Chapter 14
Sustainable Agriculture Development in Vietnam

Thi Hong Linh Phi and Thi Thanh Huyen Bui

Abstract In Vietnam, agriculture contributes significantly to economic growth, poverty reduction, food security, and social welfare. Over the last 30 years since the reform in 1986, agricultural sector in Vietnam has still shown many inner limitations and had negative spillover impacts on social and environmental dimensions. Based on the perspective of sustainable development, agricultural development in Vietnam has been far from being sustainable. In this paper, we will propose a group of indicators in order to measure sustainable agricultural development and use them to analyze the case study of Vietnam. The study results offer policy implications to develop a sustainable agricultural system in Vietnam.

Keywords Agriculture · Sustainable development · Sustainable agriculture · Vietnam

1 Introduction

Agriculture plays a critical role in developing countries. A well-developed agricultural sector can ensure food security as the population increases, generate jobs for rural workers, offer more opportunities in foreign trade and create a solid platform for industries (World Bank, 2008). Over the last few decades since the 1986 reform, the agricultural sector has achieved great success that significantly contributes to the socio-economic development of Vietnam. Different to harsh condition of starvation before 1986, Vietnam has not only ensured food security but also boosted the agricultural export turnover over the years. The agricultural sector has experienced a better structural transformation contributing to income generation for farmers and successful pursuit of Vietnam's development goals. However, agricultural development in Vietnam has revealed a number of weaknesses including low growth rate,

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A. T. Nguyen, L. Hens (eds.), *Global Changes and Sustainable Development in Asian Emerging Market Economies Vol. 2*, https://doi.org/10.1007/978-3-030-81443-4_14

insignificantly growing labor productivity, and rapidly growing emission in agricultural production. Therefore, these weaknesses will hinder agricultural development in Vietnam. Thus, Vietnam need to focus on offering better policies for sustainable agricultural development, contributing to the achievement of the national development goals in the future.

This study will provide a systemic review of existing theories to clarify the implications of sustainable agricultural development (contents, measurement criteria), use the recommended indicators to produce a situational analysis of Vietnam's agricultural development and thus propose adjustments in the future.

Literature Review Sustainable agricultural development has been much researched by many researchers. However, the concept of sustainable agricultural development has not been completely agreed yet. There are more than 70 definitions of sustainable agricultural development (Zhen & Routray, 2003). Of which are some concepts that the research team can access as follows:

In 1989, on the basis of the Bruntland Commission's definition of sustainable development, the FAO Council defined sustainable agriculture and rural development as:

> "… the management and conservation of the natural resource base, and the orientation of technological and institutional change so as ensuring the attainment and continued satisfaction of human needs for present and future generations. Such sustainable development (in the agriculture, forestry and fishery sectors) conserves land, water, plant and animal genetic resources, is environmentally non-degrading, technically appropriate, economically viable and socially acceptable".

By 1997, FAO specified the criteria to meet the sustainable development process of agriculture and rural areas, including: (*i) Meeting the basic nutritional requirements of present and future generations, qualitatively and quantitatively, while providing a number of other agricultural products; (ii) Providing durable employment, sufficient income, and decent living and working conditions for all those engaged in agricultural production; (iii) Maintaining and, where possible, enhancing the productive capacity of the natural resource base as a whole, and the regenerative capacity of renewable resources, without disrupting the functioning of basic ecological cycles and natural balances, destroying the sociocultural attributes of rural communities, or causing contamination of the environment; (iv) Reducing the vulnerability of the agricultural sector to adverse natural and socioeconomic factors and other risks, and strengthening self-reliance.*

Mollison and Slay (1994) asserted that sustainable agriculture is a system designed to be ecologically stable, economically viable, capable of meeting the human demands without exploiting the land, and polluting the environment.

According to Zhen and Routray (2003), an important principle of sustainable agriculture development is achieving long-term efficiency goals while preserving natural resources, especially land and water.

Swaminathan (2006) suggested that sustainable agriculture development must be stable and long-term efficiency without causing harms to the ecological and social system.

According to Pretty (1995), agricultural development is a learning process, not a goal, so in his study "Agriculture sustainability: concepts, principle and evidence" in 2008, he suggested that sustainable agriculture development should adhere to the following principles: (i) Applying ecological and biological cycles to production process; (ii) Restricting the use of nonrenewable inputs that are harmful to either environment or health of both producers and consumers; (iii) Effectively use of knowledge and skills of producers, thereby improving self-reliance and using human capital to replace external costly production factors; (iv) Effectively use collective capacity of people to solve common problems of agriculture and natural resources such as disease, irrigation.

