International Journal of Research in Human Resource Management

E-ISSN: 2663-3361
P-ISSN: 2663-3213
IJRHRM 2024; 6(2): 273-281
www.humanresourcejournal.com
Received: 11-08-2024
Accepted: 18-09-2024

Phan Thi Thanh Huyen
Vietnam National University of Agriculture, Vietnam

Tran Trong Phuong
Vietnam National University of Agriculture, Vietnam

Corresponding Author:
Phan Thi Thanh Huyen
Vietnam National University of Agriculture, Vietnam

Vietnam's human resources in agriculture under the context of Industrial Revolution 4.0

Phan Thi Thanh Huyen and Tran Trong Phuong

DOI: https://doi.org/10.33545/26633213.2024.v6.i2c.225

Abstract
The study proposes solutions to ensure human resources for Vietnam's agricultural development in the Industrial Revolution 4.0 (4IR). Human resource quality is the most essential aspect of a country's socioeconomic development. Under the 4IR, agricultural human resources have a chance to approach science and technology in the agricultural production process. Applying the new technologies makes it easier for producers, managers, and consumers to keep an eye on the whole production process, guaranteeing safe, transparent, and highly connected production that complies with contemporary consumption patterns. However, it also creates challenges such as a surplus of unskilled workers, and a scarcity of high-quality human resources. Therefore, it is necessary to complete mechanisms and policies to encourage students studying agricultural majors; and preferential policies for lecturers; reinvent instructional programs, methodologies, and soft skills to mix theory and practice; diversify the content and methods of training; collaborate with businesses; forecast agricultural human resource needs.

Keywords: Agriculture, human resources, industrial revolution 4.0, Vietnam

1. Introduction
4IR originated from the initiative of the German Federal Government in 2011 at the Hannover Technology Fair (Kagermann and Wahlster, 2022) [25]. According to Khuyen and Son (2020) [27], Industry 4.0 is the integration of digital technology, biotechnology, and physics to create smart manufacturing. It is understood as a comprehensive concept including a set of new technologies such as the Internet of Things (IoT), artificial intelligence, augmented reality, virtual reality, robots, big data analytics, 3D printing, and cloud computing (Rojko, 2017) [48]. To optimize operations and reduce costs, these technologies are connected to the Internet-of-Things system to collect information in the Cloud and Edge, which is then processed by artificial intelligence algorithms (Friha *et al.*, 2021; Liu *et al.*, 2020) [16, 30].

4IR has promoted the Fourth Agricultural Revolution, known as Agriculture 4.0. The first three industrial revolutions have profoundly reshaped the agricultural sector from Indigenous agriculture (Agriculture 1.0) to mechanized agriculture (Agriculture 2.0) and precision farming (Agriculture 3.0) (Friha *et al.*, 2021; Liu *et al.*, 2020) [16, 30]. The core elements of Agriculture 4.0 are information technology, digital technology, and artificial intelligence (Cuong and Ngoc, 2019) [11]. According to Tuan and Xiem (2018) [51], agriculture 4.0 is a closed process applying technology from high-quality seeds, smart fertilizers, herbal pesticides, and precision farming; reducing seed loss and greenhouse gas emissions; automating from harvest, storage, transportation, and processing; applying cloud computing for traceability. Agriculture 4.0 uses digital technology and aims for a smarter, more efficient, and environmentally responsible agriculture (Javaid *et al.*, 2022) [24].

Numerous studies have demonstrated that new technologies have the potential to change agricultural practices. Smart farming is used to modify the amount of fertilizer, pesticide, and herbicide levels. Drones help detect weeds, while robots help farmers milk animals... Applying new technologies helps farmers organize production better, thereby bringing higher production efficiency (Ferrag *et al.*, 2021; Price, 2022) [14, 39]. Khuyen and Son (2020) [27] have stated that agricultural production in the context of the Industrial Revolution 4.0 (4IR) will create high-quality and safe food products while ensuring food security to respond to climate change. The application of new technologies is a key strategy for raising the agriculture sector's productivity in developing countries (Damba *et al.*, 2020) [13];

improving productivity and income (Addison *et al.*, 2020; *Bacco et al*., 2019) [2, 4]; increasing the efficiency of the supply chain (Arora *et al.*, 2022) [3, 4]; overcoming seasonal labor shortages (Javaid *et al.*, 2022) [24]; and promoting sustainable agricultural development (Ferrari *et al*., 2022; Javaid *et al.*, 2022) [15, 24].

In Vietnam, agriculture is crucial to the reform process because it eliminates hunger, reduces poverty, and ensures food security (Wegren and Elvestad, 2018) [55]. Vietnam's agriculture has experienced significant transformations and made numerous worthwhile advancements since the reform. Especially in light of the severe COVID-19 pandemic, agriculture is seen as a cornerstone of the economy and a bright point, with an average annual growth rate of more than 3.0% from 2020 to 2023. In addition to guaranteeing food security, its export value reached 53.01 billion USD in 2023, lower than the target of 54 billion USD set at the beginning of the year. Although the target was not achieved, the trade surplus set a record of 12.07 billion USD, an increase of 43.7% compared to 2022, accounting for over 42.5% of the country's trade surplus (Chu Khoi, 2024) [8]. Despite optimistic outcomes, agriculture continues to face challenges such as population expansion, urbanization, diseases, supply and demand disruptions, climate change, high input prices, logistical costs, and a lack of highly skilled people resources. Restructuring is required to address these challenges. Moreover, considering its potential and benefits, agriculture's GDP share at current prices is only 12% (General Statistics Office of Vietnam, 2023) [17].

To overcome the above challenges and create new motivation to change agriculture from "agricultural production thinking" to "agricultural economic thinking", towards multi-value integrated agriculture, ecological agriculture, sustainable development, modern countryside, and civilized farmers, mastering science and technology, the Party and State is interested in 4.0 technology. Smart governance, digital transformation, and smart agriculture are the emphasis of Directive No. 16/CT-TTg (Prime Minister of Vietnam, 2017) [41]. Decision No. 749/QD-TTg identified digital transformation in agriculture as one of eight priority areas, in which “farmers” are at the center of digital transformation (Prime Minister of Vietnam, 2020) [43].

