# Concepts for the Modernization of Water Management in the Bac Hung Hai Irrigation System

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## Abstract

The Red River delta includes 9 irrigation systems with duty of irrigation and drainage for both many different regions and sectors. Most of which are dependent on the water level and flow of the Red River. In this context, the water users get water more nearly water source of Red river have water storage to serve their own region The downstream areas not only suffer water shortages but also suffered getting polluted water and not guarantee to use. These have led to a serious conflict between the use water objects in different areas within irrigation systems. It also leads to conflicts between downstream regions and upstream hydropower sector.

The objective of this study is to harmonize the water demand between different water use sectors and between sub-regions in the irrigation system in the context of tensions over water use today. Also contributing to additional policies and mechanisms aimed at enabling people to express opinions, aspirations and their responsibilities in the activities related to irrigation systems management.

By using the method of impact assessment, which is a combination of technical calculations and community consultation, this research has unveiled the preliminary results of the impact on water quantity and quality to sub-regions within Bac Hung Hai irrigation system. The impact analysis has found that there is an unequal use of water between the sub-regions. There are several upstream sub-regions use water quite wasteful whereas many downstream sub-regions endure water shortage regularly. Also occurrence of water pollution spread among sub-regions due to discharge directly into the channel. This problem began around ten years ago and is growing rapidly has caused major contradictions within the irrigation system. The main reason is due to the

management model of Bac Hung Hai irrigation system by one state company for general management was no longer appropriate. This study proposes a management model in a smaller scale with the establishment of water user organizations to promote the participation of citizens in the management of irrigation systems.

## Introduction

In the present status quo, the upstream water-users take advantage of their location and maximize their water consumption while indiscriminately discharging waste at the tail-end. Meanwhile, the downstream water-users are at a disadvantage but are passive in exercising their water rights. The severe scarcity of clean water has given rise to disputes between the local communities and the power generator industry, and between different water use sectors within the irrigation system. Thus it is urgent to find a visual method for sharing, monitoring and management of water resources. The aim of this research is to provide the scientific and practical basis to harmonize water distribution and water pollution treatment in irrigation systems of Red River Delta to solve the problem of water resources allocation between various sectors and to ensure water quality as the state standard in the region. The Red River delta has nine large distribution systems extracting water directly from the main rivers to supply water for various productive sectors and domestic water supply. In the Red River Delta, Bac Hung Hai irrigation system is the largest one, and it is exposed to the impact of the above mentioned issues.

According to the results of survey and analysis, the Irrigation and Drainage Management Company (IDMC) responsible for the management, IDMC Bac Hung Hai is the type of company to exploit irrigation works. This is a state organization to manage and exploit the key works and the main channel of irrigation systems with medium and large scale and complex operation. The remaining works on the smaller scale there is also need to manage and distribute in more specific level. But the water use organizations manage including the works system on small scale or infield irrigation system has not been managing

satisfactorily. In fact, the management and exploitation of irrigation works of the basic irrigational organizations had an important contribution to maintaining and promoting the efficiency of irrigation projects in agricultural production and other economic sectors. However, the basic irrigational management in many localities of Bac Hung Hai irrigation system has not been adequate attention leads to operating efficiency of the basic irrigational organizations still less effective. So far, most of the provinces in Bac Hung Hai irrigation system have not yet regulations on development of water use organizations in the province, which means that not yet the Participatory Irrigation Management orientation is one of the causes leading to the water use organizations have not been widespread development. The allocation of funds directly to companies of exploiting irrigation works making the relationship between water users (service enjoyment) and the company (service provider) becomes weakened. While the implementation of Decree 67 focused mainly on disbursement procedures, disregard the role of water users, the strategy to develop Participatory Irrigation Management has not yet been adjusted and completed accordingly and has limited the implementation results of the strategic framework proposed.