Vu (2013) employed various approaches in sustainable agriculture development including (i) organic agriculture; (ii) conservation agriculture; (iii) selecting appropriate farming sites; (iv) limiting the use of external inputs; (v) integrated pest management; (vi) integrated nutrition management; (vii) production biogas in farms; (viii) expanding grassland areas; (ix) agroforestry systems, agriculture coping with climate change. In addition, the author also mentioned the concept of sustainable agriculture development based on the value chain, which is about developing a sustainable agricultural value chain from production to commerce, encouraging sustainable production processes.

Luu and Truong (2016), although not giving a specific concept of sustainable agriculture development, when analyzing the current situation of sustainable agriculture development in Vietnam during 1989–2014, approached the following aspects: (i) economic (growth rate, labor productivity, efficiency of capital use, contribution of factors to agricultural sector's growth); (ii) social (quantity and quality of labor, poverty rate, income inequality between rural and urban areas, improvement in the health issues and nutrition of citizens, educational and training level of rural civilians); (iii) environmental (emission from both agricultural production and soil as well as quality of water).

Some studies above showed that existing literature on sustainable agriculture development has approached different perspectives such as agricultural practices or the results of development. From the practical perspective, sustainable agriculture development refers to the principles and ways that agriculture production process must comply to the continuity and expansion of agricultural production to meet the demand that requires the improvement of the citizens' life quality (FAO, 1989, 1997; Pretty, 1995, 2008; Vu, 2013). Using result-based perspective, Zhen and Routray (2003) and Luu and Truong (2016) concluded that sustainable agriculture development deals with aspects of growth, the capacity to use resources, and the spillovers effect of agriculture that can impose the opposite effects to promote the development of agriculture. The division of these approaches is not fully complete because in fact, the results of sustainable agriculture development and agricultural practices are closely related. Sustainable agriculture development depends on the sustainability of the practice in agriculture. Particularly, the approach according to practical perspective is more appropriate for ecological studies. From an economic perspective, this study sees sustainable agriculture development as a result, agricultural practices will be considered factors affecting sustainable development outcomes.

With this approach, based on the overview of some concepts above, "sustainable agriculture development" can be seen as the process of maintaining the increase in scale and improving efficiency. The productivity of the agricultural sector also creates the positive impacts to social and environmental aspects.

With this concept, sustainable agriculture development covers the following basic contents:

Maintaining an increase in scale: maintain a stable and long-term growth rate.

Improving production efficiency: shown through improving the efficiency of using input resources to improve productivity, quality, and the competitiveness of agricultural products.

The positive spillovers effect on society: agricultural growth leads to improvement in social issues such as raising farmers' incomes, contributing to reducing the income gap between rural and urban areas, improving the living standards of farmers (rural areas), fulfilling the living conditions of people in order to increase the quality of the population in the agricultural and rural areas.

The positive spillovers effect on the environment: agricultural production is associated with environmental protection, preservation of natural resources, and biodiversity.

These will be the basis for giving out the indicators applied to analyze the situation of sustainable agriculture development in Vietnam in the following content.

2 Methodology

Based on the concept of sustainable agriculture development proposed above, the authors analyze the situation of sustainable agriculture development in Vietnam according as follows:

Firstly, analyzing situation of sustainable agriculture development in each specific aspect of the content.

Secondly, analyzing overall situations of sustainable agriculture development level through measuring the sustainability of agriculture.

With such an approach, the study is conducted as follows:

2.1 Data Collection

This study uses secondary data collected from reports of agencies and organizations from Vietnam and other foreign countries, including data collected from the Statistical Yearbook of General Statistics Office of Vietnam, data from the Vietnam Household Living Standards Survey of General Statistics Office of Vietnam, statistics of the World Bank and the World Food Organization (FAO). This study uses desk research approach to collect this type of data.

2.2 Data Analysis

After collecting the data, the authors use descriptive statistics approach to analyze data and then evaluate the current situation of agriculture development in Vietnam in the following steps:

1. Measure sustainable agriculture development in each specific aspect of the content as follows:

   Maintaining an increase in scale: analyzing growth rate.

   Improving production efficiency: analyzing the efficiency of the resource use, including labor (labor productivity) and capital (through increase in investment), and dependence on external resource factors.

   Spillovers effect on society: analyzing indicators of per capita income, expenditure structure, qualifications, and physical strength of the people in agricultural sector.

   Spillovers effect on the environment: analyzing indicators of agricultural-generated waste (CO_2) and the use of chemical fertilizers and pesticides.
2. Measure overall sustainable agriculture development: calculating and analyzing Sustainable Agricultural Index (SAI).

