

Mekong River Delta Agricultural Mechanization Development: Case Study in Vinh Long Province, Viet Nam

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Abstract— Agricultural mechanization is an essential path to the industrialization of rural regions. Viet Nam has more than 40% of the population in the agriculture sector, contributing nearly 30% of the country's GDP and still is an agricultural country. Mekong River Delta (MRD) is the most significant agriculture production region of Viet Nam in which Vinh Long is one of sample province might be representative for MRD. This paper presents case study of recent status of mechanization in agriculture, and some recommendations for development the agricultural mechanization in the province. The statistical methods, SWOT analysis, problem approach and practical research have been used. The results indicate that the ratio of agricultural mechanization in Vinh Long might be not to satisfaction to the development of agriculture production. The agricultural field using walking tractors and shoulder engines, investment and financial policies, skill and training level of farmers and agricultural infrastructure such as rural transportation system, irrigation system, and agricultural production industrial processing are the main factors strongly influence on the development of agricultural mechanization in Vinh Long. Some studies proposed recommendations as solutions for sustainable development of the agricultural mechanization are presented in this study, such as agricultural production needs to be reorganized; developing system for training high quality and skill people to work in mechanization process; increase investments in science and technology for agricultural mechanization; setting up the policies to attract businesses and individuals invest in developing mechanization; removing blockages on "agricultural land limit" policy; and creating financial policies supporting to agricultural production investors.

Keywords— agricultural mechanization; Mekong river delta; Vinh Long province; agriculture production.

I. INTRODUCTION

Viet Nam has produced many kinds of agricultural products, including food grain like paddy, maize, soybean, peanuts; tropical fruits and vegetable; freshwater, and fish. The agriculture sector contributed to the Viet Nam's GDP in 2018, with nearly 30% in which more than 40 billion USD earned from exported agricultural productions [1]. Regionally, Mekong river delta (MRD) is the key area in terms of the agricultural output of Viet Nam where produces most of the tropical fruits, freshwater fish, and especially half of Vietnam paddy yields [2]. For example, the MRD with totaling about 25 million tons of paddy has been produced per year, and it takes into account for 95% of Vietnam rice production exported [3]; most of Viet Nam tropical fruits is supported by MRD, and there has 100% of

catfish exported by Viet Nam come from MRD. Vinh Long are one of thirteen provinces in the MRD located between two main rivers are Tien River (Song Tien) and Hau river (Song Hau), with 70% of the population is farmers. Agricultural production contributes to around 38% of the GDP of the province [4]. Two of these rivers play an important role in supplying fresh water for agriculture production development in the province and in the MRD so appropriated irrigation system is one of the critical points for the agriculture sector and adapt with the climate change [5-8].

Generally, in developing countries and particularly, in Vietnam, agricultural mechanization has allowed an increase to the plant area and contributed towards enhancing yields, labor capacity, and quality of farming products [9]. Planting, caring, tending, and harvesting a crop requires not only a significant amount of power supported but also needs a

suitable range of tools, equipment, and farm machines. The agricultural mechanization development process depends on many factors such as the industrialization process, agricultural machinery manufacturing industry, the credit policies to farmers and to the agriculture sector, the agriculture education, researching, extension and technology transfer system, and the priority policies from the government [10-12]. Therefore, the investigation studies the agricultural mechanization reality status, and finding out the suitable development solutions plays an essential role in MRD agricultural mechanization development process in general and in Vinh Long Province in particular. This paper presents the reality status and the solutions for agricultural mechanization development in Vinh Long province as a sample case of MRD agricultural mechanization towards the next ten years.

II. MATERIALS AND METHOD

Due to the case study, some empirical methods were used in this study.

A. Field Investigation

A field investigation conducted directly for the current status of agricultural mechanization. The agricultural technology is getting developed on recent agricultural production in all eight districts/city/town with 103 communes/wards per 109 ones totally in Vinh Long Province as shown in table 1. The survey sheets developed for conducting study are designed and developed as the detailed survey form with over 30 related indicators for agricultural production at the household and commune level in the province.