In recent years, the irrigation projects especially the investment project of irrigation works from international organizations in Vietnam are linked to the establishment of cooperative organizations for water consumption. Some pilot projects of transferring management and establishing Participatory Irrigation Management model by Asian Development Bank (ADB), World Bank (WB), Agency of French Development (AFD), Japan International Cooperative Agency (JICA), the non-governmental organization (NGO), etc financed initially achieved some positive results, but also some models back to the starting point. Currently, the donors continue to have the large support programs to strengthen the participation of local people in irrigation management. However, most of these projects are still in the startup phase, are being or have recently been made, and have not yet the specific conclusion. Along with the activities of international projects, many localities should implement socialization manage irrigation projects through the transfer programs of medium and small works as well as forming people organizations. The participation of citizens is important

contribution to the formulation, management, exploitation and protection of irrigation works. Some provinces have mobilized people to participate, to arouse the power of community, cohesion of the role and responsibilities of people with irrigation services that they benefit as An Giang, Tuyen Quang, Dak Lak, etc. However, the guidelines on the establishment and organization of operation of the cooperative organizations for water consumption in Bac Hung Hai system not yet specific. At the same time has not yet specified the organizations and individuals to sign the decision to establish and approve the charter and regulations of the cooperative organization for water use in irrigation works of commune and inter-commune. On the other hand most of the province could not arrange funds to implement the consolidation of cooperative organization for water use. So many places have not yet had cooperative organization for water use, or have had the cooperative organization for water use, but not yet enough capacity to receive the works with effective decentralization.

One of the other exists of water use organizations is the staff capacity is limited with 83% of staff are untrained on expertise and professional. Circular 40 of the Ministry of Agriculture and Rural Development (Dec/2011) has not defined the content, processes and procedures for the implementation of training and certification for water use organizations. Therefore some districts have not established the stations of exploiting irrigation or cooperative organizations for water consumption, so the district appointed temporarily officials in economic room of district to manage. The economic room of the district is an agency has the state management function combined management and exploitation of irrigation works. Moreover, the district staff is not enough manpower to manage and operate the hydraulic work, leading to the actual status is the irrigation works have not yet real managers, not ensure effective and sustainability of irrigation works.

Currently, many localities have not yet stipulated ceiling infield irrigation fee, revenues are not enough for the cooperative organization for water use to maintenance, dredging canals, payment for transferring water. This makes the works be fast degradation, damage and not effective as design. Many cooperative organization for water use disbanded risk. The advocacy on irrigation charge

exemption policy under Decree 67 of the Government is not yet clear, so majority of farmers have reliant thought, don't file infield irrigation charges and don't consciously use save water. Some localities exempted irrigation charges to on-farm for people, so the people in some local suppose the Government completely free of irrigation charge for in agricultural production, so don't submit infield irrigation charges. This has a negative impact on revenues and thereby negative impact the operation, increase the risk of disintegration of the cooperative organization for water use in some localities.

The findings of this research provided the basis and criteria for sharing water and assessing water quality in the irrigation system. The research will also contribute to the improvement of mechanisms and policies on water management, and will propose new methods for making the irrigation systems of Red River delta adaptable to the major changes in the new period.

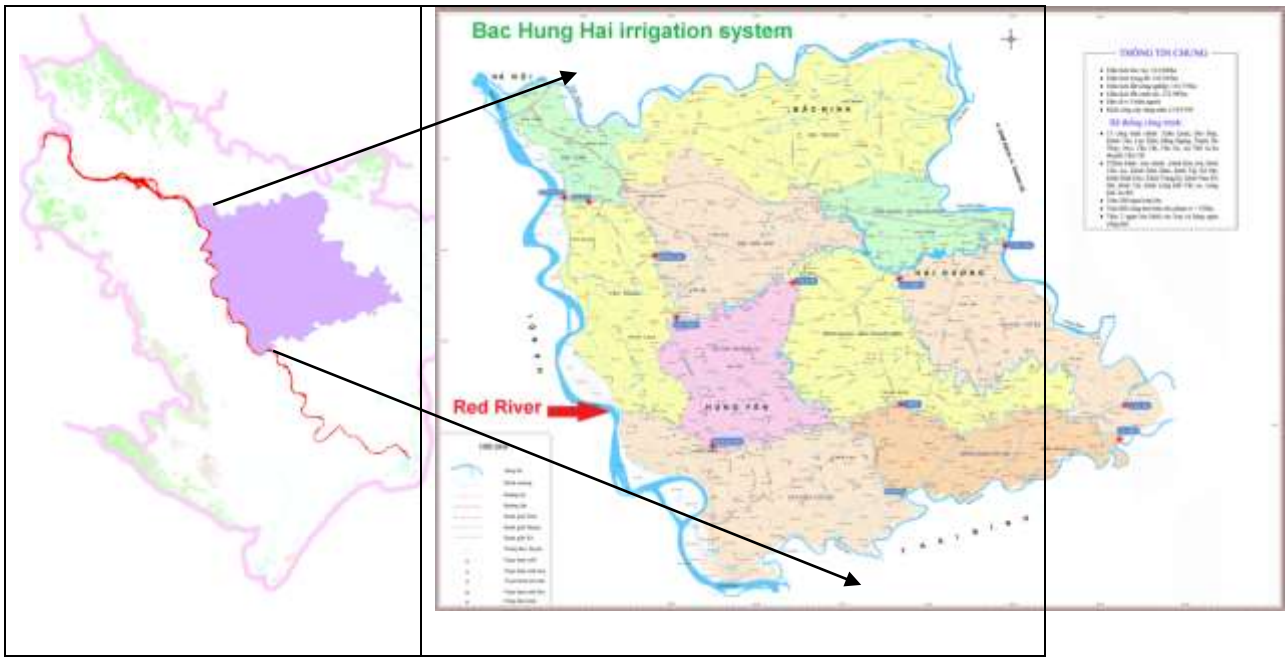
Previously, when the Red River water level was high enough, water supply was sufficient for irrigation systems of the Red River delta and the water demands for the sectors and households were ensured in all stages of the year. But from 2007 onwards, the Red River water level is becoming gradually depleted due to water storage of the upstream reservoirs. Currently, due to the very strong changes in population, land use pattern and pace of urbanization have led to the higher water demands both in quantity and quality. Also, the event of the upstream water storage makes the Red River water level go down for many years. The water demands of regions within Red River delta are always in the state of tension, but the irrigation systems do not have the sufficient capacity to meet the demands. The amount of water from the Red River flowing to downstream is no longer sufficient for the irrigation systems of Red River delta. Besides, when this meager amount of water taken through the large intakes to supply for sub-regions, water users in the areas near the Red River often do not want to share water to the other water users in the canal tail areas. Apart from the issue of quantity, the water quality issue also causes arising many conflicts. Due to the impact of strong urbanization, the emergence of the uncontrolled discharge into the irrigation systems has made many parts can't take this scanty water source. So