   This index was used by Hatai and Sen (2008) to calculate Orissa's sustainable agriculture index in India. The SAI method is similar to the human development index (HDI) released in 1992 by the United Nations. Specifically:

$$SAI = \left(I_E + I_S + I_{EN}\right)/3$$

   In which:

   Sustainability indicators for each sector is calculated based on the average of the I_{Xi} sub-indices. Where: I_E is the economic index, I_S is the social index, I_{EN} is the environmental index. These components are calculated according to one of the two below formulas according to the principle: if the component index has a positive impact on sustainability, select formula (14.1), whereas if the component index has the opposite effect, choose formula (14.2).

$$I_{Xi} = \frac{Xi - Xmin}{Xmax - Xmin} \tag{14.1}$$

or

$$I_{Xi} = \frac{Xmax - Xi}{Xmax - Xmin} \tag{14.2}$$

   To calculate the sub-indices, the authors applied the calculation and selected the indicators based on specific indicators measuring each aspect of the sustainable development content in accordance with the data conditions in Vietnam. In

principle: (i) It is feasible to collect calculated data. (ii) Change with space and time. (iii) Ensure sustainability on each pillar: Economic, social, and environmental. (iv) Widely accepted (Zhen & Routray, 2003).

Since then, data used to calculate SAI include (Table 14.1):

However, because the gap between the max and min values of the two groups of economic and environmental indicators is too large, the research team applies the way that UNDP adjusted to calculate the income index in HDI as follows:

$$I_E = \frac{\ln(Xi) - \ln(Xmin)}{\ln(Xmax) - \ln(Xmin)}$$

$$I_{Ei} = \frac{\ln(Xmax) - \ln(Xi)}{\ln(Xmax) - \ln(Xmin)}$$

The value of SAI will be in the range (0÷1), when the SAI value is closer to 1, the agriculture is more sustainable, and the closer to 0, the less sustainable. In more details, based on the Likert scale, it can be divided into five intervals: 0÷0.2 means unsustainable, 0.2÷0.4 means low sustainable, 0.4÷0.6 means medium sustainable, 0.6÷0.8 means relatively sustainable, 0.8÷1 means very sustainable.

3 Results

3.1 Increasing the Scale of the Agricultural Sector

Based on the statistical yearbook's data of the General Statistics Office, the authors calculated the agricultural growth rate of Vietnam over the last decade as follows (Fig. 14.1):

The figure above shows that the agriculture's growth is unstable and tends to decrease.

Table 14.1 Data used to calculate SAI (SAI)

	Data	X_{max}	X_{min}
IE	Agriculture labor productivity (USD constant price 2010)	140.340,96 (Argentina- 2010)	204,15 (Mozambique- 2010)
IS	Rural to urban income ratio (%)	100	0
	Percentage of trained employed agriculture population	100	0
IEN	The volume of chemical fertilizer (kg/ha)	6.225,78 (Qatar-2010)	0,084 (Rwanda- 2010)
	The volume of CO_2 emission by agriculture (ton/ha)	8.156,11 (Turks and Caicos Islands)	0,105 (Saint Pierre and Miquelon)

Source: The authors

Calculating from the statistics of the General Statistics Office, the average growth rate of the agricultural sector was 3.83% in the 2001-2005 period, 3.38% in the 2006-2010 period, 3.06% in the 2011-2015 period, and only 2.46% in the 2016-2018 period. The growth rate of the agricultural sector decreased, especially in the period from 2009 up to now, due to: (i) In the period of 2005-2014, the agricultural sector received little investment attention and necessary support, the proportion of investment in agriculture was low and decreased. At current prices, the percentage of agricultural investment in the total social investment decreased from 7.4% in 2005 to 6.15% in 2010 and 5.04% in 2014. At constant prices, the growth rate of investment capital for agriculture in some years was even negative, such as in 2011 (−8.3%), 2012 (−9.91%), 2014 (− 4.79%); (ii) From 2013 up to now, implementing the project of restructuring agricultural production, the proportion of investment in agriculture has tended to increase (reaching 6.31% in 2018), but the weather is unfavorable, consecutive epidemics make agricultural production fluctuate.

Therefore, the growth rate was not only decreasing, but also unstable. There are several years that agricultural sector had quite good growth, but there are years the growth rate decreased sharply, such as in 2009 and 2016. The reason for the sharp decrease in the growth rate in 2009 (only 1.91%) was due to the continuous epidemics in the Central Highlands and Southern Central Coast. In 2016, growth rate also decreased to 1.36% due to the cold weather, frost in the Northern provinces, drought and saltwater intrusion in the southern provinces (Mekong Delta) at the beginning of the year, incidents of marine environment in the Central region mid-year.

It is shown that Vietnam's agricultural sector is still heavily dependent on natural conditions, reflects its outdated production technology level. At the annual Climate Change Summit in Katowiice (Poland), Germanwatch (2019) shows that Vietnam is one of the 10 countries most affected by climate change. Thus, extreme weather events will tend to increase, directly threaten Vietnam's agricultural production.

