion.

II. STANDARDS ON ORGANIC AGRICULTURAL PRODUCTION PROCESS IN VIETNAM

There are 46/63 provinces and cities that are implementing and having the organic production movement nationwide. Currently, the number of farmers engaged in organic production is 17,168. There are 97 organic production enterprises, excluding unregistered small business households and 60 exporting companies with a turnover of about 335 million USD/year (GSO, 2020). Vietnamese organic agricultural products are consumed domestically and exported to 180 countries around the world, of which the US, EU, China, Japan, Germany, UK, Korea, Russia, Singapore, France, Belgium, the Netherlands, Italy, etc. are the largest consumption markets (Wertheim-Heck and Raneri, 2020). Based on the standards for organic production, on December 29, 2017, the Minister of Science and Technology signed and issued Decision No. 3883/QĐ-BKHCHN announcing the national organic food standards:

- Standard with ID: TCVN 11041-1:2017 Organic agriculture – Part 1: General requirements for production, processing and labelling of organic agricultural products,
- Standard with ID: TCVN 11041-2:2017 Organic agriculture – Part 2: Organic farming,

These standards are suitable for the conditions of Vietnam and inherit the standards of organizations in the world. Organic agricultural production under Vietnamese standards follows these eight steps (Figure 1)

Step 1: Select the farming area. The organic agricultural production area is ensured land safety, without any risk of being polluted by factories, hospitals, cemeteries, domestic wastewater, etc.

Step 2: Create an isolation buffer zone. It is one of the mandatory conditions to help guarantee a smooth production process, preventing external sources of infection or chemicals from other unsafe vegetable production areas, etc.

Step 3: Make hot compost to improve and enrich the soil

Step 4: Preparing the farming land, eliminating the source of pests before sowing with the sun heat or microbial products is necessary.

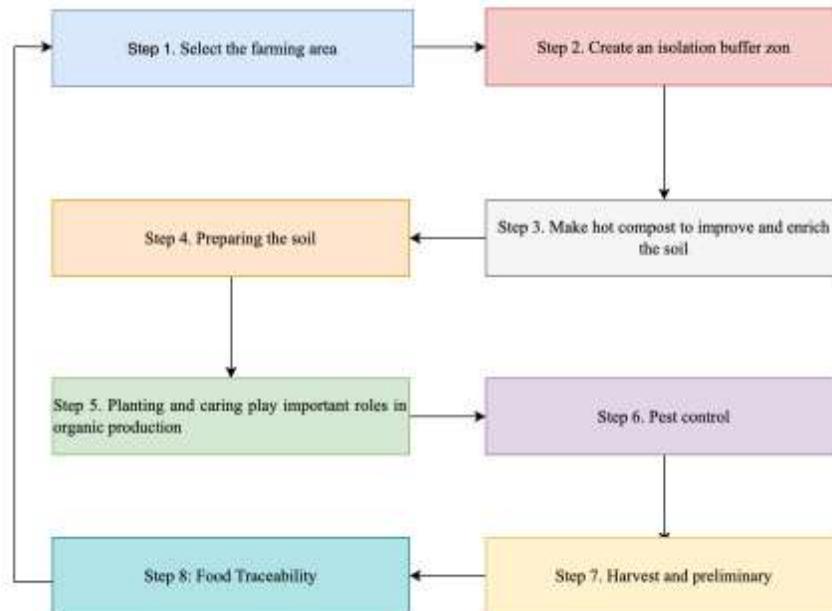
Step 5: Planting and caring play vital roles in organic production. It is necessary to rotate - intercrop to increase biodiversity while re-regulating ecological balance and no growth stimulants.

Step 6: Pest control. It is necessary to grow lure plants that attract or repel them in combination with traps to control pests. Herbs and hands are allowed to control weeds without any use of pesticides.

Step 7: Harvest and preliminary. After harvesting, purify vegetables with clean water with maximum damage is 10%.

Step 8: Food traceability. It is an important step to verify and evaluate whether vegetables meet organic standards or not. Vegetables, after verification, are labelled with the organic logo on the packages.