that is upset traditional livelihoods of the people. Instead, they have to go to other places to buy water at very high prices and even to abandon their farm and move to other jobs.

## Data and Methodology

The study was conducted in Bac Hung Hai irrigation system with geographical location in the middle of the Red River Delta, the natural areas 214,932 ha, is determined by the following coordinates: from 20º30' to 21º07' North latitude, from 105º50 'to 106º36' East longitude.

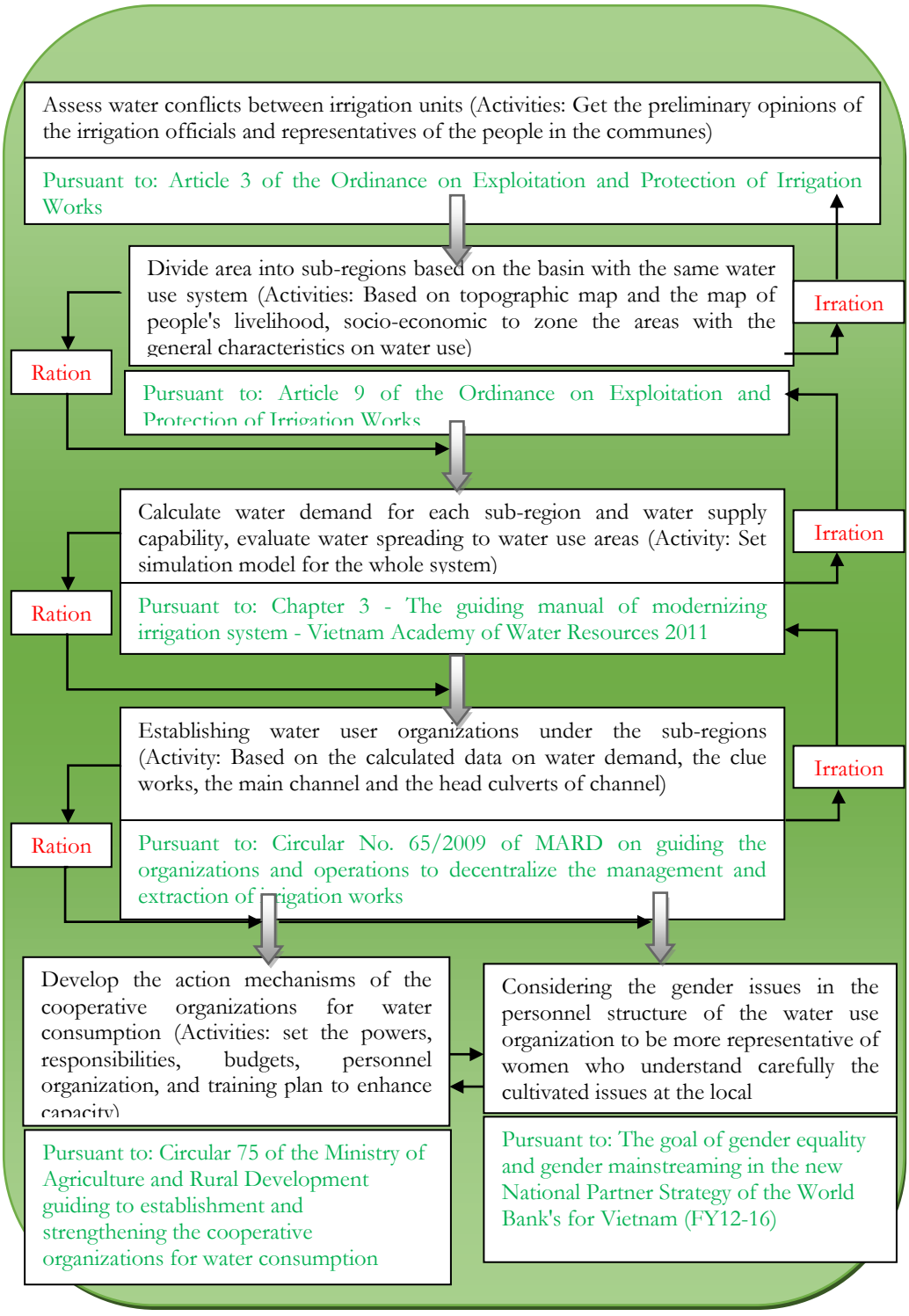
Figure 1 - Location of Bac Hung Hai irrigation system in Red river delta