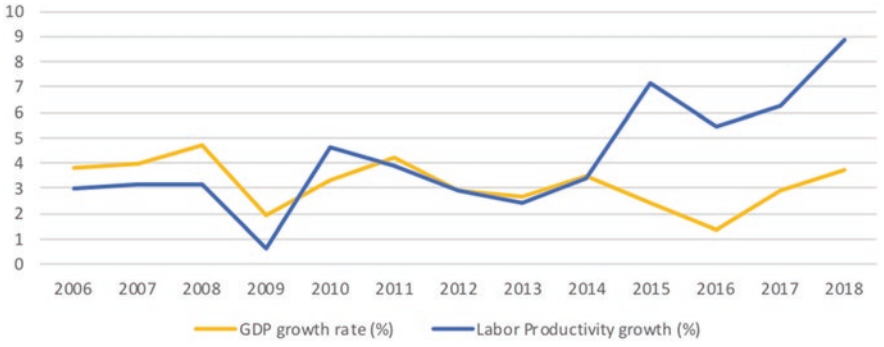

Fig. 14.1 Growth rate of GDP and labor productivity of agriculture sector. Source: Calculated from Statistical Yearbook 2018 - GSO Vietnam (2018a)

3.2 *Production Efficiency of the Agricultural Sector*

Labor efficiency, as shown by the labor productivity of the agricultural sector, has improved but still very low.

Although the labor productivity of the agricultural sector in Vietnam increased over time and faster than the GDP growth rate, which were 6.7%, 3.69%, and 2.47% in the periods of 2016-2018, 2011-2015, and 2006-2010, respectively, it still remains low. In 2018, labor productivity of agriculture reached 24.46 million VND/labor (constant 2010 price), only about 38% of the labor productivity of the whole economy.

In addition, Vietnam's agricultural labor productivity is lower than many other countries with similar income levels and Vietnam's labor productivity gaps with these countries are also increasing. According to World Bank data, in 2018, Vietnam's agricultural labor productivity reached 1209.85 USD, approximate 56.7% of the low-middle income countries, 38.2% of middle-income countries, 70.4% compared to India, and 56.8% compared to Uzbekistan (calculated at US $2010 constant price). A low labors productivity once again reflects the outdated production technology level of Vietnam's agricultural sector (Fig. 14.2).

The efficiency of investment capital in the agricultural sector is low, reflected in the high coefficient of increase in investment output in the agricultural sector.

On average, in the period of 2006-2010, the coefficient of increase in investment output in the agricultural sector was 4.16. It was 3.53 when 2009 was excluded (because, agricultural growth decreased sharply due to natural disasters, epidemic in 2009). It was 3.22 in the period of 2011-2015 and 5.72 in the period of 2016-2018 (excluding 2016, it was 4.2) (Table 14.2).

The coefficient of increase in investment output tends to increase in the period of 2016-2018 due to the impact of the agricultural production Restructuring Scheme, whereby, applying science and technology is promoted. However, with low level of

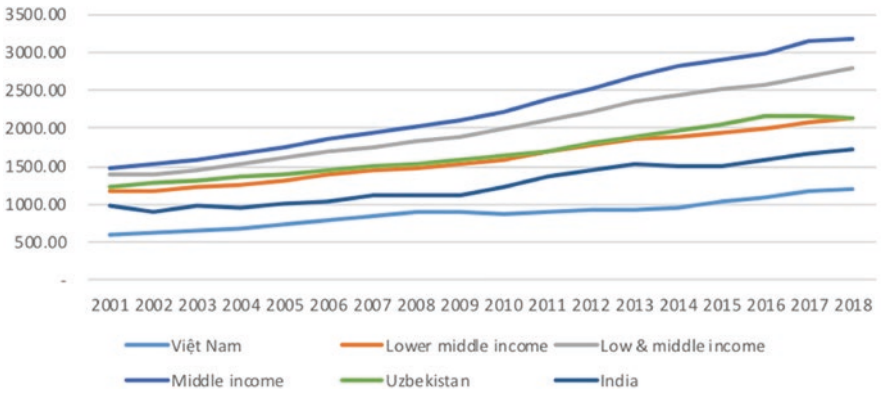

Fig. 14.2 Agricultural labor productivity of Vietnam and some countries. Source: World Development Indicators, Last Updated Date 10/7/2019

Table 14.2 The coefficient of increase in investment output

Period	The coefficient of increase in investment output in agricultural sector	The coefficient of increase in investment output whole economic	The coefficient of increase in investment output in agricultural sector/ The coefficient of increase in investment output whole economic
2006-2010	4.16/3.53[a]	6.29	66.1%/56.1%[a]
2011-2015	3.22	5.39	59.7%
2016-2018	5.72/4.2[a]	4.98	79.33%/66.8%[a]