The more science and technology advance in 4IR, the more advanced machinery and equipment are needed, and the more skilled workers are needed. High-educated workers can swiftly adopt new production methods, maximizing productivity. Human resources in guaranteed quantity and quality are crucial to agricultural restructuring and rural development. Unfortunately, our country's agricultural human resources are still poor, vocational training is rare, and the number of agricultural majors has dropped drastically in recent years. These are major challenges for agricultural development requiring the application of science and technology in production. Therefore, it is necessary to assess the situation of agricultural human resources in Vietnam to answer the following questions: *How are agricultural human resources in Vietnam? What obstacles do agricultural human resources face in the 4.0 industrial revolution? What solutions are needed to develop Vietnamese agriculture human resources in the 4.0 industrial revolution?*

2. Methodologies

The study refers to published scientific research works and statistics data sources to evaluate the current status of agricultural human resources and agricultural development in the context of the 4.0 industrial revolution. In addition, the study also synthesizes and evaluates the state's policies related to developing agriculture and human resources in the context of the 4.0 industrial revolution. The analysis method of opportunities and challenges is used to evaluate the situation of human resources that affect agricultural development. The expert method is used to consult the opinion of scientists and managers as a basis for proposing solutions for agricultural human resources in the context of the 4.0 industrial revolution in Vietnam.

3. Results and Discussion

3.1. Agricultural human resources in Vietnam

According to Table 1, the labor force reached a record high of 51,287.0 thousand civilians by the end of 2023, an increase of 2,162.6 thousand civilians compared to 2010 (a rise of 4.40%). Although the labor force nationwide increased by 4.4%, it decreased rapidly in agriculture sector (agriculture, forestry, and fishery) from 23,563.2 to 13,815.4 thousand civilians in the stage of 2010 - 2023 (a decrease of 42.17%) (General Statistics Office of Vietnam, 2024) [18]. From 2011 to 2020, the Southeast labor force declined from 1.24 million to 778 thousand civilians, and the Mekong Delta labor force declined from 10.2 to 9.36 million civilians (Huy Lan, 2023) [22]. Civilians came to industrial zones and cities to find work, which is why the labor force decreased. Vietnam’s urbanization ratio increased rapidly between 2010 and 2020, from 30.5% to nearly 40% (Central Executive Committee of the Party, 2022) [7] and 42.6% in 2023 (General Statistics Office of Vietnam, 2023) [17]. Theoretically, by relocating the labor force from rural to urban areas, urbanization can boost economic growth (Cao *et al.*, 2020) [5]. Numerous studies identified and analyzed migration and the tendency of the labor force to relocate from rural to urban areas (Harris and Todaro, 1970; Lewis, 1954) [29].

Table 1: The labor force in Vietnam

Years	Whole country (1,000 people)	Agriculture sector	
		Total (1,000 people)	Percentage (%)
2010	49,124.4	23,890.3	48.6
2015	53,110.5	23,135.7	43.6
2020	53,609.6	17,724.6	33.1
2021	49,072.0	14,262.3	29.1
2022	50,604.7	13,937.6	27.5
2023	51,287.0	13,815.4	26.9

Source: General Statistics Office of Vietnam, 2024.

The quality of agricultural human resources in our country is quite far behind that of developed countries and some countries in the region. The situation of "surplus teachers, lack of workers" has not been effectively resolved, leaving human resources wasted and the benefit of cheap labor gradually eroding. The rate of trained and vocationally trained workers is still low, the structure of human resources by training level is inadequate, and the situation of "too many teachers, not enough workers" has not been effectively resolved, leading to wasteful use of human resources; the advantage of cheap labor is gradually lost. Decision No. 579/QD-TTg stated that 55% of workers are to

be trained by 2015 and 70% by 2020 (Prime Minister of Vietnam, 2011) [40]. However, only 27.1% of all workers in the economy who are 15 years of age or older have vocational training at the end of 2023. Figure 1 showed the proportion of workers aged 15 and over in the agriculture sector who have received vocational training is still low, ranging from 2.4 - 4.5% from 2010 to 2023 (General Statistics Office of Vietnam, 2023) [17].

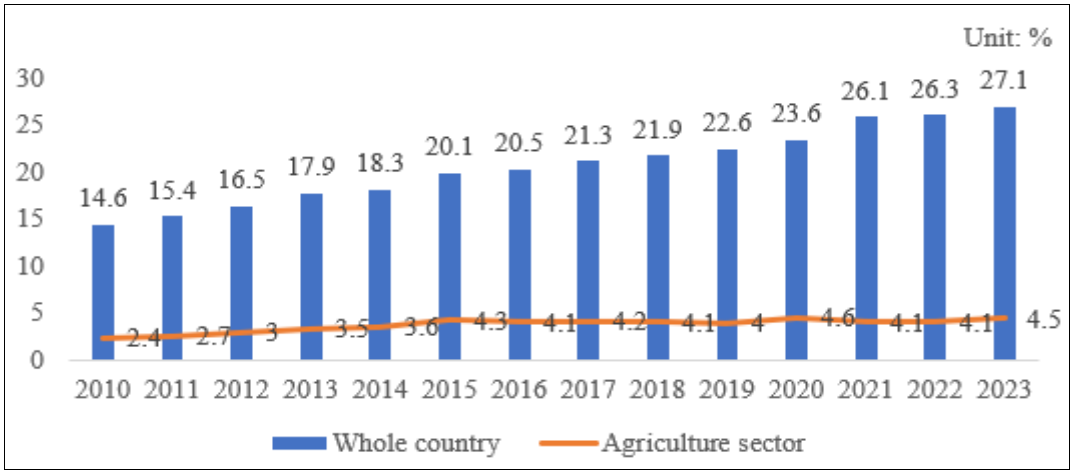

Fig 1: Employed workers who are 15 years of age or older in VietNam

The application of advanced science and technology depends on human resource quality. A survey of 70 farmers and 48 extension workers, (Agussabti *et al*., 2022) [1] found that both were positive about smart farming technologies. However, farmers are less ready than extension workers due to their limited capabilities. This entails concentrating on the enhancement of farmers' capabilities and economic growth by equipping them with the necessary smart farming technology tools to get beyond the obstacles to the quick adoption of smart technology in production and the hefty costs associated with it. Research by (Zied *et al*., 2019) [56] also showed that educated farmers adopt new agricultural technologies more easily. Another study also found that female-headed households have fewer learning opportunities, which further widens the technology adoption gap between male-headed and female-headed households (Mishra *et al*., 2020) [32].

