Research on Impacts of Increasing Water Supply Guarantee for Agriculture in Dry Season to Hydaulic Works Operation in Northern Delta in Vietnam

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Over 50 years, irrigation systems for agriculture in Vietnam were designed with a water supply guarantee not more than 75%. According to Vietnam standard 285:2002: Hydraulic works - The basic stipulation for design, stipulates that hydraulic works are designed to ensure water supply guarantee for irrigation is 75% and for living is from 80% to 95%. Guarantee of water supply, especially during dry season, depending on capacity of incoming water sources, capacity of hydraulic works to be built and will be built - is a problem that there is no scientific research so far. On the other hand, in case of sufficient water sources, the impact of increasing the water supply guarantee for agriculture and irrigation operation is also a major issue that has not been considered. This research is very necessary, with a great socio-economic significance.

Key Words : *water supply guarantee, water demand, water balance,Red river delta.*

1. INSTRODUCTION

Over 50 years, irrigation systems for agriculture in Vietnam were designed with a water supply guarantee which is not more than 75%. According to Vietnam standard 285: 2002: Hydraulic works - The basic stipulation for design, stipulates that Hydraulic works are designed to ensure water supply guarantee for irrigation is 75% and for living is 80% to 95%.

Nowadays, land area for agriculture in Vietnam in general and in Red River delta region in particular is declining due to demand of industrial land, residential land, urbanized land .... At the same time, water demand for agricultural development in direction of commodity production and modernization of agriculture, diversification of agricultural production forms and increase of crop productivity needs to be paid attention; As a result, water supply for agriculture must be more and more stable. According to reference in agricultural field, irrigation water supply in Vietnam with frequency of 75% is low and not suitable for actual development requirement, it is definitely necessary to study about increasing the water supply guarantee to higher level.

On March 6th, 2009, Ministry of Agriculture and Rural Development issued Official Letter - Technical guidance on Canal solidification in accordance to guideline of the Government which stipulates the water supply guarantee for agriculture is 85%.

Increasing the guarantee of water supply for agriculture is an urgent requirement. However, the guarantee of water supply, especially during dry season, depends on capacity of incoming water sources, capacity of the hydraulic works to be built and will be built - is a problem that there is no scientific research. On the other hand, in case of sufficient water sources, impact of increasing the water supply guarantee for agriculture and irrigation operation is also a major issue that has not been considered. This is an important basis to propose the research: " Research on impacts of increasing water supply guarantee for agriculture in dry season to hydraulic works operation in the Northern Delta in Vietnam" . This research is very necessary, with a great socio-economic significance.