Figure 1
Organic Agricultural Production Process in Vietnam



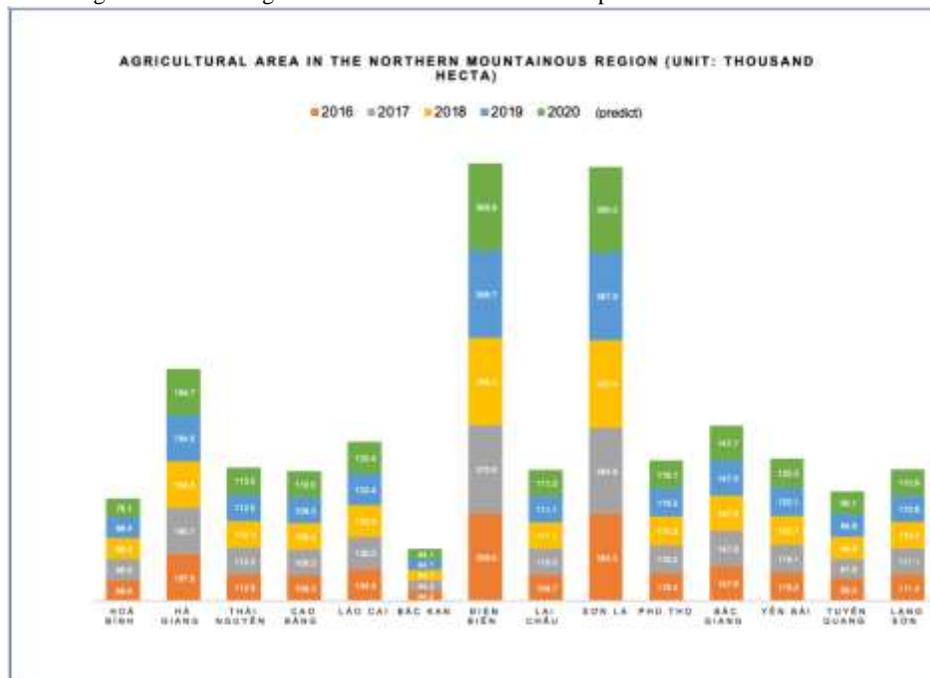
At each step, the production fully follows the regulations to ensure the quality of safe vegetables according to Vietnamese standards. The difficulty is to create a buffer zone because if the organic farming land is in a large agricultural area, it is easily affected by chemicals spread from other sides. Thus, selecting a place to develop organic agriculture is necessary. The northern midland and mountainous of Vietnam have the most advantages when small agricultural areas are interspersed with high mountainous, suitable for planning organic agricultural production.

III. CONTEXTUALISING THE STUDY AREA: THE NORTHERN MIDLAND AND MOUNTAINOUS AREAS OF VIETNAM

The midland and northern provinces of Vietnam hold a unique geographical position. The government is investing and upgrading the transport network in the region, so it is increasingly convenient for exchanging with other provinces in the country and building an open economy. This territory is the largest area among the economic zones, including 14 districts. The Northern Midlands and Mountains bordered China's Guangxi and Yunnan provinces to the north, Laos to the west, and the Red River Delta and North Central Coast to the south and southeast, respectively (Figure 3). As the headwaters of many rivers flowing to the lowlands, the development of organic agriculture solves the problem of regional economic development, maintains ecological stability while reducing environmental and source water pollution. The total natural area of the region is 9,520 thousand hectares (accounting for 28.74% of the total area of the country – figure

2), of which 56.93% is forestry land and only 22.23% for agricultural farming (Figure 4). The total area of organic agriculture is about 15,000 hectares. Previously, this area focused on developing fruit trees, perennials, industrial plants and afforestation. Tea is the most widely grown organic product in this area, which brings both economic efficiency and soil erosion resistance better than many other species. However, it is possible to intercrop that both effectively prevent erosion and keeping the soil more fertile.

Figure 2
Agricultural farming area of 14 northern mountainous provinces from 2016 to 2020



(Source: GSO, 2020)

The primary characteristics of the Northern midland and mountainous area for analyzing advantages and disadvantages when choosing organic vegetable development planning include:

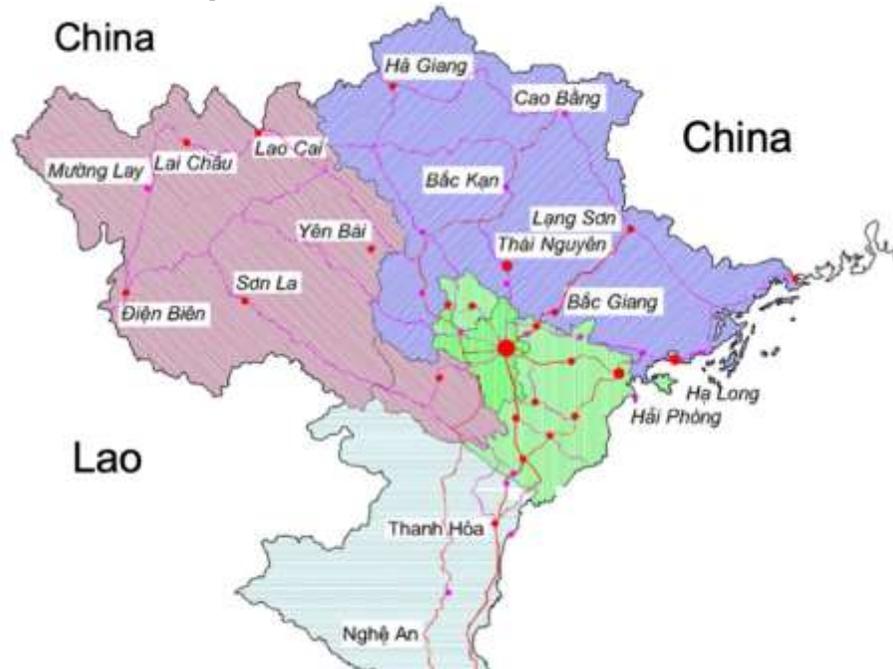
- Geographical location: This area bordered China and Laos with favourable trade opportunities.
- Topographical features: The Northern Midlands and Mountains include the Northwest mountains and the Northeast mountainous areas. The Northwest is a region consisting mainly of medium and high mountains. The Northeast mountainous region consists primarily of medium and low mountains.
- Climate features: The climate in the region is featured by a humid tropical monsoon, cold winter, influenced by mountainous terrain. Despite not having a high ground

in The Northeast, this area suffers the coldest winter in Vietnam. While being affected by the weaker northeast monsoon in the Northwest, due to the high terrain, the winter is cold. This climate feature is suitable for developing various short-term seasonal crops such as temperate, tropical and subtropical vegetables.

- Population and labour resources speciality: sparse population, low-skilled labour, many poor households with the highest illiteracy rate in the country. Nomadism, along with the current situation of burning forests for cultivating, affecting the ecological balance heavily.
- Traffic: Despite the developed national highway, the hilly terrain makes it challenging to transport in the high mountainous areas. Some highland areas are difficult for industrial development.

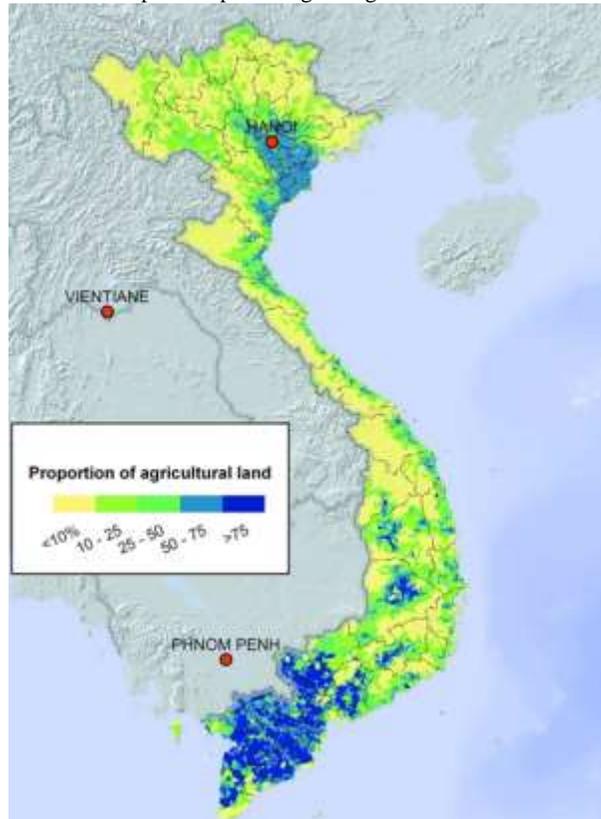
Figure 3

Map of the Northern Midlands and Mountains of Vietnam



(Source: Designed by Alotrip, data from GSO, 2020)

Figure 4
Map of the percentage of agricultural land



(Source: Designed by AgroInfo, data from GSO, 2020)

The advantages and disadvantages of developing organic agricultural products in the Northern mountainous region are analyzed in Table 1 below:

Table 1 Advantages and disadvantages when developing organic agriculture in the Northern mountainous region	
Advantages	<ul style="list-style-type: none"> - The climate is cold in winter and cool in summer, suitable for growing vegetables and short-term crops that are flexible with each weather condition. - 80% of the region's labour force is working in agriculture. - People have experience in growing food crops in mountainous terrain. - Clean water source - This area has no industrial plants, so there is little pollution of heavy metals. - Good air quality in highland areas.