After a process of discussion between the parties, including IDMC Bac Hung Hai, Department of Agriculture of the 4 provinces (Hanoi, Bac Ninh, Hung Yen, Hai Duong) and the Institute of Water Resources Engineering - Water Resources University, a strategic framework was drafted for the implementation process as shown in Figure 2. Thereby apply the following methods: (i) Method of water

demand calculation, (ii) Modeling method to simulate the water supply possibility, (iii) Method of water quality assessment, (iv) Social survey method.

Figure 2 - Strategic framework for the establishment of cooperative organizations for water allocation



## 1. Method of water demand calculation

Based on the main channel, the IDMC Bac Hung Hai divided into 10 geographical regions as shown in *Figure 1*, each region is surrounded by the main channel. The study is based on syllabus of Planning and Design of Irrigation systems - The Agriculture Publisher 2006 to calculate water needs for each region.

- Calculating water requirement for agriculture: The on-farm agricultural water requirement is indicated by their rogation coefficient for crops. We calculate for rice and crops under Chapter 3 of above syllabus. Based on meteorological data, hydrology, soil, plant seeds and the growth characteristic of plants in each region, the calculated results of irrigation coefficient for the region as the Table 1.
- Calculate water demand for livestock: The number of cattle at present time and forecasts for the future are statistic under "Agricultural planning report in 2020, vision 2030" in districts such as Table 2. According to Annex C.1-Vietnam standard 4454_2012 (the water supply standard for stations, feedlots of cattle and poultry as follows:

- Cattle: 70 liter per one each day
- Pigs: 15 liter per one each day
- Poultry: 2 liter per one each day

According to calculationsasChapter5 of above syllabus, we have the calculated results as shown in Table 3.

- Calculate the water need for economic livelihood: According to Chapter 5 of above syllabus, we calculate the water demand for livelihood is divided into urban and rural. According to Table 3.1 of TCXDVN_33_2006 standard, the standard for drinking water, living and other water demand are counted per capita for the population. For the regions of Cam Giang - Hai Duong City and Southwest Cuu An is taken under section II (Urban type II and III). The rest is taken under section III (Urban type IV, type V and rural population). The water use standard in current

period is taken equivalent to water consumption standard for the period of 2010. The water use standards in future period are taken equivalent to water consumption standard for the period of 2020. The population at current time and forecasts for the future are statistic under "Agricultural planning report 2020, vision 2030" in districts such as Table 4.

The amount of water required for the regional living activities by the formula:

$$W = \frac{N.q}{1000} \quad \text{(Cubic meter per day night)}$$

Among that:

W: the amount of water required for living activities of people in a day (cubic meter per day night)

N: The number of people using water

q: Water consumption standard (liter per day night)

The results calculated as Table 5.