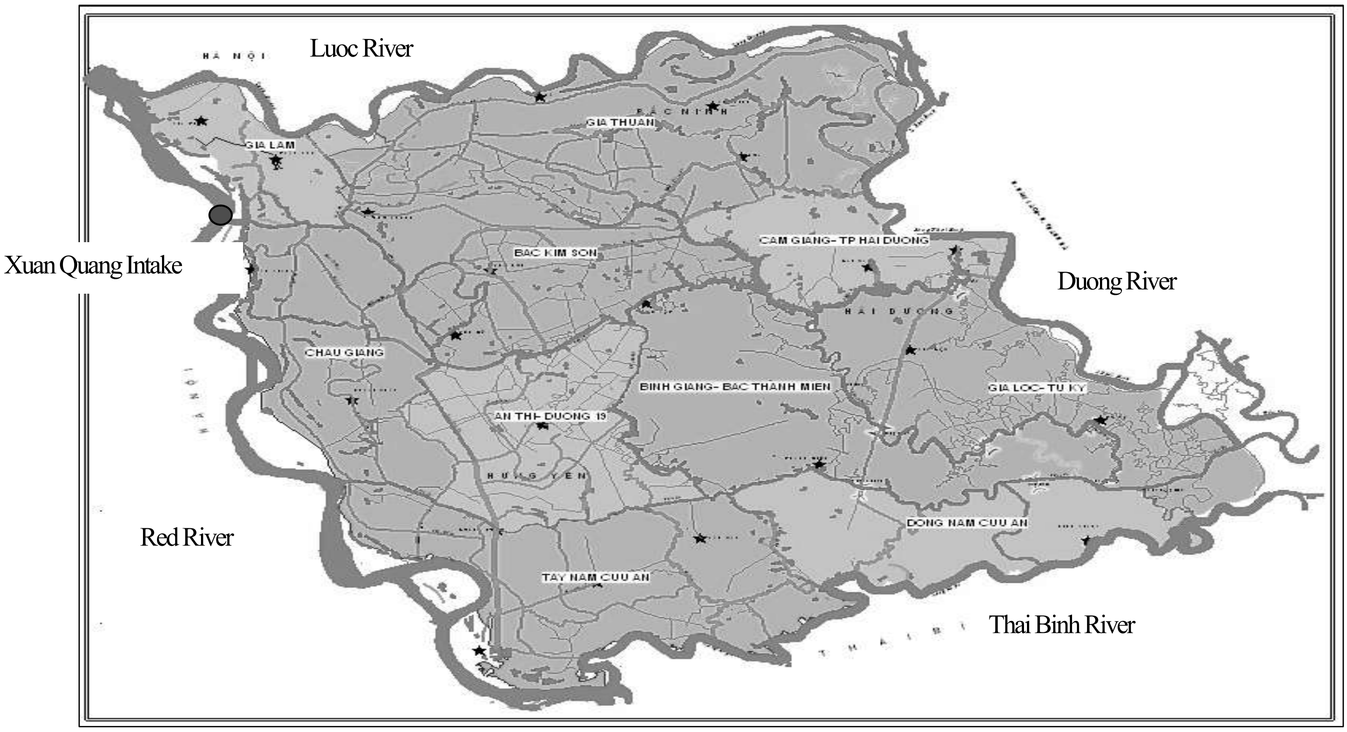

Fig. 1 Bac Hung Hai Irrigation system.

2. TYPICAL RESEARCH AREA

Bac Hung Hai is one of the most systematic urbanization and industrialization area in Red river delta, with large industrial zones. The process of urbanization and industrialization has led to a steady change of water demand in the region over years.

Moreover, Bac Hung Hai is the largest annual rainfall variation in the Northern Delta. The largest difference of rainfall between $P = 75\%$ and $P = 85\%$ at Hung Yen station is 14.0%, Thai Binh station is 12.53%. Therefore, this region also has the greatest impact on water demand when the guarantee of irrigation is increased.

For the reasons mentioned above, this research will focus on Bac Hung Hai irrigation system.

Bac Hung Hai irrigation system is surrounded by 4 large rivers: Duong river, Thai Binh river, Red river, Luoc river. Total area of irrigation system is 200.230 ha. Some main hydraulic works in Bac Hung Hai irrigation system: Xuan Quan Intake (built in 1959), Bao Dap Intake (built in 1959), Cau Xe Intake (built in 1969), An Tho (built in 1977).

3. RESEARCH METHODOLOGY

Calculate the water supply requirement for agriculture at the guarantee of 75% and 85%, and for other water users as defined in Vietnam standard 285: 2002 Hydraulic works in the Northern Delta at present and forecast to until 2020.

Using the results of calculating amount of water in the Northern Delta by Institute of Water Resources Planning, calculate balance between water resources and water supply requirement for agriculture.

Amount of water for agriculture is calculated based on balance equation written in a period of time per unit area. Usually the period is one day, one week, half a month, one month or one crop, and the unit area is usually 1 hectare. General form of water balance equation:

$$m_i = W_{out} - W_{in} \pm \Delta W \qquad (1)$$

m_i: amount of water required for crop during the *i* period (mm /day).

W_{out}: amount of water is out from the field during *i* period.

$$W_{out} = ET_{crop} + P_{erc} + L_{prep} \qquad (2)$$

ET_{crop}: evaporation in the *i* period (mm / day).

P_{erc}: amount of water leaks into aquifer and canal during *i* period (mm /day).

L_{prep}: amount of water for soil preparation (mm /day).

W_{in}: amount of water goes to the field during *i* period (mm/day).

$$W_{in} = Eff_{Rain} + N \qquad (3)$$

Eff_{Rain}: effective rainfall that plants can use during i period (mm/day).

N: amount of water flowing from other fields to caculation field during i period (mm/day).

$\triangle W$: amount of water that decreases in the field during i period (mm /day).