	- mountainous terrain separates the farming areas are separated. There is no need to create an isolation buffer zone.
Disadvantages	- Although the total area occupies one-third of the country, the proportion of agricultural farming is less than 20% (Figure 2). - Low level of education, the poverty rate accounts for 17% of the total households in the region. Many people cannot speak the Vietnamese Mandarin language (2.5% of the total population in the area). - The number of untrained workers is over 76%.

Promoting the development of organic agriculture based on the advantages and disadvantages in the Northern mountainous region, the Government will solve the following social problems:

- To raise people's awareness of the environment through government-supported training sessions on the importance of clean water and ecosystems
- To create stable jobs for people and sustainable development of the regional economy based on the production of organic agricultural products.
- To re-plan areas for cultivation and people's living, changing practices of shifting cultivation and nomadism and avoiding indiscriminate deforestation.
- The development of organic agriculture is suitable for the intellectual level in this area while industrial or high-tech is not ready.

IV. METHOD OF FORECASTING ORGANIC AGRICULTURAL PRODUCTION IN THE NORTHERN MOUNTAINOUS PROVINCES OF VIETNAM

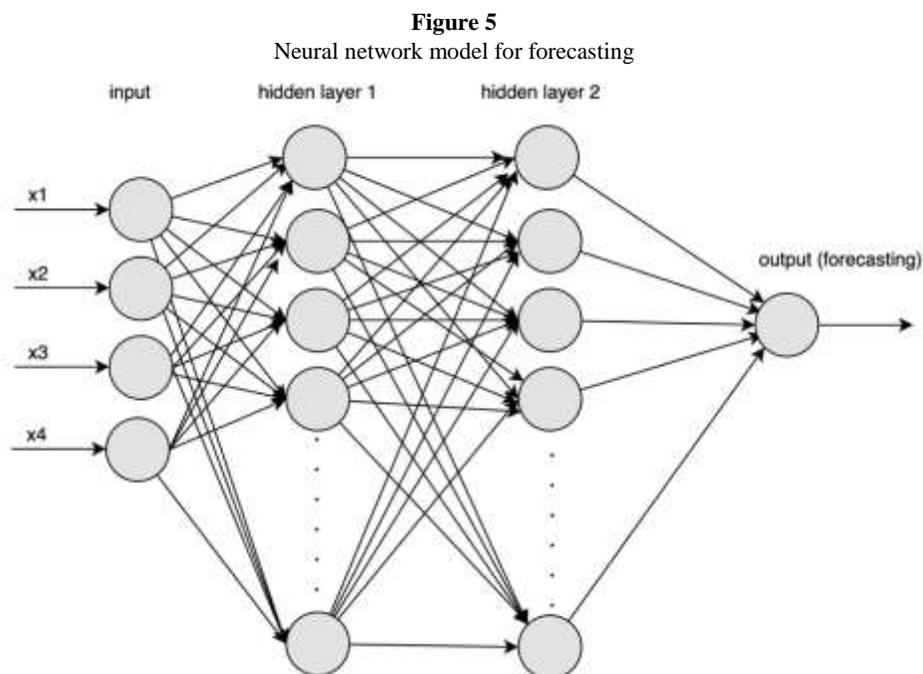
A. Neural Network Model

The artificial neural network simulates a computational process of a biological neural network. It is a network of single neurons (also called nodes) connected. The data is processed by passing connections and calculating new values at the nodes. The ability to be used as an arbitrary function approximation mechanism that 'learns' from observing data is the most significant advantage of artificial neural networks. An Artificial Neural Network (ANN) consists of 3 main components: Input and output with only one layer each. However, the hidden layer can have one or more layers depending on the specific problem. Hidden layers receive signals from the previous one. Then they are processed, transfer to the next layer. The operation of the ANN is to describe how the nervous system works with its interconnected neurons. Many studies apply artificial neural networks in various fields such as finance, trading, business analysis, business planning. Neural Network is also widely used for other economic, business management such as forecasting, marketing research, risk forecasting and fraud detection.

Recently, numerous studies have applied ANN models in forecasting to achieve better results than previous regression prediction models thanks to the fast learning speed and low error (Prashar et al., 2017; Sobhanifard, 2018; Bonelli et al. 2017).

B. Using Neural Network Model for Forecasting Organic Agricultural Production in the Northern Mountainous Provinces of Vietnam

The study applies an artificial neural network model to forecast organic agricultural production in the northern mountainous provinces of Vietnam. The neural network model used in this study consists of four layers with two hidden layers. There are four units in the input layer, one unit in the output layer and 50 units for each hidden layer. The study tried to adjust the number of units in each layer along with the number of the layer in the model tested and found out this architecture is the most suitable.



