Reclamation status of rice irrigation systems in Ninh Binh Province of Vietnam

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Abstract. A study area covers Ninh Binh Province as a whole that has 67.125 hectares of agricultural land, including 55.125 hectares of arable land. Ninh Binh has 13 major drainage basins. Water resources are unevenly distributed across the catchment areas. Due to a dense drainage system, every year Ninh Binh is hit by heavy flooding during the wet season. With a total length of all channels and a lock-weir network, just 22.4 % of channels are concrete lined, i.e. only every fourth kilometer of channels is concreted, thus leading to high irrigation losses. To tackle current challenges related to the effective use of irrigation systems in Ninh Binh, it is necessary to organize annual inspections and assessments of the current state of water supply networks, irrigation systems, etc.

1. Introduction

Vietnam has a relatively developed irrigation system that sufficiently contributes to increased cultivation area, time required for crop production, soil improvement, food security promotion and export. There are 234,000 km of all types of canals in the country, but just 23 % are lined. Moreover, almost all internal irrigation canals are unlined, and just 16 % are concrete lined. Water quality in many systems does not meet the requirements of irrigated agriculture, which affects the efficiency and quality of agricultural produce, especially in the Red River Delta and the Mekong Delta regions.

The Fourth Party Congress (1986) initiated economic reforms in Vietnam, thereby opening up new opportunities for economic growth in the agricultural sector. Currently, Vietnam is one of a few countries in Southeast Asia with relatively developed irrigation systems, with thousands of large, medium and small irrigation systems for watering and drainage.

According to statistics provided by the General Directorate of Water Resources, as early as 2014, there were 6,648 reservoirs of all types, about 10,000 large electric pumping stations, 5,500 large irrigation canals, 234,000 km of canals, 25,960 km of dams and 904 small irrigation systems with an irrigation area of 200 300 ha. In addition, more than 755,000 small and medium-sized pumps are currently operated by cooperatives and farms.

A total area of rice grown comprises more than 7.3 million hectares. In particular, a sown area in winter and spring is 2.99 million ha, in summer and autumn – 2.05 million ha, and in the off-season – 2.0–2.3 million ha. What is more, 1.5 million ha of vegetables and industrial crops are also irrigated by irrigation systems.

Rice is one of the most popular and revered cultures in the world. Rice culture is spread in more than 60 countries worldwide. For half the global population it is one of the chief foods (China, Japan, India, Indonesia, Vietnam, etc.). A world rice area is about 150 million hectares. Over 3 billion people consume it and obtain approximately 30 per cent of dietary requirement for calories from rice. Over
50% of agrarian labor resources are employed in rice farming globally. Consumer demand for rice is increasing annually, and, according to the FAO forecast, by 2020 it will amount to 781 million tons, exceeding the demand for wheat by 2–3%.

Rice is the chief crop of all agricultural products in Vietnam. Rice fields occupy vast areas across the country on the plains and, in some places, in the mountains. As far back as 20 years ago, Vietnam began to import rice. From 1990 to 2005, its production tripled and stabilized. Vietnam is the 3rd largest rice producer in the world. The yield of this crop in Vietnam is one of the highest in the entire Southeast Asia. Three rice crops are produced per year in the Mekong Delta region, and two crops in the Red River Delta region. About 52% of the country’s rice is grown in the Mekong Delta region. Nearly 90% of the total exports accrue to this region. A lot of farms in the delta have adopted an effective “shrimp-rice” model – shrimps are bred in irrigation canals supplying water to rice fields [1–5].

2. Materials and methods
A study area covers Ninh Binh Province as a whole with geographic locations from 105°30' to 106°10' east longitude and from 20°00' to 0°30' north latitude. A total area of the region is 140,574 ha. Ninh Binh shares its northern and eastern borders with Hà Nam, and Nam Định Provinces along the Day River. It is bounded to the northwest by Hòa Bình Province, to the west and southwest by Thanh Hóa Province. The province is bounded by the East Sea to the south sharing an 18-kilometer costal area. Land resources are represented mainly by coastal (saline soils) to lowland (alluvial soils) and mountainous soils.