Source: Calculated from Statistical Yearbook 2018 - GSO Vietnam (2018b)
[a]Calculated data after excluding 2 years with considerable changes in agricultural growth rate due to natural conditions (2009 and 2016)

technology in agricultural production, in addition with comparing the coefficient of increase in agricultural output to the whole economy, it is clear that efficiency of investment in the agricultural sector in Vietnam is low. The ratio of the coefficient of increase in investment output of agricultural sector to the coefficient of increase in investment output of the whole economy is increasing, meanwhile, the coefficient of increase in investment output of the whole economy of Vietnam is very high (1.5 to 2 times higher) compared to other countries with the same period of rapid growth and the same level of technology as Vietnam today (South Korea in the period of 1981-1990 was 3.2, Japan in period of 1961-1970 was 3.2, China in the period 1991-2003 was 4.1).

Agricultural production is a processing nature, dependent on agricultural materials imported from abroad.

The processing nature of agricultural production is reflected in the fact that domestic agricultural production is highly dependent on inputs import both for the crop and livestock industries. Domestic livestock depends on food sources and raw materials for processing food from abroad. According to the Ministry of Agriculture and Rural Development, domestic maize and soybean production only meet 50-55% of the demand for animal feed production and processing, thus, along with the growth of the domestic livestock industry, the import of food and feeding ingredients also increases. In 2018, 70% of total raw materials for animal feeding were imported.

In cultivation, currently, Vietnam can only produce a number of types of fertilizer such as NPK, urea, and phosphorus, some types of domestic materials cannot be produced at all and must be imported. Besides potassium fertilizer, SA fertilizer, Vietnam also has to import a large amount of pesticides. Production dependent on material produced from abroad makes the efficiency of agricultural production low.

3.3 Spillovers Effect on Society

Based on the evaluation criteria proposed above, an analysis of the spillovers effect of agriculture on social aspects through analyzing living standards and quality of population in agriculture sector and rural areas shows the followings:

Firstly, the income disparity between urban and rural areas is increasing.

Increasing in per capita income, the relative gap between rural and urban areas (according to survey data of Household Living Standards (2016) has narrowed, the average monthly per capita income of rural area was 47.83% compared to rural in 2006, increased to 53.2% in 2016) but, the absolute gap is getting bigger, in 2006 the average monthly per capita income of rural area was 883,7 thousand dongs higher than of rural area but in 2016 the gap increased to 1443.5 thousand dongs (constant price, 2010).

Secondly, living standards in rural area are still low.

With a low income level, expenditure in rural areas is also much lower than that in urban areas, according to the results of the Household living standard survey in 2016, the average monthly expenditure per capita of rural areas is only 56.7% compared to urban areas. At the same time, due to the lower income, the ratio of expenditure to income of rural areas is also higher than that of urban areas (in 2016, the average urban population spent 67.2% on expenditures, while rural areas spent 71.6%). Thus, the accumulation of rural people is much lower than in urban.

In addition, analyzing the expenditure structure of rural people shows that: because of the lower income, rural people are spending a larger proportion of income on essential needs (food, drinking, smoking) compared to urban people. In the expenditure structure for life, rural people spend about 52.9% on food, drinking, smoking; only 4.9% on education, while the corresponding figures in urban areas are 48.7%, 6.7%. The share of spending on education is lower but the proportion of spending on health in rural areas is higher than in urban areas (6.4% vs. 4.8%) means that the quality of life rural people is lower and rural people face more difficulties in improving their quality of life.

In addition, the poverty rate in rural areas is still high. According to data released by the General Statistics Office (2019), the income poverty rate of rural areas in 2016 was 7.5%, much higher than in urban areas (2%). Not only income poverty, multidimensional poverty in rural areas is also still quite severe, in 2018, the multidimensional poverty rate in the rural area was 9.6% compared to 1.5% in the urban area. These data show that not only the income is lower but also the living condition in rural areas is worse.

Thirdly, labor quality in agriculture sector is much lower than in other sectors.

Data from Statistical Yearbook of General Statistics Office of Vietnam showed that the percentage of trained employed population of agriculture is much lower than other sectors in the economy, in 2018, percentage of trained employed population at 15 years of age and above of agriculture was only 4.1%, while the average percentage of the whole economy was 21.9%. The process of improving the labor force in agriculture has also been slower than in the whole economy (Table 14.3).