Numerous studies have also highlighted that one of the elements influencing worker productivity is the caliber of human resources (Hoa, 2021; Wang *et al*., 2022) [21, 54]. Data in Table 2 showed labor productivity in the agriculture sector steadily increased between 2010 and 2023, going from 17.6 million VND/person to 88.5 million VND/person (an increase of 502.84%). However, compared to the whole economy, its labor productivity was still quite low, with only 44.41% (General Statistics Office of Vietnam, 2024) [18]. Furthermore, Vietnam's labor productivity is significantly lower than that of other ASEAN nations, coming in at around 12 times less than that of Malaysia, 2.1 times less than that of Thailand, and 1.8 times less than that of the Philippines (Huyen *et al*., 2024) [23].

Table 2: Labor productivity in Vietnam

Years	Whole country (Million VND)	Agriculture sectors	
		Value (Million VND)	Percentage (%)
2010	55.8	17.6	31.54
2015	97.7	32.5	33.27
2020	150.1	57.4	38.24
2021	173	75.0	43.35
2022	188.7	81.9	43.40
2023	199.3	88.5	44.41

Source: General Statistics Office of Vietnam, 2024.

The key to increasing an economy's potential and competitiveness is labor productivity. One of Vietnam's main concerns is increasing labor productivity, which is also the quickest path to the country's economic development and ability to catch up to other nations. Thus, on November 8, 2023, Prime Minister approved the national program on increasing labor productivity by 2030 with main goals: make labor productivity the engine of fast, sustainable growth; seize the chances presented by the 4IR; enhance Vietnam's human resources and market economy; foster regional connectivity; and advance digital transformation, science, technology, and innovation. Specific targets include a 6.5% annual growth rate in labor productivity overall and 7-7.5% for the agriculture, forestry, and fishery sector (Prime Minister of Vietnam, 2023) [46]. Human resources are considered the key to achieving the above goals.

3.2. Vietnam's agriculture in the context of Industry Revolution 4.0

3.2.1. Legal framework

The 4IR is affecting many aspects of the economy and society. It presents various opportunities and challenges for any nation, business, and individual. The advancement of science, technology, and innovation, as well as increased accessibility and proactive engagement in the 4IR, have all been encouraged recently by the government. The Party Central Committee published Resolution No. 06-NQ/TW on November 5, 2016, emphasizing the necessity of *"commercializing and modernizing agriculture, strongly shifting to large-scale production, in-depth agricultural development, based on science and technology, with high productivity, quality, competitiveness, and added value. Changing the agricultural sector from producing mostly food to one that is varied and tailored to the unique assets of each place*". This was the premise for implementing the 4IR in agriculture, or Agriculture 4.0. Intending to create solutions to enhance the deployment of Industry 4.0 technology and prevent any potential negative effects of this revolution, the Prime Minister issued Directive No. 16/CT-TTg in 2017 (Prime Minister of Vietnam, 2017) [41].

To promote proactive involvement in the 4IR and the national digital transformation process, the Politburo

released Resolution No. 52-NQ/TW at the end of 2019 with goals: Vietnam will also rank among the top three ASEAN nations in the Global Innovation Index (GII), the digital economy will account for about 20% of GDP and labor productivity will increase by an average of over 7% per year by 2025; By 1930 Vietnam will rank among the top 40 in the Global Innovation Index (GII), the digital economy will account for about 30% of GDP and labor productivity will increase by an average of over 75% per year; By 2045, Vietnam will become one of the leading innovation centers in Asia with high labor productivity and it will master the modern technologies in all fields of socio-economy, environment, national defense and security (Party Central Committee, 2019) [35].

The project “Promotion of the sharing economy in Vietnam" was approved by the Prime Minister in August 2019 with the signing of Decision No. 999/QD-TTg, which included numerous regulations and policies that will be changed to improve the climate for emerging "sharing economy" models. Furthermore, the Decision guarantees fair treatment for both new and established business models while promoting innovation, digital technology use, and the growth of the digital economy (Prime Minister of Vietnam, 2019) [42]. The Prime Minister approved the "National Digital Transformation Program to 2025, with a Vision to 2030" on June 3, 2020, with Decision No. 749/QD-TTg. The program's main objectives include developing high-tech agriculture with a focus on smart agriculture, and precision agriculture; increasing the share of digital agriculture in the economy; transforming agriculture must be founded on data platforms; utilizing digital technology to automate production, business, management, and supply chain monitoring procedures while guaranteeing speed, accuracy, transparency, and food safety and cleanliness; strongly transforming management through digital means to ensure timely operations and policies (Prime Minister of Vietnam, 2020) [43].

The 13th National Party Congress set the criteria to actively support national digital transformation, build the digital economy, and establish the digital society to produce a breakthrough in enhancing production, quality, efficiency, and competitiveness of the economy. The specific goals of documents of the 13th National Congress of Delegates clearly stated that by 2030, Vietnam will strive to complete the construction of a digital government, the digital economy will reach about 30% of GDP and e-government and digital economy will be among the top 50 countries in the world and 3rd in the ASEAN countries. High-quality human resources are identified as a strategic breakthrough, a decisive factor in promoting the application of science and technology and transforming the growth model in the context of 4IR and international integration (Communist Party of Vietnam, 2021a) [9].