The equation (1) then becomes:

$$m_i = (ET_{crop} + P_{erc} + L_{prep}) - (Eff_{Rain} + N) \pm \triangle W \qquad (4)$$

The fators in equation (4) are defined as belows:

P_{erc}: according to experience, it depends on the type of land, crop method, management of irrigation system.

Eff_{Rain}: determined from design rainfall, depending on frequency P = 75% and P = 85%.

N: no water coming from other places, $N = 0$.

ET_{crop}: field evaporation, it depends on a number of factors, including climate factors and non-climate factors:

+ Climate factors include temperature, humidity, wind speed, number of sunshining hours... With higher temperature, lower humidity, faster wind, more illumination, the more evaporation and againt.

+ Non-climate factors such as crop type, growth period of crop, land tillage, etc. affectting to amount of evaporation on field (ET_c).

Determine amount of ET_{crop} field evaporation using the following formula:

$$ET_c = ET_o\, K_c \qquad (5)$$

In which:

ET_c: amount of water evaporation (mm / ha)

ET_o: amount of evaporation from ground, which is determined by Penman's climate factors.

K_c: crop coefficient, depends on type of crop and growth period of crop, determined according to the guidelines of Food and Agriculture Organization of the United Nations (FAO).

Using Penman-Monteith formula to determine amount of evaporation from ground :

$$ET_o = C\,\{WR_n + (1\text{-}W) f(u)\,(E_a\text{-}E_d)\} \qquad (6)$$

In which:

W: coefficient, depends on temperature and latitude.

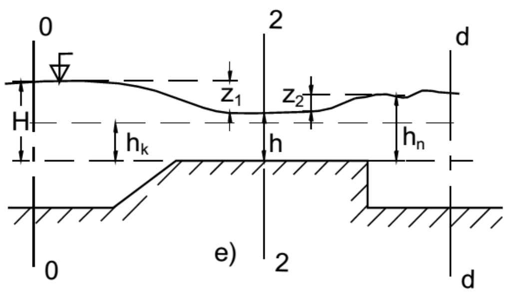

Fig. 2 Intake profile section.

R_n: radiation net expressed by evaporating equals (mm/day).

$f(u)$: wind speed correction function

$$f(u) = 0.27\,x\,(1 + U_2 / 100) \qquad (7)$$

C: adjustment coefficient, to balance influence of weather conditions of day and night in the table.

U_2: average wind speed, 2 m from the ground (km /day).

In case of wind speed measured at level z from the ground, the following formula is used:

$$U_2 = U_z\, x\, (2 / Z)^{0.2} \qquad (8)$$

U_z: average wind speed per day at level z from the ground (km /day).

E_a: saturated vapor pressure at average air temperature (mbar).

E_d: saturated vapor pressure at dewpoint temperature.

$$E_d = e_a\, x\, H_r / 100 \qquad (9)$$

H_r: humidity ratio (%).

Determining the flow through Xuan Quan intake at P = 75% and P = 85% by writing Bernulli equation for section (0-0) and (2-2):

$$H+\frac{\alpha v_o^2}{2g}=h+\frac{\alpha v^2}{2g}+\sum\zeta\frac{v^2}{2g} \qquad (10)$$

Finally the formular becames:

$$Q=\varphi_n b h_n\sqrt{2g(H_o-h_n)} \qquad (11)$$

In which:

Q: flow of water through the intake (m^3/s).

φ_n: coefficient checked in hydraulic spreadsheet, $\varphi_n = 0.9$.

Table 1 Water balance of Bac Hung Hai irrigation system in 2010.

No	Items	Unit	P=75%	P=85%
1	**Water demand**			
	Flow of Water Demand	m^3/s	131,94	133,46
	Volume of Water Demand	$10^6 m^3$	319,19	322,87
2	**Incoming water**			
	Flow of Water through Intake	m^3/s	74,0	71,0
	Volume of Water through Intake	$10^6 m^3$	179,20	171,76
3	**Water balance**			
	Flow	m^3/s	-57,94	-62,46
	Volume	$10^6 m^3$	-140,17	-151,10

Table 2 Water balance of Bac Hung Hai irrigation system in 2020.

