

SUMMARY OF DOCTORAL THESIS

Name: Mohamed Farig Saad Ragab

Title:

Assessment of Agricultural Water Management at Branch and Tertiary Canal Levels in the North Nile Delta, Egypt

(エジプト・ナイルデルタにおける支線・三次水路レベルの農業用水管理評価)

---

The world's agriculture sectors consume the largest demand for water. More than two-thirds of the water used from the earth's rivers, lakes, and aquifers is used for irrigation. In Egypt, the agricultural sector consumes about 80% to 85% of the available water resources. The real challenge is that the agricultural sector employs 29.6% of the population and accounts for 11% of the country's exports. The country heavily relies on the Nile River as the sharing rainfall quota per capita is only 20 m<sup>3</sup>. The situation is further exacerbated by the increasing population of Egypt which is the second-largest in Africa. The Nile River water is fixed and limited to 55.5 billion m<sup>3</sup> per year. This agreement was decided in 1959 between Egypt and Sudan when Egypt's population was 20 million. The agreement has not been updated, and with a 100 million population, the per capita sharing water is 700m<sup>3</sup>, which is below the limit of water scarcity according to international standards. Recently, Egypt is suffering from severe water crises, which cause high demand competition and result in uneven water distribution among farmers.

In the North Nile Delta of Egypt, there is water scarcity (end of Egypt's irrigation system) and seawater intrusion (sea level is at 6 m) that threatens agricultural production, soil quality, and water supply. In the range of 25% to 30%, some lands are affected by different degrees of salinity. Thus, the Ministry of Water Resources and Irrigation (MWRI) allocated paddy rice areas in a range of 40% to 50% of the total irrigated area to control seawater intrusion and maintain soil salinity. Also, to mitigate the water scarcity in the North Nile Delta, the MWRI implemented the Irrigation Improvement Project (IIP). The goal of the project has been to improve the irrigation infrastructure by changing the scattered pumps owned by farmers to one lift point and establishing the Water User Associations (WUAs). The modernization of the irrigation infrastructure has increased farmers' interest to grow paddy rice and boost their income. The cultivated area has doubled of the allocated area by the government. As a result, a severe water shortage occurred in some locations.

The main objective of the study is to examine the impact of cropping patterns on water delivery performance through the assessment of equity and dependability by using prevailing and newly proposed indicators. Also, regarding the equity assessment, a new concept has been introduced which considers not only water volume but also the timing of irrigation such as daytime and nighttime. This would be through (I) monitoring farmers' irrigation practices in summer where water demand peaks and investigating the extent of sufficient and equitable water distribution, (II) assessing water delivery performance in terms of sufficiency, dependability, and equity, and (III) assessing the equity of water distributions in terms of irrigation timing such as daytime and nighttime irrigation.

In the first chapter, an introduction to the objectives and methodology of the study is presented. It is included the challenges that face global agriculture, such as water scarcity, increasing population, and climate change. The challenges that face Egypt's water sector and the limited water resources were also shown. The chapter also shows the challenges facing the government to implement the Irrigation Improvement Project (IIP) and the factors that affect the full utilization from the objective of the project, such as increasing the paddy rice area.

In the second chapter, the historical overview of the irrigation development in Egypt from flooding irrigation to canals system and intensive agriculture was discussed. The irrigation system network, management, and governing entities were included to show the structure of the irrigation system and the different projects that implemented to modernize it, such as the Egypt Water Use Project (EWUP), Irrigation Improvement Project (IIP), Integrated Irrigation Improvement Project (IIIMP), and the National Canal Rehabilitation Project (NCRP). Due to different challenges facing the irrigation sector, such as limited water resources and increasing population, the chapter also included a review of Egypt's water threats and water delivery performance.

In the third chapter, the extent of sufficient and equitable water distribution was assessed in the Dakalt branch canal, North Nile Delta of Egypt, where paddy rice is concentrated and water shortages occur. In this study, cropping patterns, water sufficiency, and yield were assessed along the branch canal from upstream to downstream. Results showed that increasing paddy rice area upstream caused water insufficiency downstream compared with the others. The insufficient and inequitable supply affected rice yields because the average yield downstream in 2013 and 2014 was  $7.6 \text{ t ha}^{-1}$ , while those for upstream and midstream were  $10.0$  and  $10.5 \text{ t ha}^{-1}$ , respectively. This study clarified the mechanism impact of cropping patterns on water delivery performance and yield.

In the fourth chapter, the impacts of overplanting paddy rice on water delivery performance have been discussed quantitatively. Further, the amount of water that could have been saved if farmers would follow the planned area (40% to 50% of the total irrigated area) was quantified. Results showed that the average adequacy for the investigation period was good at one location, fair at 2 locations, and poor at 3 locations in both years. The planned adequacy and dependability downstream and equity among locations improved compared to the actual condition in both years. Under the condition that paddy rice area is the upper limit planned by the government, about 12.3% and 9.6% of water could be potentially saved each year. In this study, I proposed new concepts to improve the evaluation indicators of dependability and equity.

In the fifth chapter, a new approach has been introduced to assess the equity of water distributions not only based on water volume but also the timing of irrigation. The actual conditions of water supply during the daytime and nighttime among upstream, midstream, and downstream locations are analyzed. Results showed that due to excessive pumping of water by upstream farmers, the canal water level downstream was lowered to a level in which downstream cannot pump water. As a result, downstream farmers often pump water at night. Downstream received more than 30% of the water supply during the nighttime, while upstream received 13% of the water supply. As a result, the numbers of irrigation events downstream from 24:00 h to 03:00 h were more than upstream by 8 and 7 events in 2013 and 2014, respectively. In this way, a new evaluation of equity of water distribution was proposed in consideration of the irrigation timing.

To summarize the study, Chapter 6 is the conclusion of this study. Furthermore, improvement of water delivery performance, especially through strengthening the functions of water user associations at the branch and tertiary canal levels is recommended.