Decision No. 127/QD-TTg has identified the goal of promoting the application of artificial intelligence. By 2030, Vietnam will become an innovation and creativity center with the application of artificial intelligence, and the development of solutions (Prime Minister of Vietnam, 2021) [44]. Decision No. 5275/QD-BNN-VP identified the goal of 80% of agricultural databases being built and updated on a Big Data platform (Ministry of Agriculture and Rural Development, 2021) [31].

Decision No. 2151/QD-BNN-VP on the "Plan for digital transformation in agriculture and rural development for the period 2022-2025" was released by the Ministry of Agriculture and Rural Development on June 15, 2022, to provide precise guidelines for the digital transformation of the agricultural sector. The objectives of this are to: provide exact direction for the agricultural sector's digital revolution. These aim to create a basic environment and digital agricultural ecosystem; set institutions; promote the change from "Agricultural production" to "Agricultural economy"; advance high-tech agriculture toward a focus on smart agriculture and precision agriculture; and increase the share of digital agriculture in the economy.

3.2.2. Application of Technology 4.0 in agriculture

In many countries worldwide, Agriculture 4.0 has significantly supported solving the problem of costs, labor, and production efficiency and better meeting domestic food needs. According to Vietnam Digital Agriculture Association (2021) [53], IoT platforms, big data, and artificial intelligence have begun to be applied through digital technology products such as software that allows analysis of data on the environment, genetic resources, crops, and growth stages of crops that consumers can access and monitor these parameters in real-time. These technologies have brought significant results to the agricultural sector. However, it is still quite new, most of the Agriculture 4.0 process has not been fully applied yet.

In farming, smart indoor farming systems, controlled automatically or semi-automatically with a closed process, are being created by many farming models that use digitalized machinery systems that are fitted with sensors and connected to the internet (IoT sensors) and combined with net houses, greenhouses, and membrane houses. Presently, numerous regions have implemented identification codes to oversee, regulate, track provenance, and enhance the caliber of agricultural commodities. Examples of these include rice in the Mekong Delta; coffee, passion fruit, and dragon fruit in the Central Highlands; longan and lychee in Hai Duong, Bac Giang, Hung Yen, Son La, and so on. Furthermore, many dragon fruit-producing facilities from Binh Thuan to Tien Giang, as well as flower and mushroom production in Ba Ria-Vung Tau, Hanoi, have adopted the technology of using monochromatic LED lights to give enough light for plant growth. Kha (2017) [26] stated that the VIFARM software links globally for each production package, the Agricheck software of Dai Thanh Joint Stock Company, traceability of origin, production process, processing process, and preservation time are all included in the IoT technology application.

Numerous kinds of rice farming have effectively employed Industry 4.0 technological technologies. The "3 reductions - 3 increases" model (reducing the number of seeds, fertilizers, and pesticides; increasing productivity, quality, and efficiency) has been applied to rice cultivation in many Red River Delta and Mekong River Delta provinces. This has increased rice yield from 0.3-1.5 tons/ha and profit from 1-3 million VND/ha in comparison to the traditional rice production model (Lam and Hai, 2012) [28]. In Dong Thap, the "Best Rice Cultivation" model of My Dong Cooperative, in partnership with Rynan Smart Fertilizers Company, has implemented smart farming techniques (one-time biological product spraying, slow-release fertilizer, and solar energy sensors to control water levels) with the Jasmine rice variety. This has resulted in increased productivity with 7

tons of rice/ha, decreased pests and diseases, and saved laborers (Tuan and Xiem, 2018) [51]. By using smart buoys and water monitoring systems, Rynan Holding JSC reduced over 30% of irrigation water use, 50% of labor, seeds, pests, and over 40% of fertilizer use, as well as greenhouse gas emissions. It has also decreased the impact of saline intrusion. All of this has increased profits by almost 20% when compared to conventional rice cultivation (Ha, 2020) [19].

Applying IoT, blockchain, biotechnology, and artificial intelligence to large-scale farms in livestock farming has many notable benefits, including lower costs, disease prevention (Kha, 2017) [26] and increased production efficiency (Vietnam Digital Agriculture Association, 2021) [53]. Numerous procedures in cattle farming have used digital technology and remote camera monitoring systems to automate the supply of feed and nutrition for the animals. They have also used ozone sterilizers and sophisticated disinfection systems in addition to barn systems that regulate temperature, humidity, and ventilation, all of which help to reduce the risk of disease in livestock farming (Kha, 2017) [26]. The TH TrueMilk Group and Vinamilk Company have been leaders in applying biotechnology, new material technology, automation technology, and information technology in disease, biosafety, operation, and livestock management. These innovations have increased productivity and profits; guaranteed quality; and decreased costs (Quyet Thang, 2022) [47].

The technologies used in aquaculture to control offshore fishing fleets include GPS, GIS, purse seine (vertical) receivers, net and drop net systems, ultrasonic fish finders, flow meters, and satellite phones. Biotechnology has brought high efficiency in selecting and crossbreeding varieties with high productivity, high quality, disease resistance, and good environmental tolerance. Recirculating aquaculture systems - RAS, biofloc technology, nanotechnology, sea cage farming technology, and cold water fish farming technology have all been researched and applied. Artificial intelligence has been used in shrimp farming to monitor water quality, feed management, and shrimp health. Automation technology has been widely applied in seafood farming to help reduce production costs and ensure product quality (Vietnam Digital Agriculture Association, 2021) [53].

A pioneer in the field of smart farming, Lam Dong is home to 21 businesses that have embraced and utilized big data, blockchain, and IoT technologies (such as plant growth monitoring cameras, different kinds of environmental sensors, and automated greenhouse systems; sensor systems linked to computers, cellphones, LED systems, and GIS systems, among others). As of right now, the entire province of Lam Dong covers around 200 hectares using the 4.0 smart agricultural production process, which increases the value of agricultural products by 1.5-2 times compared to traditional crops (Ha, 2020) [19].