No	Items	Unit	P=75%	P=85%
1	**Water demand**			
	Flow of Water Demand	m^3/s	123,81	125,11
	Volume of Water Demand	$10^6 m^3$	299,52	302,67
2	**Incoming water**			
	Flow of Water through Intake	m^3/s	93,0	90,0
	Volume of Water through Intake	$10^6 m^3$	224,99	217,73
3	**Water balance**			
	Flow	m^3/s	-50,81	-35,11
	Volume	$10^6 m^3$	-74,54	-84,94

b: width of the intake , $b = 19$ (m).

H_o: upstream water level of Xuan Quan intake (m).

h_n: downstream water level of Xuan Quan intake (m).

Calculation result as table 1, table 2:

For Bac Hung Hai irrigation system, it can be seen from the Figure 1 that when irrigation water guarantee is increased from P = 75% to P = 85%, demand of water will increase slightly.

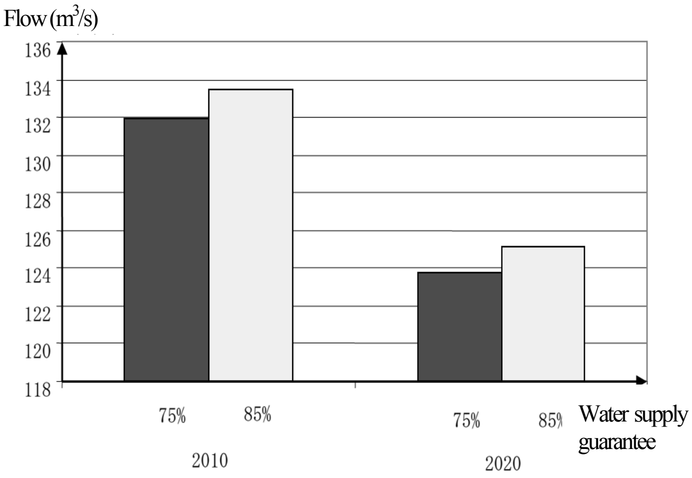

Fig.3 *Comparison chart of water demand in Bac Hung Hai irrigation system with P = 75% and P = 85% 2010 and 2020*

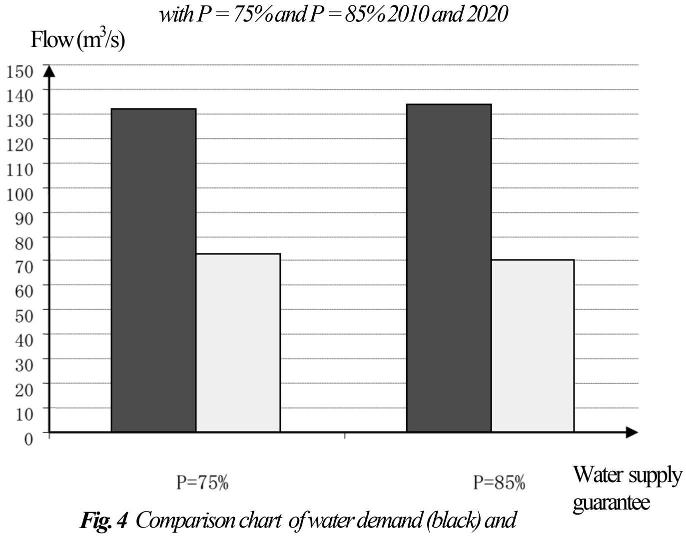

Fig. 4 *Comparison chart of water demand (black) and incoming water (grey) in 2010*

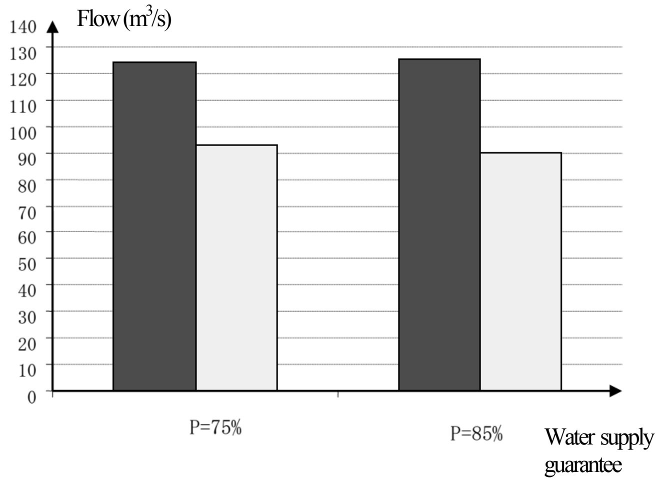

Fig. 5 *Comparison chart of water demand (black) and incoming water (grey) in 2020*

In February 2010, for *P* = 75%, water demand of the system was 131.94 m^3/s; for *P* = 85%, water demand of the system was 133,46 m^3/s. The rate of increase of P = 85% compared to P = 75% is 1.15%.