According to land statistics in 2018, Ninh Binh has 67,125 hectares of agricultural land, including 55,125 hectares of arable land. Forestry accounts for 13,000 ha, including natural forests covering an area of 10,400 ha. Over 20,000 hectares are occupied by rocky areas with a reserve of tens of billions cubic meters of limestone, and mountainous areas account for 22% of the natural area of the province.

The climate in the study area is characterised by subclimate features typical of the Red River Delta. It is hot and humid, with cold winters and drizzles. Summers are hot and rainy strongly affected by the northeastern monsoon, while coastal, mountainous and foothill areas are influenced by the southeastern monsoon. The average annual rainfall is 1750–1850 mm.

A methodological basis for the study is system analysis, mathematical statistics, theory of experimental design, theory of automatic regulation. Experimental studies were based on generally accepted methods for hydraulic, water-balance experiments and included field surveys of rice systems [5–8].

3. Reclamation status of rice irrigation systems
Ninh Binh has great water potential. Thus, a total river water area is about 32.34 billion m³, of which about 30.9 billion m³ (95.67%) of water comes from the Nong River in the upstream. There is little rain-driven moisture, only 1.44 billion m³ (4.33%). Water resources are distributed unevenly by season. The flood season concentrates 80–85% of the total runoff, and high water levels often cause long-term floods, especially in the low-lying communes of Nho Quan and Gia Viên rural districts. In the dry season, 15–20% of the annual rainfall is received, which leads to a decrease in water level, droughts, and an increased content of salts in irrigation water. Ninh Binh has 13 major drainage basins. Water resources are distributed unevenly across the catchment areas, about 78% of water resources are concentrated in the Đạ River basin (about 30.7 billion m³, including about 25 billion m³ from the Nong River). All other catchments provide only 22% of the water. This makes inland surface water resources highly dependent on the basin outside the province, both in stocks and in quality (Fig. 1).
Ninh Binh is a province with a complex topography, including mountainous, semi-mountainous, low-lying and coastal lowland areas. Of the above features, significant funds have been invested in the construction of irrigation systems to monitor floods and storms, mitigate the effects of natural disasters and agricultural production, and to ensure the economic growth, including transport, tourism, construction of river dams, sea dykes, reservoirs, sewerage, pumping stations, canals, etc. The province has 576 km of dams, of which 31 km account for sea dams, 420 km for river dams and 125 km of roads. Class II and III dykes (small dams) should be invested and repaired annually to meet the demand for flood and storm prevention. In particular, over 50 km of river dykes and 20 km of sea dykes have been reconstructed.

In addition, about 600 km of canals have been reconstructed, which is more than 70 % and contributes to increased crop productivity. The province has received 110 new pumping stations with 595 pumps with a capacity of 340-8000 m³/h. The total irrigation capacity of pumping systems makes up 30,579 ha with 21 reservoirs to occupy an area of 1,447.2 ha and supply 14.5 million cubic meters
to the peninsular zone, thus being able to provide irrigation to about 4,500 hectares. Besides, there are 232 irrigation canals able to support an irrigated area of 15,140 ha and watered area of 23,850 ha (Fig. 2).

Two sea dams – Binh-Minh-2 with a length of 22.8 km and Binh-Minh-3 with a length of 18.34 km – were built in 2014. They were subsequently modernized with an aim of creating a protective belt to protect both the population and the rice systems of the region. This further reduced flooding in Hoàng Long area and ensured the safety of thousands of houses with almost 60 thousand people residing a natural area of 10 thousand hectares, including 5,161 hectares of agricultural land in Nho Quan and Gia Viễn districts.

Due to a dense drainage system, every year Ninh Binh is hit by heavy flooding during the wet season. Thus, heavy rains from October 9 to October 12, 2017 caused a subsequent flood in the province. At that time, during the flooding on the Hoang Long River, the water level at the Ben De Dam reached a peak of 5.53 m, exceeding the historical flood of 1985 by 20 cm. Despite the good implementation of flood prevention measures, the economic losses in Ninh Binh Province amount to almost 2 billion Vietnamese dongs or about 100 thousand dollars.