Science and technology have established specialized production zones and concentrated livestock farming toward high-tech and organic agriculture. Statistics showed that organic farming areas increased from 53,350 to 237,693 in the stage of 2016-2019. The number of organic production enterprises is 97, of which 60 enterprises participate in the agricultural product export market with a turnover of about 335 million USD/year. Vietnam's organic agricultural products have been consumed domestically and exported to 180 countries, including the US, EU, China, Japan, Germany, the UK, Korea, Russia, Singapore, France, Belgium, the Netherlands, Italy, etc (Phuoc and Huong, 2021) [38]. According to Phai *et al.* (2022) [37], the number of enterprises applying high-tech agricultural models has increased sharply in recent years with 49 enterprises. TH Group (dairy), Dabaco (livestock), Nafoods (fruit cultivation and processing), Vingroup (vegetables), South Central (shrimp), Ba Huan, Loc Troi, and others have achieved great accomplishments at both regional and international levels.

3.3. Human resources opportunities and challenges in Vietnam's agriculture production in the context of Industrial Revolution 4.0

3.3.1. Opportunities

- Human resource quality is the most essential aspect in a country's growth and socioeconomic development. Therefore, attracting and using skills and fostering human resources as the center of growth has become a strategic orientation and philosophy of action for our country's development, as stated in the Party's congress documents. The 13th National Congress consistently focused on a few key industries and fields and encouraged research, transfer, and strong application of the 4IR's achievements in all areas of social life (Communist Party of Vietnam, 2021b) [10]. On that basis, the state has issued a system of legal policies to create a favorable legal corridor and promote the development of agricultural human resources in both quantity and quality. They include Labor Code, Employment Law; Vocational Education Law; Education Law; University Education Law... To efficiently utilize the opportunities of the 4IR, Resolution No. 19-NQ/TW further highlighted: *"Create breakthroughs in human resource development, training, and improving vocational skills to satisfy market demand, completely rethink the structure and subject matter of vocational training for rural workers, enhancing credentials and skills, particularly for young people...*" (Central Committee of Vietnam, 2022) [6]. The 2021-2030 strategy for sustainable agricultural and rural development, with a view to 2050, also improves vocational training, research, application, transfer, and innovation. In particular, it innovates the form of organization and enhances the quality of vocational training for farmers to meet the needs of the 4IR, implements digital transformation and a digital economy to "intellectualize farmers," and promotes focused scientific research on the transfer and application of new and advanced technologies and digital transformation… (Prime Minister of Vietnam, 2022) [45]. On May 8, 2023, Resolution No. 37-NQ/BCSD was issued to improve agricultural and rural human resource training by 2030: *"Training and developing human resources to meet quantity and quality requirements to effectively implement the goal of building ecological agriculture, modern rural areas, and civilized farmers. Forming a team of professional, knowledgeable, and highly skilled farmers to lead the rural economy's development; planning a team of leaders, experts, and scientists to research, access, transfer modern technology, and promote innovation…"* (Party Committee of the Ministry of Agriculture and Rural Development, 2023) [36].

- With many agricultural training schools, the agricultural sector can increase human resources in quantity and quality. According to statistics, the country has about 50 university

training institutions with majors in agriculture, forestry, fisheries, and irrigation. As of 2022, the training institutions of the Ministry of Agriculture and Rural Development have trained 38 doctoral training majors; 39 master's training majors, 97 university majors, 112 college majors, and 122 intermediate majors. Training institutions always innovate teaching methods; invest and upgrade their facilities, thereby gradually improving the quality of training to meet practical requirements.

- Agricultural development in the context of the 4IR will be an opportunity for agricultural human resources to learn and use new science, technology, and innovations in the production, harvesting, preservation, transportation, processing, and consumption of agricultural goods. This will boost the added value of agricultural output. Hyper-connectedness, automation, and artificial intelligence have created a large number of new jobs with high skill.
- Innovations in technology, specifically information technology, can increase farmers' ability to adapt to change by increasing access to weather and market information. Digital technologies can help farmers operate and manage their production processes better, for example, they can make decisions about when to harvest or when to sell their agricultural products.

3.3.2. Challenges

- The agricultural sector is characterized by labor-intensive and capital-intensive processes (Schmitz & Moss, 2015), resulting in high expenses for enterprises. The agricultural sector is characterized by the use of many unskilled workers, creating jobs for low-skilled human resources. However, numerous studies imply that agriculture 4.0 and labor-saving technology like smart agriculture and robots may lead to a labor surplus (Curry *et al.*, 2021; Son, 2018) [12, 50]. With the advent of robots, certain industries will require a tenth of the current workforce. As a result, nine out of ten of the remaining workers will need to move jobs or lose their jobs (Ngoc, 2018; Nhung, 2022) [33, 34]. It demonstrated that artificial intelligence has resulted in notable social efficiency in Lam Son Sugar Company in Thanh Hoa, Vietnam, the automated monitoring system could replace 40 accountants who arrange transport plans for 32,000 hectares of sugarcane. TH TrueMilk Company needed 800 workers to prepare, sow, irrigate, and harvest 2,000 hectares of grassland. Automation systems eliminated the necessity for this human resource (Cuong and Ngoc, 2019) [11].
- Vietnam's agriculture production still lacks human resources, particularly high-quality human resources; in particular, teams and experts capable of mastering advanced technology and techniques are lacking; additionally, the percentage of untrained agricultural, forestry, and fishery workers aged 15 and over remains high (above 90%) (General Statistics Office of Vietnam, 2024) [18]. Untrained or low-skilled workers will limit the application and transfer of scientific and technical advances; market access; and use of investment capital in agricultural production. Furthermore, many agricultural programs emphasize theory over practice, thus graduates lack practical knowledge. This is seen as a significant obstacle and difficulty that impacts the accomplishment of the objectives of the 13th National Party Congress Resolution on the development of ecological agriculture, civilized farmers, and modern rural areas, as well as the application of Agriculture 4.0. The Ministry of Agriculture and Rural Development aims to train an average of 1.5 million rural workers annually nationwide by 2030 to innovate and increase the efficacy of training top-notch human resources to meet the demands of developing the agriculturae sector. Over 70% of agricultural workers will be trained by 2030. In the agriculture sector, the percentage of employees with degrees and certificates (from elementary school and higher) will rise from 4.6% in 2020 to 10% in 2030.
- In higher education and vocational training institutes, the number of students studying agriculture tends to decline significantly. From 2016 to 2020, the number of students registering for majors and fields of agriculture, forestry, irrigation, and fisheries decreased by more than 30% compared to the period 2011-2015. Some traditional agricultural majors have very few or even no students registering to study. By 2022, just 7,100 students were enrolled in agriculture, forestry, fisheries, and veterinary medicine (accounting for 1.37% of the total). In the stage of 2016 - 2021, the number of students in college, primary, and short-term vocational training decreased from more than 6,000 to 4,300 students; the primary and vocational training system under three months decreased from more than 2,400 to 532 students The secondary level decreased from more than 2,900 to 2,100 in the period 2017 - 2021 (Van Nhi, 2023) [52]. This is a big challenge to the lack of human resources supply for the agricultural sector in the context of the 4IR.