Four input variables in this model are:

- The changing rate in production of organic agriculture in the northern mountainous provinces
- The changing rate in the organic agricultural area of Northern mountainous provinces
- The changing rate in investment capital in agriculture of the northern mountainous provinces
- The changing rate in agricultural production labour in the northern mountainous provinces

V. RESULTS

A. Data

The study collects data for training from 2015 to 2020 from many sources such as surveys, statistical data from the Ministry of Agriculture and Rural Development, Vietnam Association of Organic Agriculture, General Statistics Office of Vietnam.

1. Data from Vietnam Organic Agriculture Association: Organic agricultural production output of northern mountainous provinces
2. Data from the Ministry of Agriculture and Rural Development: Area of organic agricultural land of northern mountainous provinces
3. Data from the General Statistics Office of Vietnam: Investment capital in agriculture of the northern mountainous provinces, the proportion of labour in the region.

B. Results

The forecasts are from 2021 to 2025 (stage 1 of the 2021-2025 development scheme). The author converted the input values to a year-by-year growth rate. For example, the production of organic agriculture in the northern mountainous provinces in 2017 increased by 27% in comparison with 2016. The organic agricultural production area in the region in 2017 increased by 17% in comparison with 2016. After normalizing the input data, the neural network model is used for training, predicting and testing the results.

We used a machine learning tool as Rapid Miner to train neural network model and apply it to forecast. The error_measurement is listed in table 2 below.

Table 2

Measurement	Value
MSE	0.42953855
RMSE	0.6553919
R ² (R squares)	0.8313014
Mean residual deviance	0.42953855
Mean absolute error	0.5747689
Root mean squared log error	0.20429842

According to the above measurement errors, the model is reliable for predicting the changes in organic vegetable production in the northern midland and mountainous areas of Vietnam.

The study presents a forecast of changes in organic agricultural production by year from 2021 to 2025. The results after running the model and applying it in the forecast witness an increasing rate over the years, depending on the area of organic agricultural production expanded. In addition, the factor of investment capital and the percentage of farmers shifting to organic farming also affect the increase in output year by year. Table 3 shows the results of changes in the production of organic agriculture from 2021 to 2025. This change is compared from year to year and represents an increase or decrease in production output.

Table 3
Forecast results of changes in organic agricultural production output by year

2021	2022	2023	2024	2025
7.5%	8.33%	12.08%	13.66%	12.65%

VI. DISCUSSION AND CONCLUSION

Food issues are getting more and more attention all over the world, so many countries are now tightening food security barriers with a series of criteria to assure the quality of imported food. A strong nation is a healthy community of people without being poisoned by water, food and diseases (Kushwah et al. 2019). Therefore, organic food solves three main problems:

- People are paying more and more attention to their health because the rate of cancer and genetic mutations is increasing. In Vietnam, 35% of cancers come from eating and drinking. People will look to organic products to avoid diseases and add more nutrients and vitamins than other conventional products.
- The Government cares about people's health, food security, prevention of environmental pollution, chemicals generated in farming and producing food to create a strong nation, sustainable economy. Since the efficiency in producing organic agriculture is 20-30% higher than conventional agricultural production.
- With the common goal of preserving a healthy living environment, organic agricultural products can be exported to other countries, increasing the country's GDP (Sardiana, 2021).

Although Vietnam is a traditional agricultural nation, there are cities at the top of the most polluted due to industrial development. Water sources are also heavily polluted because of industrial discharges and chemicals in the process of agricultural production. This bottleneck decreases the exportation of Vietnamese products to the world. Since there is a large amount of residue of pesticides, and nutrition does not meet the import standards of many countries in the world. In addition, Vietnam is also a country with a relatively high rate of cancer, up to 35% due to eating habits. Therefore, it is necessary to adjust and re-plan and build a new roadmap for the organic agricultural products development, applying high technology to the production process to increase efficiency while reducing environmental pollution caused by chemicals.

This study presented a method to forecast the changes in the production of organic agriculture in the Northern Midlands and Mountains from 2021 to 2025. The

Government has restructured this area and developed the organic vegetable growing land to suit the economic, social and labour conditions. The results are assertive when the change in production is positive and increases over the years under the variable impacts of investment capital, human resources involved in the production and planned area for the organic vegetable farming according to the approved scheme for the period from 2020 to 2030 by the Government of Vietnam.

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