- Calculating water demand for industry: The amount of water for industry include water directly create products, water create an environment and industrial sanitation, to dilute the waste and drinking water for the workers in the factory fence. The industrial land area at the current and forecasted for future is statistic under "Agricultural planning report 2020, vision 2030" in districts such as Table 6.

According to TCXDVN_33_2006 standard, the water in the focused industrial zones is taken under the area of industrial zone with the norm of (22 cubic meter per hectare to 45 cubic meters per hectare) per day-night. According to calculations as Chapter 5 of above syllabus, the result of water requirement calculated for industry as Table 7.

- Water demand for aquaculture: The development of regional aquaculture is rapidly. The growth speed of aquaculture reached 19%, services of catching aquatic increased 17.7%. This speed showed the investment for regional aquaculture development is strong. Water surface area used for

aquaculture about 10,065 hectares, a part of waterlogged and sunken area with inefficient rice production have been converted to aquaculture. The current aquaculture area in Bac Hung Hai area is 12.151 hectare. There are 3 districts of Bac Ninh with 200 hectare of concentrated cultivating and 271 hectare of dispersed cultivating. Hung Yen province has the area of freshwater aquaculture 4,500 hectare (The area of specialized fish 4,200 hectare and other aquaculture 300 hectare). For freshwater aquaculture, there are 3 types of cultivation mainly small ponds, large water surface and sunken paddy fields. According aquaculture process, the water depth need to ensure fish farming as: Small ponds 1.5-2.0 centimeter; Large water surface 2.0-3.0 centimeter; Sunken paddy fields: 20-30 centimeter. Changing water 5 times per year, each time is 1/3 water depth. However the current state of aquaculture area in the region to be medium, majority adopted in the form of semi-intensive and intensive. Among that, the small ponds with little of water supply due to scattered in residential areas. The aquaculture zones usually cultivate about 2 to 3 farming season per year: from Nov to Feb, from Mar to Jun; from Jul to Oct. Each month to change water from 1000 to 1500 cubic meter per hectare, renovated original farm 2000 cubic meter per hectare. Applying the above characteristics, we calculated under Chapter 5 of above syllabus and the results in Table 8 & Table 9.

- The flow for maintaining environment: The flow requirement to maintain flow and dilute for environmental protection in the system is taken by 10% of total water demand in the system.
- After having a total water demand of the sectors for large area, we divided according to the area proportion in charge of pumping stations. We get water needs in many positions in charge of pump stations. This data will be used to compare to water supply ability of hydraulic model in Section 2.2.

## 2. Modeling method to simulate the water supply possibility

This method applies hydraulic model MIKE 11 (Danish Hydraulic Institute) to simulate the water supply capacity at the location. Input document include:

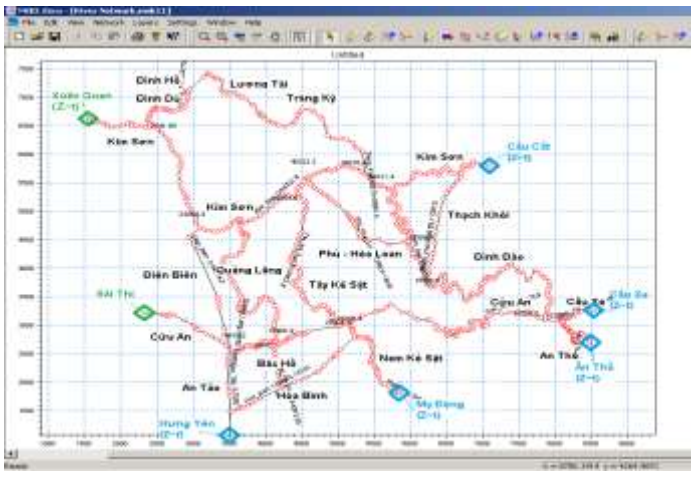
- Cross section and longitudinal section of the channel (IDMC Bac Hung Hai).
- The water level in the upper and lower boundary (National Centre of Meteorology and Hydrology).
- Parameters and operating modes of the drain (IDMC Bac Hung Hai).
- The scenarios of flushing mode in upstream Red River (Hoa Binh hydropower plant)

+ Case 1: The average flow and water level of the Red river in upstream culvert Xuan Quan reach 1.85 meter (corresponding to the frequency of previous design 75%) corresponding to the frequency current 27.5%. The average water level of the drain CauXe, An Tho, Cau Cat, etc corresponding to frequency of 27.5%.