The total survey questionnaire sheet of the whole province is 2169 by each locality as table 1. Local government, university technicians conduct these activities, and engineers, together with members of local agricultural people in the areas selected that following the methodology in a past project have been done [3].

After collection the questionnaire sheets, the research team summarizes the survey data, following the steps:

- Step 1: Create an aggregate file with Excel.
- Step 2: Input the survey data.
- Step 3: Statistics by ward/commune.
- Step 4: Statistics by district.
- Step 5: Statistics by province.

The data are accessed by the software analysis basing on the statistics method following steps:

- Step 1: Assemble general statistics and process statistics.
- Step 2: Making comparison charts/pictures/tables.

B. Analyzed method

Analyzed method: using the expert method and meeting group to examine the critical point, the agricultural production status, and technology gap is based on the survey database.

C. Brainstorming

Brainstorming to find out the solutions for agricultural engineering development in Vinh Long province.

III. RESULTS AND DISCUSSION

All paragraphs must be indented. All paragraphs must be justified, i.e., both left-justified and right-justified.

A. Main Agricultural productions of Vinh Long

As one of the provinces in MRD, the contribution of the agriculture sector to Vinh Long's GDP takes account of more than 30%, in which nearly 80% comes from cultivation products such as rice, sweet potato, and tropical fruits [13].

TABLE I
STATISTICS OF THE NUMBER OF QUESTIONNAIRES IN VINH LONG PROVINCE.

| District | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | Total |
|--|------------|------------|------------|------------|------------|------------|------------|------------|-------------|
| Number of ward/communes investigated | 5/11 | 8/8 | 11/11 | 15/15 | 13/13 | 17/17 | 14/14 | 20/20 | 103/109 |
| Number of investigate sheets at ward/commune level | 15 | 24 | 33 | 45 | 39 | 51 | 43 | 60 | 310 |
| Number of investigate sheets at household level | 90 | 143 | 195 | 280 | 236 | 306 | 246 | 363 | 1859 |
| Total | 105 | 167 | 228 | 325 | 275 | 357 | 289 | 423 | 2169 |

Note: (1) Vinh Long city; (2) Binh Minh town; (3) Binh Tân district; (4) Long Hồ district; (5) Mang Thít district; (6) Tam Bình district; (7) Trà Ôn district; (8) Vũng Liêm district

1) *Rice production*: According to the survey data, as shown in Table 2, the land area of rice cultivation in Vinh Long province in the winter-spring crop is the largest with nearly 57,500 ha compared to almost 54,000 ha of summer-autumn crop and 46,276.4 ha of other plants. The rice yield reaches the highest in the winter-spring crop, with 386.6 thousand tons compared to the one is 312.7 thousand tons in the summer-autumn crop and is 219.2 thousand tons of the other crop. Besides, the survey also indicates that the highest capacity of rice is 6.8 tons per hectare at the winter-spring crop. This capacity is too high compared to the one in another region in Vietnam.

TABLE II
AVERAGE RICE AREA, CAPACITY, AND YIELD OF 3 YEARS (2016 - 2018) IN VINH LONG PROVINCE.

| Parameters | Winter-Spring crop | Summer-Autumn crop | Another crop | Total |
|----------------------|--------------------|--------------------|--------------|------------|
| Area (ha) | 57,325.5 | 53,892 | 46,276.4 | 157,493.90 |
| Capacity (ton/ha) | 6.8 | 5.8 | 5.7 | |
| Yield (thousand ton) | 386.6 | 312.7 | 219.2 | 918.5 |