Table 14.3 Percentage of trained employed population at 15 years of age and above

	2010	2013	2014	2015	2016	2017	Pre. 2018
TOTAL	14.6	17.9	18.2	19.9	20.6	21.4	21.9
Agricultural sector	2.4	3.5	3.6	4.2	4.1	4.2	4.1

Source: GSO Vietnam (2018a, 2018b)

In addition, according to the 2016 Household Living Standard Survey, following the highest degree of people, agriculture sector accounted for only 11.9% of the total number of labor with a college degree while industry had 21.9% and service had 66.2%. The agriculture sector only accounted for 4.5% the total number of labor with bachelor degrees, the industry contributed 18.8%, and services had 76.7%. Meanwhile, the agriculture sector accounted for 82.2% of the labor who have not completed the first grade or have never gone to school, 65.1% of the workers without a degree. The low degree of labor is the reason for many difficulties to the agriculture sector in receiving and applying modern production techniques to production. This is also the reason for the unsustainable economic indicators in agriculture development analyzed above.

Beside the low degree of employees, the quality of health of the rural population is also low, reflected by the high rate of malnourished children and the slow rate of reduction. According to data in 2018, in rural areas, the current situation of malnutrition of under-five children is as follows: rate of weight-for-age malnutrition was 16.1%, rate of height-for-age malnutrition was 26.7%, rate of weight-for-height malnutrition was 6.7%, those rates are much higher than in urban areas (corresponding figures are 7%, 10.2%, and 4.8%).

The low quality of health of the agricultural and rural population is a factor that makes it difficult for having sustainable agriculture development not only in the present but also in the future.

3.4 Spillovers Effect on Environment

Assessment of sustainability in agricultural development in Vietnam over the years from the perspective of Spillovers effect on the environment shows the following manifestations:

Firstly, agricultural production is still not environment-friendly because of overusing chemical fertilizers and pesticides.

In Vietnam, environment-friendly farming practices such as organic agriculture, climate-resilient agriculture, and low-input agriculture are few. In 2017, organic production land was 57.01 thousand hectares, equivalent 0.53% of total agriculture land. Although the rate of organic production land in Vietnam was higher than in Thailand (91.26 thousand hectares, equivalent 0.41%), Indonesia (208.04 thousand hectares, equal to 0.36%), it is still very small and lower than in Philippines (200,06

thousand hectares, equivalent 1.16%); China (3023 thousand hectares, equivalent 0.59%) (FiBL & IFOAM, 2019).

Because of the low rate of organic production land, agricultural production in Vietnam is still not environmentally friendly because of overusing chemical fertilizers and pesticides:

3.4.1 Chemical Fertilizer Consumption

In 2016, Vietnam's chemical fertilizer consumption was 429.78 kg/ha, reduced by 40.92% comparing to 2002 (304.96 kg/ha). However, Vietnam is still in the group of countries with high chemical fertilizers consumption in the world. We used 1.8 times higher than Uzbekistan, Thailand (2.65 times), the Philippines (2.73 times), India (2.59), and the average of the Asia Pacific region (1.29 times). The continuous increase in using chemical fertilizers has shown that the policies to encourage businesses to produce organic fertilizers and encourage farmers to use organic fertilizer during their cultivation toward a green agriculture of the Ministry of Agriculture and Rural Development have not been effective (Fig. 14.3).

Intensive farming and chemical fertilizers consumption to improve productivity are making agricultural land degrade; soil, water, and environment are polluted. This has negatively affected the sustainability of Vietnam's agriculture.

3.4.2 Pesticide Consumption

In 2016, Vietnam's pesticide consumption was 157.28 kg/km^2 down 30.67 kg compared to 2000. Vietnam's pesticide consumption was lower than China and Malaysia, but still higher than some countries in the region, specifically India used only 28.5 kg/km^2, Thailand used 98.6 kg/km^2. Therefore, in the coming time, Vietnam must replace chemical pesticides with biological pesticides to reduce toxic

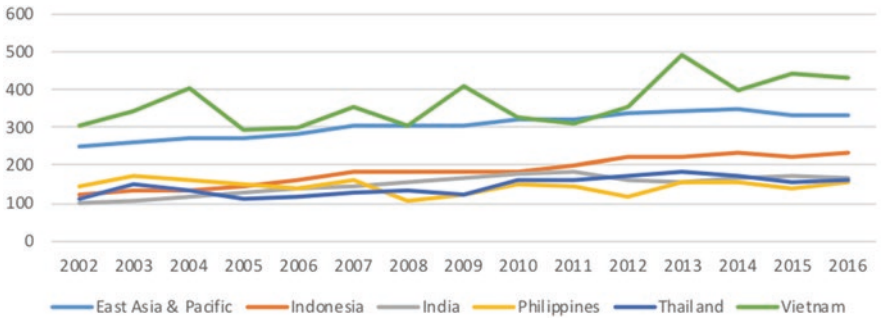

Fig. 14.3 Chemical fertilizer consumption in Vietnam and some selected countries. Source: Calculated from World Bank data, https://data.worldbank.org/indicator

Table 14.4 Pesticides consumption in Vietnam and some selected countries (*Unit: Kg/km²*)

Year	Vietnam	Thailand	India	China	Malaysia
2000	187.95	102.52	24.84	246.86	567.92
2010	178.01	327.57	22.26	343.20	814.63
2016	157.28	98.60	28.05	344.45	574.10

Source: Calculated from World Bank Data, https://data.worldbank.org/indicator

chemicals in pesticides to be released and penetrate air, water, and sediment, thereby limiting the impact on biodiversity, soil, water, and air quality (Table 14.4).