+ Case 2: The flow and water level on the Red River in upstream culvert Xuan Quan, downstream culvert Cau Xe, An Tho, Cau Cat, etc corresponding to frequency of 75% in the stages.

+ Case 3: The flow and water level on the Red River in upstream culvert XuanQuan, downstream culvert CauXe, An Tho, Cau Cat, etc corresponding to frequency of 85% in the stages.

Figure 3 - Diagram of hydraulic calculation of Bac Hung Hai irrigation system in the model MIKE 11



When we had a complete set of input data, the model computes the results of water level and flow can be supplied at the locations in the system. These results are compared with the water demand in the calculated positions in Section 2.1, it will show the redundancy or deficit which be expressed by values. The water level results corresponding to 3 cases in some position of water regulation are shown as Table 12, Table 13and Table 14. Then we simulated the water level at the regulating drains which could ensure the water supply operation of pumping stations as Table 15. From that launched an operation mode to distribute water harmonically for regions corresponding to a case of Red River water level toughest as Table 16. Finally, based on these results, we divide the large area into sub-regions in a reasonable manner to give jurisdiction to the water user organizations.

## 3. Method of water quality assessment

In terms of water quality assessment, research was conducted to collect the results of water quality at representative measuring points on the main channel as shown in Figure 4. Total numbers of monitoring points are 32 points including:

- The monitoring point of water level and flow on the Red River: culvert Xuan Quan (1)

- The monitoring points on Kim Son River: culvert Bao Dap (2), culvert Kenh Cau (7), culvert Luc Dien (9), culvert Tranh (11), culvert Ba Thuy (13), Cat bridge (15).

- The monitoring points on Dien Bien River: culvert Luc Dien (9) and Bang Ngang bridge (30).

- The monitoring points on TayKe Sat River: fork Tong Hoa (26) and culvert Tranh (11)

- The monitoring points on Dinh Dao River: culvert Ba Thuy (13), Trang Thua Bridge (24) and the fork Cu Loc (20).

- The monitoring points on Cuu An river: Bang Ngang bridge (29), fork Tong Hoa (26), culvert Neo (25), Doc Bung pumping station (22).

- The monitoring points affected by industrial emission sources: culvert Bao Dap (2), culvert Xuan Thuy (3), culvert Cau Bay (4), culvert Lac Cau (6), Doc bridge (10), Binh Han pumping station (16), culvert Binh Lau (17).

- The monitoring points affected by urban wastewater: Luong Bang Bridge (29), An Vu pumping station (32), culvert Hong Quang (27) and bridge Cat (15).

- The monitoring points affected by domestic and agricultural waste water: Nhu Quynh bridge (5), culvert Chua Tong (8), culvert Tra Phuong (28), bridge Ghe (12), culvert Thach Khoi (14), culvert Doan Thuong (23) and culvert Dong Trang (21).

- The monitoring points affected by craft villages wastewater: end of Tu Ho Sai Thi river (31).

- The monitoring points of drainage water quality in the system: culvert An Tho (19) and culvert Cau Xe (18).

Figure 4 - Location of monitoring sites in Bac Hung Hai irrigation system


The data was collected from Laboratory Centre of the Institute for Water and Environment. At these locations, water samples were collected periodically, and then they were transported to laboratory to analyze through the gauge of such

indicators as COD, NH4 +, NO2, Coliform. Then choose some localities with heavy pollution level to survey the issue of disease and cultivated capacity.

### 4. Social survey methods

The survey focused on the current state of the infield irrigation management and household economies in the regions have results of water shortage or contaminated water.

- The questions of infield irrigation management including: taking water and water dispute resolution, the ability to participate in the management and extraction of water resources, renovating and upgrading irrigation works, the proportion of men and women in management agencies.

- The questions about household economy include: the cost for manual pump support, the participation of women in farming, nature of work in production.