2) *Sweet potato production*: Sweet potatoes production in Vinh Long is the biggest producer in Vietnam recently in terms of area, capacity, and yield that is presented in table 3. They are currently grown mainly in 3 districts, such as Binh Tan, Vung Liem, and Binh Minh, of which are mostly in Binh Tan district. According to our investigation in 2018, the whole province has 12,386,20 hectares, an increase of about 2,961,5 hectares compared to 2017, equivalent to a rise of about 25,15%. The communes with large sweet potato areas (over 1,000ha) are Tan Thanh, Thanh Trung, Thanh Dong, and Thanh Loi. In recent years, with emphasis on agricultural restructuring, bringing crops to fields of sweet potatoes has increased. One unique thing is the capacity of sweet potato in Vinh Long is the highest in Vietnam; it takes double comparing the one in another province. The total yields of this product around more than 300,000 tons that play the leading sweet potato exporter of Vietnam.

TABLE III
AVERAGE SWEET POTATO AREA, CAPACITY, AND YIELD OF 3 YEARS (2016 - 2018) IN VINH LONG PROVINCE.

| Parameters | Winter-Spring crop | Summer-Autumn crop | Another crop | Total |
|----------------------|--------------------|--------------------|--------------|-----------|
| Area (ha) | 5,545.1 | 4,533.4 | 2,307.7 | 12,386.20 |
| Capacity (ton/ha) | 26.2 | 22.9 | 22.9 | |
| Yield (thousand ton) | 146,480 | 108,160 | 50,172 | 304,812 |

3) *Pomelo and citrus trees production*: MRD has been known as the biggest field of tropical fruits and is the main contributor to fruits export and local market of Viet Nam. Vinh Long province is one of the key provinces in MRD that contributes to this production. The results of an investigation indicate that the area of citrus plantation in Vinh Long province is concentrated in some districts with the average area in 3 years of 2016, 2017, 2018 is 10,971.5 ha (table 4), in that, Tra On district has the largest area of citrus with a total area of 4,211.9 ha. Annually, the yield of this product in the whole province is more than 250,000 tons (table 3). This number points out that Pomelo and citrus play an important in agricultural structure in MRD.

TABLE IV
LAND AREA, CAPACITY, AND YIELD OF CITRUS TREES AVERAGED OVER 3 YEARS (2016 - 2018) OF VINH LONG PROVINCE.

| Parameters | Pomelo | Orange | Mandarin | Total |
|----------------------|----------|----------|----------|------------|
| Area (ha) | 5,510.60 | 5,121.90 | 339 | 10,971.50 |
| Capacity (ton/ha) | 26.3 | 20 | 10 | |
| Yield (thousand ton) | 144,929 | 102,438 | 3,390 | 250,756.78 |

B. Current Status of Agricultural Mechanization in Vinh Long province

Table 5 illustrates the level of static power sources such as combustion engines and electric motors have used in

some main agricultural productions of Vinh Long [13]. For rice production, it is 3.2 HP per ha in the whole province. Similarly, this number for a power source such as tractors is nearly 5HP per ha. Comparing to the Mekong Delta region and the entire Viet Nam, agricultural production in Vinh Long is equipped with a high-power source that is in double comparing with 2.4 HP per ha in the whole Viet Nam [14]. This is quite a favorable motive for the rice mechanization process in the province. However, this capacity of tractors of Vinh Long is still behind other Asian neighbors [15-16] (equal to 1/2 Thailand, 1/3 Korea, and 1/5 China).

In opposite, this number for another plant like sweet potato and pomelo and citrus trees is low, and it is challenging for the mechanization process [13]. It is noted that although pomelo and citrus trees have equipped with a high level of power source (bigger than 10 HP per ha), the main power source is only the static engines using for watering irrigation and fertilization spraying in the form of semi-manual and human occupations.