Second, greenhouse gas emissions by agricultural production are increasing rapidly.

The total amount of carbon dioxide (CO_2) released from agricultural production into the air still tends to increase, from 57.43 million tons in 2000 to 65.22 million tons in 2016. On average period 2000-2016, the growth rate amount of CO_2 of Vietnam's agricultural sector released into the air was 2.144%/year, higher than the growth rate of China (1.439%/year), and Thailand (0.339%/year).

The average CO_2 emission per 1 ha of agricultural land in Vietnam was 9.32 tons/ha, which is also higher than Thailand (3.39 tons/ha), Indonesia (7.3 tons/ha), India (4.06 tons/ha) (calculated from FAO data, 2019). As of 2016, Vietnam was still in the category of high average agricultural CO_2 emissions.

In the period 2000-2016, the proportion of CO_2 emissions of the agricultural sector in total CO_2 emission decreased from 39.26% to 29.82%. The reason for the decreasing proportion of CO_2 emission of agricultural sector is the growth rate of emissions of agricultural production is slower than the growth rate of emissions of industrial production, transport, which shows the efforts of Vietnam's agricultural sector to reduce greenhouse gas emission and slow down the drawbacks of climate change (Fig. 14.4).

Considering the structure of CO_2 emission sources in Vietnam, rice cultivation emits the highest amount of gas (44.23%), followed by synthetic fertilizers (17%). The least CO_2 emissions are burning - crop residues (0.67%) and Burning - Savanna (0.18%) (FAO, 2019).

The high amount of chemical fertilizers and pesticides consumption together with greenhouse gas emissions from agricultural production is constantly increasing, reaches high levels and leads to environmental pollution, affecting people's health, especially rural people.

3.5 Overall Sustainable Agriculture Development Measurement

Measuring overall sustainable agriculture development by using Sustainable agriculture index (SAI) in the period of 2010-2016 gives the followed result (Table 14.5):

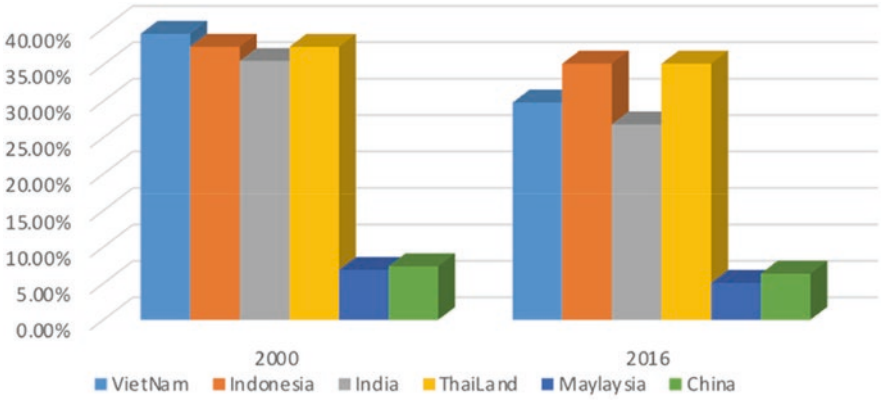

Fig. 14.4 The proportion of CO_2 emission in agricultural sector (%). Source: Calculated from FAO data (http://www.fao.org/faostat/en/?#data/GT)và EDGA (2018)

Table 14.5 Sustainable agriculture index of Vietnam in the period of 2010-2016

Year	Labor productivity (constant price 2010 USD)	I_E	Ratio per capita income between rural and urban (%)	Percentage of trained employed agriculture population (%)	Is	Chemical fertilizer consumption (kg/ha)	CO_2 emissions (tons/ha)	I_{EN}	SAI
2010	864.8	0.2090	50.2	2.4	0.263	323.3	9.432	0.432	0.301
2012	922.4	0.2191	52.8	3.0	0.279	352.3	9.474	0.428	0.309
2014	966.8	0.2264	51.4	3.6	0.275	397.8	8.911	0.425	0.309
2016	1099.6	0.2464	53.2	4.1	0.287	429.8	9.320	0.420	0.318

Source: Calculated from data of FAO (2019), World Bank (2019), GSO Vietnam (2018a, 2018b)

In the period of 2010-2016, the sustainable agriculture index (SAI) tended to increase from 0.301 in 2010 to 0.318 in 2016, the average growth rate was 0.88%/year. This shows a more sustainable trend of Vietnamese agriculture. However, with the SAI was 0.318 in 2016, Vietnam's agricultural sustainability is still low (within the range of 0.2÷0.4).