## Results

### 1. Water demand of different sectors

Table 1 - The irrigation coefficient on-farm in sub-regions for each month of the year

*Unit: litre per second each hectare*

| Order | Regions | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | BinhGiang - Northern Thanh Mien | 1.22 | 1.13 | 0.94 | 0.99 | 0.68 | 1.08 | 0.52 | 0.87 | 0.69 | 0.68 | 0.65 | 0.66 |
| 2 | Cam Giang - Hai | 1.28 | 1.1 | 0.94 | 1 | 0.73 | 0.94 | 0.45 | 0.76 | 0.64 | 0.66 | 0.71 | 0.78 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Duong City | | | | | | | | | | | | |
| 3 | TuKy - GiaLoc | 1.25 | 1.12 | 0.94 | 0.99 | 0.69 | 0.95 | 0.57 | 0.71 | 0.63 | 0.64 | 0.64 | 0.69 |
| 4 | Southeast Cuu An | 1.2 | 1.18 | 0.95 | 0.98 | 0.61 | 1.04 | 0.59 | 0.84 | 0.67 | 0.66 | 0.57 | 0.83 |
| 5 | Gia Lam | 1.76 | 1.13 | 0.94 | 0.92 | 0.93 | 0.53 | 0.82 | 1.03 | 0.71 | 0.64 | 0.64 | 0.67 |
| 6 | GiaThuan | 1.18 | 1.19 | 0.92 | 0.94 | 0.89 | 0.55 | 0.55 | 1.04 | 0.75 | 0.74 | 0.74 | 0.79 |
| 7 | ChauGiang | 1.23 | 1.18 | 0.99 | 0.85 | 0.96 | 0.95 | 0.85 | 0.84 | 0.55 | 0.62 | 0.62 | 0.66 |
| 8 | Northern Kim Son | 1.2 | 1.18 | 0.99 | 0.84 | 0.85 | 0.79 | 0.7 | 0.7 | 0.49 | 0.54 | 0.54 | 0.87 |
| 9 | An Thi | 1.34 | 1.19 | 0.96 | 0.86 | 1.01 | 1 | 0.89 | 0.88 | 0.58 | 0.65 | 0.65 | 0.52 |
| 10 | Southwest Cuu An | 1.25 | 0.87 | 0.96 | 0.95 | 1.01 | 0.94 | 0.84 | 0.83 | 0.74 | 0.83 | 0.83 | 0.67 |

Table 2 - Number of livestock in stages by regions

*Unit: One*

| **Order** | **Planning regions** | **Present** | | | | **Year 2030** | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Buffalo** | **Cow** | **Pigs** | **Poultry** | **Buffalo** | **Cow** | **Pigs** | **Poultry** |
| 1 | Gia Lam | 93 | 11,959 | 156,748 | 330,049 | 15 | 18,642 | 307,245 | 656,468 |
| 2 | GiaThuan | 1,185 | 27,586 | 334,967 | 2,877,064 | 451 | 42,967 | 656,579 | 5,722,488 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 3 | ChauGiang | 189 | 12,944 | 414,703 | 3,894,490 | 79 | 23,886 | 1,308,040 | 12,152,777 |
| 4 | Northern Kim Son | 712 | 6,62 | 352,4 | 3,450,023 | 276 | 12,217 | 1,111,528 | 10,765,815 |
| 5 | Cam Giang - Hai Duong City | 352 | 4,105 | 204,461 | 2,226,255 | 105 | 7,58 | 644,876 | 6,947,051 |
| 6 | An Thi | 349 | 8,379 | 201,516 | 2,932,194 | 72 | 15,464 | 635,613 | 9,149,926 |
| 7 | BinhGiang - Northern Thanh Mien | 985 | 12,988 | 327,331 | 3,476,901 | 370 | 23,966 | 1,032,457 | 10,849,689 |
| 8 | GiaLoc - TuKy | 1,347 | 10,372 | 434,641 | 3,632,536 | 588 | 19,141 | 1,370,931 | 11,335,348 |
| 9 | Southwest Cuu An | 584 | 29,961 | 507,204 | 6,302,491 | 249 | 55,368 | 1,599,806 | 19,666,956 |
| 10 | Southeast Cuu An | 810 | 10,159 | 237,219 | 2,160,669 | 336 | 18,75 | 748,226 | 6,742,380 |
| | **Total** | **6,606** | **135,073** | **3,171,190** | **31,282,672** | **2,543** | **237,981** | **9,415,300** | **93,988,899** |