TABLE V
POWER SOURCE EQUIPPED FOR AGRICULTURE PRODUCTION

| Kind of power source | Unit | Using for | | |
|---------------------------------|-------|-----------|--------------|-------------------|
| | | Rice | Sweet potato | Pomelo and citrus |
| Diesel and petrol engine | HP/ha | 2.9 | 9.1 | 9.1 |
| Electric motor | HP/ha | 0.3 | 0.3 | 2.4 |
| Small tractor (12 CV and under) | HP/ha | 1.15 | 0.84 | 0.6 |
| Large tractor (over 12 CV) | HP/ha | 3.8 | 1.4 | |



Fig. 1 Direct seeding of paddy in Vinh Long province

The farm machinery equipped for agriculture production in Vinh Long is shown in table 6. It is clear to see that the land preparation for agricultural production mainly uses rotary tiller combined with walking tractor, with an average of 1 machine uses for 7 ha of rice, 16 ha of sweet potato, and 15 ha of pomelo and citrus trees. The average of four-wheel

rotary tiller is 01 machine for 16 ha of rice, and there is not anyone for sweet potato and citrus trees. In comparing the capacity of machine and crop requirements completely for land preparation, the level of the equipped machine above is not able to satisfy tillage with the required crop time of about 7-10 days for a crop.



Fig. 2 Shoulder sprayer for paddy in Vinh Long

The calculation and creating solutions to increase the source of equipment is needed in the upcoming period [17]. In the planting and cultivating stages, the survey data indicate that almost all cultivation in Vinh Long is mainly done with the direct seeding method (Fig.1) or using a shoulder machine (Fig.2). Besides, the mechanization stage in pesticide spraying and fertilizing, the shoulder machines with small combustion engines are mainly used (figure 2). This is effective in preventing pests and diseases and greatly affecting the health of sprayers. Regarding harvesting, exception the harvest of rice with a ratio of harvesting by combine harvester is estimated at over 95%; other plants are harvested mostly by human power.

In terms of post-harvesting, the post-harvest paddy drying in the province has been done mostly by using the column dryer combined with fluidized bed and flat dryer. These dryers are applied mainly in both main crops as well as in other crops. The horizontal static flat dryer is dominated in the province that widely operates in the summer-autumn and autumn-winter crop, with a common capacity of 4 - 10 tons per batch and over 10 tons per batch. Paddy preservation is also conducted in an asymptotic approach to the industrial type using silos. Furthermore, post-harvest machines are not presented so much due to product transportation, post-harvest processing, product diversification, and product storage during postharvest are issues that have some limitations in Vinh Long province. Products are not being preserved after harvesting as well as a variety of product processing is also major issues challenge the agricultural mechanization process in Vinh Long.

Table 7 presents the average rate of agricultural mechanization in each stage of the agricultural production in Vinh Long province. It indicates that the rate of mechanization for paddy production is mostly complete with all stages is a mechanized exception the seeding and cultivation. The rate of industrialization in some stages of rice production has reached 100%, including paddy harvesting (Fig.3), milling and rice processing, and land preparation stage of over 95%. In opposite, the rate of

agricultural mechanization of pomelo and citrus and sweet potato is quite low; most of the stages are still manual by the human power source. Therefore, the mechanization rate in agricultural production still accounts for a low proportion; the development level of agricultural mechanization is not high, not uniform between agricultural production. The mechanization focuses on rice production, mainly in the stage of land preparation, spraying, paddy harvesting, transportation inside fields (Fig.4), and rice milling plants (Fig.5), paddy drying (Fig.6) and rice milling. Mechanization in sweet potato and fruit production is still limited. The level of farm machinery and equipment is outdated, such as paddy sowing, pesticide spraying, rotary tillers, land leveling, and so on are small machines without automation control that are suitable for small field scale. Furthermore, it can be seen that sweet potato and pomelo and citrus production in Vinh Long province in almost all stages are done by hand, costly and labor-intensive. For example, planting, cultivating, fertilizing, and harvesting of these productions are mostly done by manual with low productivity so that pushing up prices or/and lacking labor power.