In February 2020, for P = 75%, water demand of the system was 123.81 m^3/s; for P = 85%, water demand of the system was 125,11 m^3/s. The rate of increase of P = 85% compared to P = 75% is 1.05%%.

Up to 2020, agricultural land area is declining, while the demand of water for agriculture accounts for a large proportion. Therefore, total water demand of whole system by 2020 is reduced compared to the current period..

In 2010:

+ P = 75%, total water demand is 131.94 m^3/s; flow through Xuan Quan intake is only 74,0 m^3/s (56,09%), lacking of is 94 m^3/s (account for 43.91%).

+ P = 85%, total water demand increases to 133.46 m^3/s, flow through Xuan Quan intake is only 71.0 m^3/s (53.2%), laking of 62.46 m^3/s (account for 46.80%).

In 2020:

+ P = 75%, total water demand is 123.81 m^3/s, flow through Xuan Quan intake is only 93.0 m^3/s (only 75.12%), lacking of is 81 m^3/s (account for 24.88%).

+ P = 85%, total water demand increases to 125,11 m^3/s, flow through Xuan Quan intake is only 90,0 m^3/s (71.94%), lacking of is 35.11 m^3/s (account for 28.06%).

Therefore, demand of water in the current period and 2020 of Bac Hung Hai irrigation system does not sufficiently meet flow through the Xuan Quan intake.

In Northern Delta, at the present, the main hydraulic works taking water from Red River and Thai Binh River are designed and operated with guarantee P = 75%. Therefore, when irrigation water guarantee is increased to P = 85%, these works will not ensure sufficiently water supply for irrigation systems.

4. SOME ADVICES FOR IMPROVING WATER SUPPLY REQUIREMENT

(1) When water source meets water supply requirement

Renovation and repair in order to increase scale of hydraulic works and additionally build new ones to ensure that water is taken into the system as required.

For gravity irrigation areas, due to low water level in the systems, it is impossible to ensure gravity irrigation. Researching and constructing additional pumping stations will be done.

Change operation procedures of system to match the increase of guarantee. As soon as water is taken before irrigation period, and alternated irrigation should be applied.

(2) When water source does not meet water supply requirement

Enhance normal capacity of upstream reservoirs, maintain the designed water level in Hanoi at 2.5m to meet requirement.

Change kind of plant in accordance to situation of incoming water source to the system.

Use construction measures in each irrigation area, store water during periods of excess water to use for periods of lacking water. Such as storage of water in ponds, lakes, canal systems.

5. GENERAL ACCESSMENT

When increasing irrigation water guarantee, demand of water does not increase significantly. As a result, irrigation guarantee does not significantly affect operation of hydraulic works in water supply for irrigation.

The current high demand of water is attributed to factors such as the area of agricultural and industrial land, as well as urbanization, population growth, livestock and aquaculture development.... and increase of water use standards.

The water level in the Red River and Thai Binh River system is very complicated in the current period. This leads to not take enough water from hydraulic works, especially the gravity irrigation intakes.

Irrigation systems in the Northern Delta are directly affected by Red River system and Thai Binh River system. For deep-lying areas that is not affected by tidal regime, when water level is low, it is difficult to take water for gravity irrigation, and often fail to meet water supply requirement within the prescribed time. Measures such as rehabilitation, construction of more focal works, improvement of in-field canals, and addition of pumping stations on field should be undertaken to ensure irrigation of cultivated area to an increased guarantee. For the areas affected by tide regime, it is possible to take advantage of the tide to take water into the system, but we have to change operation mode. Take advantage of tide to take water, store water in the system, and use when the water source is scarce.

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