4. Solutions for agricultural human resources in the context of the 4.0 industrial revolution in Vietnam

Firstly, the State completes mechanisms and policies to encourage and support students studying agricultural majors; and preferential policies for lecturers in agricultural teaching institutions. In particular, State management agencies, Centers for Application of Science and Technology Advances, research institutes, and educational and training institutions need to develop specific policies to attract and develop a team of experts and scientists working in the agricultural sector based on the Resolution of the 13th National Congress of Delegates *"Create breakthroughs in fundamental and comprehensive innovation in education and training, develop high-quality human resources, attract and utilize talents"* and Decision No. 899/QD-TTg dated July 31, 2023 of the Prime Minister *"Building and effectively implementing the strong and breakthrough policies and solutions to attract and employ talents, especially in key sectors and fields such as science and technology; education and training; culture; social sciences; health; information and communication, digital transformation..."*. This is the political and legal basis for Vietnam to promote the development of high-quality human resources, and attract talents to contribute to sustainable agricultural development.

Second, to meet the goal of Resolution No. 37-NQ/BCSĐ in 2023 of Party Committee of the Ministry of Agriculture and Rural Development (vocational training for 1.5 million rural workers each year; over 70% of agricultural workers are trained; the rate of workers with degrees and certificates from the elementary level and above improves from 4.6% to 10% of the period 2020 - 2030 and attract an average of 200 postgraduate, 2,500 graduate, 20,000 undergraduate, 8,000 college, 20,000 secondary, and 40,000 primary students annually), training institutions must reinvent instructional

programs, methodologies, and soft skills to mix theory and practice. Diversify the content and methods of training through short-term and long-term training and development programs, and domestic and foreign study exchanges.

Third, training institutions must collaborate with businesses and research organizations to increase learners' occupational abilities. In the 4IR, practical training that matches society's needs is essential to developing an education system. Developing a training model that integrates schools and businesses is vital to improving student training and practical knowledge while fulfilling employer needs. It is necessary to strengthen digital skills for rural workers and develop high-quality human resources; promote vocational training to link with the advanced and modern production methods; expand farming types such as green, organic, and high-tech agriculture; boost added value and promote regional and local advantages.

Fourth, it is necessary to promote the forecasting of agricultural human resource needs in the context of the 4IR in the near and distant future. The 4IR affects economic restructuring in general and the agricultural sector in particular, thus many old employment may disappear and be replaced with high-value, efficient jobs. Predicting agricultural human resource demands helps companies and individuals satisfy quantity and quality needs quickly. It also helps Vietnam engage in the global economy and incorporate science and technology into industry.

Fifth, widely propagate and raise awareness for the whole society about the impact of the 4IR on the development of the economy in general and the agriculture sector in particular so that they can proactively plan to approach science and technology to master the production process. In addition, it is necessary to improve the capacity to access and apply digital technology for farmers in agricultural production.

5. Conclusion

The quality of agricultural human resources in our country is quite far behind that of developed countries and some countries in the region. The proportion of workers aged 15 and over in the agriculture sector who have received vocational training is still low, ranging from 2.4 - 4.5% from 2010 to 2023. This is the biggest obstacle to apply science and technology in agricultural production. Under the 4IR, agricultural human resources will learn and employ new science, technology, and innovations to produce, harvest, preserve, transport, process, and consume agricultural goods. Automation, artificial intelligence, and hyper-connectivity in agriculture have improved its labor productivity and added value and created many new skilled jobs. However, they have been facing challenges to keep up with scientific and technological advances to improve labor productivity and create added value in production. To solve these issues, the study proposes the following solutions: completes mechanisms and policies to encourage and support students studying agricultural majors; and preferential policies for lecturers in agricultural teaching institutions; reinvent instructional programs, methodologies, and soft skills to mix theory and practice; diversify the content and methods of training through short-term and long-term training and development programs, and domestic and foreign study exchanges; collaborate with businesses and research organizations to increase learners' occupational abilities; promote the forecasting of agricultural human resource needs in the context of the 4IR; widely propagate and raise awareness for the whole society about the impact of the 4IR.