TABLE VI
FARM MACHINERY EQUIPPED FOR AGRICULTURE PRODUCTION

| Kind of farm machinery | Unit | Using for | | |
|---|----------|-----------|--------------|-------------------|
| | | Rice | Sweet potato | Pomelo and citrus |
| Disc plow | piece/ha | 0.024 | | |
| Rotary Tiller combined with a 4-wheel tractor | piece/ha | 0.06 | 0.26 | |
| Rotary Tiller combined with walking tractor | piece/ha | 0.14 | 0.07 | 0.08 |
| cage roller | piece/ha | 0.09 | | |
| Harrow | piece/ha | 0.05 | | |
| Sowing machine | piece/ha | 0.11 | | |
| Sprayer with shoulder engine | piece/ha | 0.79 | 0.9 | 0.89 |
| cultivator with shoulder engine | piece/ha | | 0.09 | |
| Combine Harvester | piece/ha | 0.02 | | |
| Dryer | piece/ha | 0.001 | | |
| Mill machine | piece/ha | 0.001 | | |
| Water - Pump engine | piece/ha | | 0.065 | 0.07 |
| Food processing machine | piece/ha | 0.002 | | |
| Other food processing machine | piece/ha | 0.001 | | |

Similarly, the level of mechanization in post-harvest processing is also quite low; agricultural products are consumed mainly in the form of raw materials such as rice, sweet potatoes, oranges, and pomelo. The processing and

variety of post-harvest agricultural products are still limited, such as sweet potatoes, paddy and citrus fruits that leads to decreasing the value of agricultural products through processing, low value-added and unstable consuming market.

TABLE VII
AVERAGE RATE OF MECHANIZATION IN AGRICULTURAL PRODUCTION

| Stage of production | Unit | Ratio of mechanization of | | |
|--|------|---------------------------|----------------------------------|---------------------------------|
| | | Rice | Sweet potato | Pomelo and citrus |
| Land preparation (plough, harrow, tiller, cage roller) | % | 100 | 55 | 46 |
| seeding, sowing | % | 0 | 0 | 0 |
| Spraying | % | 100 | 100 | 100 |
| cultivating | % | 0 | 0 | 18 |
| Harvesting | % | 95 | 0 | 0 |
| Transportation | % | 90 | 40 | 40 |
| Dryer | % | 90 | | |
| Irrigation (Water pumping) | % | 100 | 100 | 100 |
| Post-harvest processing | | Rice Milling only | Raw material to market or export | Fresh fruits directly to market |



Fig. 3 Paddy combine harvester



Fig. 4 Transportation paddy in the field

In terms of the current status of local manufacturers in the agricultural machinery sector, the survey shows that despite a remarkable increase in types and numbers of machinery/equipment, domestic agricultural machinery/equipment accounts for only 15-20% in the agricultural machinery market [17]. The majority of agricultural machinery are imported from Japan, S.Korea, and China (70%). The local manufacturers are almost small mechanical workshops and have not equipped with knowledge and skills of technical designs and manufacturing technologies [17].



Fig. 5 Transportation paddy to milling factory by the river



Fig. 6 Paddy flat drying

Therefore, parts or accessories are far below quality standards. There is also no “supporting industries,” which provides parts or material for assembly, for agricultural machinery manufacturing. In addition, the agricultural machinery industry is one of the important sectors in providing materials for agricultural production. The increasing trend of farm mechanization replaces manual labor for enhancing production yield, reduce post-harvest losses is a driving force to develop the agricultural machinery industry [10, 18].

However, it has been shown that the market share of local manufacturers (15-20%) is quite small compared to foreign trademarks (60-80%). Among the local manufacturers, VEAM (Vietnam Engine and Agricultural Machinery Cooperation) is the leading manufacturer in which competitive advantages of VEAM in the market include wide product lines encompassing all operations in the value chain of agricultural production and long-established enterprise.