The province requires annually about 480 million cubic meters of water to provide an area of 42,000 hectares of rice and 12,000 hectares of fruit and vegetable crops. The population requires about 24 million cubic meters a year, although, the industry – an average of 630 million cubic meters a year (a total annual demand is about 1.1 million cubic meters). There are 370 facilities under state administration, including 5 river basins, 150 pumping stations, 213 floodgates and 7 dams that support state irrigation systems to span 38,807 ha and 61,742 ha – for initiative irrigation. Cooperatives and local irrigation companies manage about 1,000 divisions that support irrigation to span 8,757 ha and 4,495 ha – for initiative irrigation (Table 1).

It can be seen from the table that with a total length of all channels and a lock-weir network, just 22.4 % of channels are concrete lined, thus leading to high irrigation losses. Concerning the classes,
there are more (35.6%) class I concrete channels, while every 25th kilometer is class III channels. In individual seasons, class III irrigation channels lose up to 50–60% of the compensation water discharge and the rainy season often leads to flooding. These problems are someway related to decentralized management of irrigation operations with no clear-cut delineations of responsibilities and authorities for each level of irrigation management in the province. The public administration that includes the Ministry of Agriculture and Rural Developmen is currently responsible for the management and exploitation of irrigation systems in the province of Ninh Binh.

Table 1. Current state of irrigation and waste canal network, km

| Sub-divisions of the province: districts and cities | Total | Including channel classes |
|---------------------------------------------------|-------|--------------------------|
|                                                   | Total length of channels | Incl. concrete lined | I class | Including channel classes | II class | III class |
|                                                   | Total length of channels | Incl. concrete lined | Total length of channels | Incl. concrete lined | Total length of channels | Incl. concrete lined |
|                                                   | Concrete lined | 4599.7 | 1030.4 | 1130.8 | 399.8 | 1887.6 | 568.7 | 1581.3 | 61.9 |
| Nho Quan                                          | - | 704.7 | 328.6 | 236.8 | 118.9 | 315.2 | 208.2 | 152.7 | 0 |
| Gia Viên                                          | 654.9 | 166.3 | 153.6 | 81.3 | 286.0 | 69.7 | 215.3 | 14.8 |
| Hoa Lư                                            | 420.7 | 112.6 | 141.6 | 58.8 | 134.5 | 52.4 | 144.6 | 3.0 |
| Yên Mô                                            | 731.9 | 131.5 | 187.5 | 37.6 | 219.6 | 61.8 | 324.8 | 32.2 |
| Yên Khánh                                         | 1175.4 | 149.1 | 196.6 | 52.7 | 404.8 | 89.9 | 574.0 | 7.6 |
| Kim Sơn                                          | 657.6 | 92.3 | 110.9 | 16.7 | 447.2 | 75.0 | 99.5 | 0.6 |
| City of Ninh Binh                                 | 73.1 | 19.1 | 41.3 | 18.4 | 31.9 | 0.7 | 0 | 0 |
| City of Tam Đíp                                   | 181.4 | 30.9 | 62.5 | 15.4 | 48.4 | 11.7 | 70.4 | 3.7 |

4. Conclusion

To tackle current challenges related to the effective use of irrigation systems in Ninh Binh, it is necessary to organize annual inspections and assessments of the current state of water supply networks, irrigation systems, etc., to develop flood and drought protection plans and guidelines for regular maintenance and prevention of salinization of water sources and rice fields. The Irrigation Law does not yet exist. The operation management is in accordance with the Decree On the Operation and Protection of Irrigation Activities, which is still incomplete and fragmentary. Labor standards, wages, norms of electricity cost, irrigation and drainage, mechanisms and policies for irrigation activities are still poorly funded, which calls for further improvement. Forecasting flood control and irrigation is still inefficient and requires tighter control and early solution for concreting irrigation and discharge channels, most significantly, class III. Finally, it is obligatory to engage local communities in the maintenance and protection of irrigation systems [8–10].

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