6. References

1. Agussabti A, Rahmaddiansyah R, Hamid A, Zakaria Z, Munawar A, Bakar B. Farmers' perspectives on the adoption of smart farming technology to support food farming in Aceh Province, Indonesia. Open Agriculture. 2022;7:857-870. Available from: https://doi.org/10.1515/opag-2022-0145
2. Addison M, Ohene-Yankyera K, Aidoo R. Quantifying the impact of agricultural technology usage on intra-household time allocation: Empirical evidence from rice farmers in Ghana. Technology in Society. 2020;63:101434. Available from: https://doi.org/10.1016/j.techsoc.2020.101434.
3. Arora C, Kamat A, Shanker S, Barve A. Integrating agriculture and industry 4.0 under "agri-food 4.0" to analyze suitable technologies to overcome agronomical barriers. British Food Journal. 2022;124(7):2061-2095. Available from: https://doi.org/10.1108/BFJ-08-2021-0934.
4. Bacco M, Barsocchi P, Ferro E, Gotta A, Ruggeri M. The Digitisation of Agriculture: A Survey of Research Activities on Smart Farming. Array. 2019;3-4, 100009. Available from: https://doi.org/10.1016/j.array.2019.100009.
5. Cao S, Yu N, Wu Y, Wang Z, Mi J. The Educational Level of Rural Labor, Population Urbanization, and Sustainable Economic Growth in China. Sustainability. 2020;12(12). Available from: https://doi.org/10.3390/su12124860.
6. Central Committee of Vietnam. Resolution No 19-NQ/TW on June 16, 2022 of the fifth plenum of the 13th CPV Central Committee on Agriculture, Farmers, Rural to 2030, vision to 2045; c2022.
7. Central Executive Committee of the Party. Resolution No. 06-NQ/TW dated January 24, 2022 on planning, construction, management, and sustainable development of Vietnamese urban areas to 2030, with a vision to 2045; c2022.
8. Chu Khoi. Agricultural, forestry, and fishery exports aim for new records. Vietnam Economic Journal. 2024;7+8. Available from: https://vneconomy.vn/techconnect/xuat-khau-nong-lam-thuy-san-huong-toi-ky-luc-moi.htm.
9. Communist Party of Vietnam. Documents of the 13th National Congress of Delegates-Volume 1; c2021a. National Political Publishing House.
10. Communist Party of Vietnam. Resolution of the 13th National Congress of the Communist Party of Vietnam; c2021b.
11. Cuong LS, Ngoc HK. Application of Science and Technology to the Development of Clean Agriculture in Vietnam - An Urgent Need - before the Impact of the Fourth Industrial Revolution. Environment Journal. 2019;5:47-48.
12. Curry GN, Nake S, Koczbersk G, Oswald M, Rafflegeau S, Lummani J, *et al*. Disruptive innovation in agriculture: Socio-cultural factors in technology adoption in the developing world. J of Rural Studies 2021;88:422-431. Available from: https://doi.org/10.1016/j.jrurstud.2021.07.022.

13. Damba OT, Ansah IGK, Donkoh SA, Alhassan A, Mullins GR., Yussif K, *et al*. Effects of technology dissemination approaches on agricultural technology uptake and utilization in Northern Ghana. Technology in Society. 2020;62:101294. Available from: https://doi.org/10.1016/j.techsoc.2020.101294.
14. Ferrag MA, ShuL, Hamouda D, Choo R. Deep Learning-Based Intrusion Detection for Distributed Denial of Service Attack in Agriculture 4.0. Electronics. 2021;10:1257. Available from: https://doi.org/10.3390/electronics10111257.
15. Ferrari A, Bacco M, Gaber K, Jedlitschk A, Hess S, Kaipainen J, *et al*. Drivers, barriers, and impacts of digitalization in rural areas from the viewpoint of experts. Information and Software Technology. 2022;145:106816. Available from: https://doi.org/10.1016/j.infsof.2021.106816.
16. Friha O, Ferrag MA, Shu L, Maglaras L, Wang X. Internet of Things for the Future of Smart Agriculture: A Comprehensive Survey of Emerging Technologies. IEEE/CAA J. of Automatica Sinica. 2021;8(4):718-752. Available from: https://doi.org/10.1109/JAS.2021.1003925.
17. General Statistics Office of Vietnam. Statistical Yearbook; c2023. Statistical Publishing House.
18. General Statistics Office of Vietnam. Labor and employment; c2024. Available from: https://www.gso.gov.vn/lao-dong/.
19. Ha CT. Smart Agriculture strategic lever for Vietnam's economic development. Journal of Event Numbers; c2020. Available from: https://consosukien.vn/nong-nghiep-thong-minh-don-bay-chien-luoc-phat-trien-kinh-te-viet-nam.htm.
20. Harris JR, Todaro M. Migration, Unemployment & Development: A Two-Sector Analysis. American Economic Review. 1970;60(1):126-142.
21. Hoa NQ. Human capital and productivity growth in agriculture in Vietnam. J. of Science - Vinh University. 2021;50(2):43-54.
22. Huy Lan. Agricultural labor tends to decrease rapidly; c2023. Available from: https://nld.com.vn/giao-duc-khoa-hoc/lao-dong-nong-nghiep-co-xu-huong-giam-nhanh-
23. Huyen PTT, Ha NT, Loan TN, Hue NT. Examining the Concentration of Agricultural Land in Vietnam: Trends, Implications, and Solutions. J. of Food and Agricultural Technology Research. 2024;3(1). Available from: https://doi.org/10.69501/sdh30v74.
24. Javaid M, Haleem A, Singh RP, Suman R. Enhancing smart farming through the applications of Agriculture 4.0 technologies. International J. of Intelligent Networks. 2022;3:150-164. Available from: https://doi.org/10.1016/j.ijin.2022.09.004.
25. Kagermann H, Wahlster W. Ten Years of Industrie 4.0. Sci J. 2022;4(3). Available from: https://doi.org/10.3390/sci4030026.
26. Kha LQ. Smart Agricultureoirst Steps in Vietnam; c2017. Available from: https://iasvn.org/homepage/Nong-nghiep-thong-minh---buoc-di-ban-dau-o-Viet-Nam-10204.html.
27. Khuyen TN, Son DT. Industrial Revolution 4.0 in agriculture and development orientation of agricultural processing industry in Vietnam. Agriculture and Rural Development J. 2020;1:3-12.
28. Lam NH, Hai HTN. Implementation results of the model "3 reductions 3 increases" in Vietnam. Science Journal - Hue University. 2012;75A(6):75-81.
29. Lewis WA. Economic Development with Unlimited Supplies of Labour. The Manchester School. 1954;22(2):139-191. Available from: https://doi.org/10.1111/j.1467-9957.1954.tb00021.x.
30. Liu Y, Ma X, Shu L, Hancke G, Abu-Mahfouz A. From Industry 4.0 to Agriculture 4.0: Current Status, Enabling Technologies, and Research Challenges. IEEE Transactions on Industrial Informatics. 2020;17(6):4322-4334. Available from: https://doi.org/10.1109/TII.2020.3003910.
31. Ministry of Agriculture and Rural Development. Decision No. 5275/QD-BNN-VP dated December 31, 2021 on approving the Digital Transformation Plan of the Ministry of Agriculture and Rural Development in 2022; c2021.
32. Mishra K, Sam A, Diiro G, Miranda M. Gender and the dynamics of technology adoption: Empirical evidence from a household-level panel data. Agricultural Economics. 2020;51. Available from: https://doi.org/10.1111/agec.12596.
33. Ngoc CTB. Improving the quality of Vietnamese human resources in the Industrial Revolution 4.0. Financial Journal; c2018. Available from: https://Tapchitaichinh.vn/Nang-Cao-Chat-Luong-Nguon-Nhan-Luc-Viet-Nam-Trong-Cuoc-Cach-Mang-Cong-Nghiep-4-0.Html.
34. Nhung PTH. Impact of the Industrial Revolution 4.0 on the development of commodity agricultural production in Vietnam. International J. of All Research Writings. 2022;3(8):21-25.
35. Party Central Committee. Resolution No. 52-NQ/TW dated September 27, 2019 on some guidelines and policies to proactively participate in the Fourth Industrial Revolution; c2019.
36. Party Committee of the Ministry of Agriculture and Rural Development. Resolution No. 37-NQ/BCSD dated May 8, 2023 on innovation and improving the effectiveness of training high-quality human resources to meet the needs of sustainable development of the Agriculture and Rural Development sector in 2025 and orientation to 2030; c 2023.
37. Phai HV, Tri HD, Dep HM. Application of science and technology in agricultural production: Achievements, limitations, and solutions. Journal of State Management; c2022. Available from: https://Www.Quanlynhanuoc.vn/2022/08/08/Ung-Dung-Khoa-Hoc-Cong-Nghe-Vao-San-Xuat-Nong-Nghiep-Thanh-Tuu-Han-Che-va-Giai-Phap-Thao-Go/.
38. Phuoc VH, Huong TTT. Vietnam's green agriculture growth and present concerns. Financial Journal. 2021;2(9). Available from: https://tapchitaichinh.vn/Phat-Trien-Nong-Nghiep-Xanh-o-Viet-Nam-va-Nhung-van-de-Dat-Ra-Trong-Boi-Canh-Hien-Nay.
39. Price C. Agriculture 4.0: Bioinformationalism and Postdigital Hybrid Assemblages. In M. A. Peters, P. Jandrić, & S. Hayes (Eds.), Bioinformational Philosophy and Postdigital Knowledge Ecologies; c2022. p. 113-131. Springer International Publishing. Available from: https://doi.org/10.1007/978-3-030-95006-4_7.