C. Recommendations for Development the Agricultural Mechanization of Vinh Long Province

Finding out a way to develop agricultural mechanization in a country or a region is not easy work but does not mean impossible [10]. Some group of solutions for developing this sector in Vinh long province as a sample for MRD are suggested as follows:

Firstly, the agricultural production needs to be reorganized. Organizing large commodity production, building concentrated raw material areas associated with processing industry clusters is the most important thing. It is required to review planning and to direct agricultural production in the province towards the direction of concentrated farming. It also suggested establishing a large field to create conditions for farmers, enterprises, and agricultural production organizations to quickly apply mechanization into all the mechanization stages from production, storage, processing, transportation until consumption of products. This is subject to focus on investing in modern processing technology, creating high added value, restructuring product structure, and giving priority for advanced agricultural product processing and preservation technologies and manufacturing high-quality products. It also expected to develop a number of new agricultural products named with the national brand, with advanced processing and preserving technologies and capable of competing in the world market.

Secondly, mechanization in agriculture requires a high quality and skill people to run and to apply technology and engineering [18-22]. It is mentioned that increase investments in science and technology for mechanization and agricultural processing industry development should be one of the priorities in agricultural production. In addition, building up the policies of state-owned education to training and to fostering in order to raise the capacity of science and technology staff and laborers in the agricultural electro-mechanical industry and the agro-processing industry is a fundamental policy.

Thirdly, the provincial government needs to set up policies to attract businesses and individuals invest in developing state-of-the-art technology, manufacturing agricultural machines and processing agricultural products, and trading and services in machinery, equipment, and technology for agricultural mechanical development. The local policies must encourage organizations and individuals to develop patents for agricultural machines and equipment, application of informatics technology [18-20], using smartphones for controlling agricultural automation production, building software for traceability of agricultural products, and so on [23-24]. Furthermore, trading promotion and consumption of domestically produced agricultural machines as well as transferring and applying science and technology to introduce new scientific advances and machines into agricultural businesses, and people are also priority recommendations.

Fourthly, the province should propose to the central government to adjust policies and modify land laws towards the direction of encouraging and creating favorable conditions for agricultural land accumulation, removing bottlenecks on "land limit," and strongly developing the agricultural land based on free-market rules. Agricultural

land creates favorable conditions for agricultural product processing enterprises in mechanization to build up concentrated raw material areas.

Lastly, the financial source of mechanization development investment is still mainly from private enterprises and individuals participating in agricultural production in the province. Therefore, it is strongly recommended that the province's policies must focus on the benefits that investors might earn from their investment. For example, the policy is emphasized in supporting interest rate, the exemption of payment in case of loan time extending, and the State's support capital to pay interest on bank loans when investors purchase new agricultural machines in the first three years.

IV. CONCLUSION

Agricultural mechanization is an essential path to industrialization and modernization of rural regions and contributing to increasing labor productivity, reducing production costs, and rearranging agricultural labors. The recent status of mechanization in agriculture and some recommendations for developing the agricultural mechanization in the Vinh Long province as a sample province of the Mekong River Delta (MRD) are presented. The agriculture production and the level of agricultural mechanization in Vinh Long have been investigated in which shows that there has a difference in mechanization rate between plants in the agricultural sector. The main factors that strongly affect to the development of agricultural mechanization in Vinh Long are the agricultural field size, using walking tractors and shoulder engines, investment, and financial policies, skill and training level of farmers, and agricultural infrastructure. The agricultural production needs to be reorganized, the system for training high quality and skill people, increase investments in science and technology for AGRICULTURAL mechanization, setting up the policies to attract businesses and individuals invest in developing mechanization, removing blockages on "agricultural land limit" policy, and creating financial policies supporting to investors are some proposing recommendations for sustainable development of the agricultural mechanization in Vinh Long province.

ACKNOWLEDGMENT

This research is funded by the Department of Science and Technology of Vinh Long province under project No. 15 /HD-2018. Thanks to the Department of Agriculture and Rural Development, and the Department of Industry and Trading of Vinh Long province, Nong Lam University Ho Chi Minh city and Ministry of Agriculture and Rural Development of Viet Nam helped and supported so much to do this research.

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