Analyzes the components of SAI:

Although economic index (I_E) growth rate is the highest (the average growth rate of 2.78%/year), it is the lowest component index of SAI, which is only about 0.2÷0.4. This shows that the economic sustainability of Vietnam's agriculture is very low, similar to the content analyzed above (growth rate is decreasing, agricultural output is unstable, the efficiency of input factors is not high).

The social index (I_S) increased 1.44%/year (slower than the increase of I_E), the value of I_S is little higher than I_E and also in the range of 0.2÷0.4. This means that

the impact of economic growth on the social is positive but very little. This is because the growth rate of agriculture is not high enough to deal with the social problem in agriculture sector and rural area. Most of social progress in agriculture and rural areas are not directly due to the development of the agricultural sector but because of the impact of other policies and programs such as the New Rural Program, the Vocational Training Program for Rural Laborers of the Ministry of Agriculture and Rural Development.

The environment index (I_{EN}) is the highest component index but tends to decrease (decline rate is 0.47%/year) and lies at lower bound of 0.4÷0.6, showing that environmental sustainability is low and decreasing. It means that environmentally friendly farming methods have not developed strongly enough to restrict the environmental pollution.

4 Conclusions and Discussion

From the analyzes above, it can be seen that agriculture development in Vietnam is not sustainable: (i) growth rate is decreasing, unstable, the ability to maintain the increase in scale, and the resistance against negative factors is still limited; (ii) The efficiency of input resources (capital and labor) is low, domestic agricultural production is highly dependent on imported materials; (iii) The Spillovers effect of agricultural development on social aspects is limited (living standards in rural area are still low, the quality of the population in agriculture and rural areas is much lower than in urban areas); (iv) Agricultural production do not protect environment (chemical fertilizers and pesticides and greenhouse gas emissions are continuously increasing and reaching a higher level); and (v) The overall assessment shows that the sustainability of Vietnam's agriculture is still low.

From above limitations, there are requirements for innovation in Vietnam's agricultural production in the coming time toward maintaining a high and stable growth rate based on the application of high-tech science and technology to increase productivity, increasing the efficiency of using input resources, applying green agricultural cultivation methods to protect the environment. With such development directions, some key solutions should be implemented, including:

Restructuring the agricultural sector toward sustainable development.

In order to develop agriculture sustainability, increase productivity, increase efficiency of agricultural production, reduce environmental pollution, it is necessary to accelerate the restructuring of the agricultural sector toward sustainable development, i.e., development of industries and production, utilizing comparative advantage of agricultural products, developing high-tech application agriculture, and green agriculture.

Enhancing investment attraction for developing science-applied agriculture, high-tech agriculture, and green agriculture.

To improve production efficiency and labor productivity, reduce the consumption of fertilizers, pesticides, and emissions due to agricultural production; the

application of science and technology, development of hi-tech agriculture, and Green agriculture industry are the inevitable. However, in order to attract investment in agricultural development toward this direction, it is necessary to complete policies to attract investment in developing agricultural production, such as land accumulation policy; credit policy; tax policy.

Training and retraining for laborers to improve agricultural labor skills.

The low in quality of labor in agriculture is the main reason for difficulty in sustainable agriculture. In order to develop agriculture sustainability, it requires farmers to have knowledge, awareness of sustainable agricultural production; advanced techniques and farming methods; responsibility and ability to apply the achievements of science and technology in the production process; knowledge of markets, laws, business. Therefore, it is necessary to provide training and retraining courses in order to equip farmers with this knowledge.

Reorganizing the agricultural production model toward modernization.

Building and reorganizing modern agricultural production models is an important content to promote sustainable agriculture development. Accordingly, the agricultural production models must create favorable conditions for the application of science, technology, and advanced agricultural production methods, and perform the function of linking farmers with the market and stakeholders to strengthen the value chain of agricultural products, increase the value of agricultural goods.

Strengthening linkage in agricultural production.

It is necessary to strengthen linkages in agricultural production, including vertical linkages between farmers and stakeholders (enterprises and researchers) and horizontal links (between farmers), not only within a locality but also regional linkages to form agricultural value chains, agricultural clusters to increase the value of agricultural goods.

In conclusions, with about 15% of GDP and 38.1% of labor (as of the end of 2018), the agricultural sector still plays an important role in the economy, so sustainable agricultural development is still a condition that ensures successful implementation of Vietnam's development goals. Although the article still has certain limitations, the comments are drawn after analyzing the status of agricultural development in Vietnam over the pastime and some suggestions mentioned above will be suggested to the development of Vietnam's agriculture in the coming time, contribute to the implementation of the set development goals toward a prosperous Vietnam.

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