40. Prime Minister of Vietnam. Decision No. 579/QD-TTg dated April 19, 2011 of the Prime Minister approving the Vietnam human resource development strategy for the 2011-2020 period; c2011.
41. Prime Minister of Vietnam. Directive No. 16/CT-TTg dated May 4, 2017 on enhancing capacity to access the 4th Industrial Revolution; c2017.
42. Prime Minister of Vietnam. Decision No. 999/QD-TTg dated August 12, 2019 on approving the project to promote the sharing economy model; c2019.
43. Prime Minister of Vietnam. Decision No. 749/QD-TTG dated June 3, 2020 on approving the national digital transformation program to 2025, with a vision to 2030; c2020.
44. Prime Minister of Vietnam. Decision No. 127/QD-TTG dated January 26, 2021 on promulgating the national strategy on research, development, and application of artificial intelligence by 2030; c2021.
45. Prime Minister of Vietnam. Decision No. 150/QD-TTg dated January 28, 2022 on approving the sustainable agriculture and rural development strategies for the period 2021 - 2030 with a vision toward 2050; c2022.
46. Prime Minister of Vietnam. Decision No. 1305/QD-TTg dated November 8, 2023 on approving the national program on increasing labor productivity by 2030; c2023.
47. Quyet Thang. TH Group: Application of 4.0 technology to farm cluster achieves world record; c2022. Available from: https://baotainguyenmoitruong.vn/tap-doan-th-ung-dung-cong-nghe-4-0-vao-cum-trang-trai-dat-ky-luc-the-gioi-337397.html.
48. Rojko A. Industry 4.0 Concept: Background and Overview. International J. of Interactive Mobile Technologies. 2017;11:77. Available from: https://doi.org/10.3991/ijim.v11i5.7072.
49. Schmitz A, Moss CB. Mechanized agriculture: Machine adoption, farm size, and labor displacement. AgBioForum. 2015;18(3):278-296.
50. Son VK. Applying the Industrial Revolution 4.0 in Agriculture. Quang Binh Science and Technology Information J. 2018;6:17-21.
51. Tuan ND, Xiem NT. Vietnam's agriculture enters the Industrial Revolution 4.0. Agriculture and Rural Development J. 2018;8:3-10.
52. Van Nhi. Human resources for agriculture 4.0: Current situation and solutions; c2023. Available from: https://Iasvn.Org/Tin-Tuc/Nguon-Nhan-Luc-Cho-Nong-Nghiep-4.0-Thuc-Trang-va-Giai-Phap-17878.Html.
53. Vietnam Digital Agriculture Association. Overview Report on Digital Transformation of Vietnam Agriculture; c2021.
54. Wang SL, Hoppe R, Hertz T, Xu S. Farm Labor. Human Capital, and Agricultural Productivity in the United States. Economic Research Report. 2022;302.
55. Wegren S, Elvestad C. Russia's food self-sufficiency and food security: An assessment. Post-Communist Economies. 2018;30(5):1-23. Available from: https://doi.org/10.1080/14631377.2018.1470854.
56. Zied M, Bedhiaf S, Dhehibi B, Oueslati M, Jebali O, Salah B. Factors affecting innovative technologies adoption by livestock holders in arid area of Tunisia. New Media. 2019;18:3-18. Available from: https://doi.org/10.30682/nm1904a.
57. Zhang S and Ma Y, Cui Q. Assessing the impact of the digital economy on green total factor energy efficiency in the post-COVID-19 Era. Front Energy. Res. 2021;9:798922. Available from: https://doi.org/10.3389/fenrg.2021.798922.