Table 3 - Waterrequirementfor livestock in BacHung Hai area

*Unit: litre per second*

| Order | Planning regions | Present | | | | | Year 2030 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Buffalo | Cow | Pigs | Poultry | Total | Buffalo | Cow | Pigs | Poultry | Total |
| 1 | Gia Lam | 0.14 | 17.99 | 36.28 | 11.46 | 65.88 | 0.02 | 28.05 | 71.12 | 22.79 | 121.99 |
| 2 | GiaThuan | 1.78 | 41.51 | 77.54 | 99.9 | 220.73 | 0.68 | 64.65 | 151.99 | 198.7 | 416.01 |
| 3 | ChauGiang | 0.28 | 19.48 | 96 | 135.23 | 250.98 | 0.12 | 35.94 | 302.79 | 421.97 | 760.82 |
| 4 | Northern Kim Son | 1.07 | 9.96 | 81.57 | 119.79 | 212.4 | 0.42 | 18.38 | 257.3 | 373.81 | 649.91 |
| 5 | Cam Giang - Hai Duong City | 0.53 | 6.18 | 47.33 | 77.3 | 131.34 | 0.16 | 11.41 | 149.28 | 241.22 | 402.06 |
| 6 | An Thi | 0.53 | 12.61 | 46.65 | 101.81 | 161.59 | 0.11 | 23.27 | 147.13 | 317.71 | 488.21 |
| 7 | BinhGiang - Northern Thanh Mien | 1.48 | 19.54 | 75.77 | 120.73 | 217.52 | 0.56 | 36.06 | 238.99 | 376.73 | 652.34 |
| 8 | GiaLoc - TuKy | 2.03 | 15.61 | 100.61 | 126.13 | 244.37 | 0.88 | 28.8 | 317.35 | 393.59 | 740.62 |
| 9 | Southwest Cuu An | 0.88 | 45.08 | 117.41 | 218.84 | 382.2 | 0.37 | 83.31 | 370.33 | 682.88 | 1136.89 |
| 10 | Southeast | 1.2 | 15.2 | 54.9 | 75.0 | 146.4 | 0.5 | 28.2 | 173.2 | 234.1 | 436.0 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cuu An | 2 | 9 | 1 | 2 | 4 | 1 | 1 | | 1 | 3 |
| | **Total** | **9.94** | **203.23** | **734.07** | **1086.2** | **2033.45** | **3.82** | **358.07** | **2179.47** | **3263.5** | **5804.87** |

Table 4 - Current population and population forecast for Bac Hung Hai area

*Unit: person*

| **Order** | **Province** | **Current population** | | | **Population in 2030** | | |
|---|---|---|---|---|---|---|---|
| | | **Total** | **Urban** | **Rural** | **Total** | **Urban** | **Rural** |
| 1 | Hai Duong | 1,062,532 | 192,807 | 869,724 | 1,227,224 | 222,692 | 1,004,532 |
| 2 | Hung Yen | 1,240,002 | 129,429 | 1,110,572 | 1,432,202 | 149,491 | 1,282,711 |
| 3 | BacNinh | 386,808 | 29,181 | 357,628 | 446,764 | 33,704 | 413,060 |
| 4 | Gia Lam | 311,953 | 204,251 | 107,702 | 360,306 | 235,910 | 124,395 |
| **Total** | | **3,001,295** | **555,668** | **2,445,626** | **3,466,495** | **641,797** | **2,824,698** |

Table 5 - Results of the flow requirement for domestic water supply

*Unit: cubic meter per second*

| **Order** | **Province** | **Current population** | | | **Population in 2030** | | |
|---|---|---|---|---|---|---|---|
| | | **Total** | **Urban** | **Rural** | **Total** | **Urban** | **Rural** |
| 1 | Hai Duong | 0.87 | 0.27 | 0.6 | 1.55 | 0.39 | 1.16 |
| 2 | Hung Yen | 0.95 | 0.18 | 0.77 | 1.74 | 0.26 | 1.48 |
| 3 | BacNinh | 0.29 | 0.04 | 0.25 | 0.54 | 0.06 | 0.48 |
| 4 | Gia Lam | 0.36 | 0.28 | 0.07 | 0.55 | 0.41 | 0.14 |
| **Total** | | 2.47 | 0.77 | 1.7 | 4.38 | 1.11 | 3.27 |

Table 6 - The area of industrial land of Bac Hung Hai region

*Unit: hectare*

| Order | Province | Current industrial land area | Industrial land area in 2030 |
|---|---|---|---|
| 1 | Hai Duong | 1711,40 | 4646,45 |
| 2 | Hung Yen | 884,10 | 2559,37 |
| 3 | BacNinh | 446,72 | 1206,13 |
| 4 | Gia Lam | 432,00 | 1124,24 |
| **Total** | | **3474,22** | **9536,20** |

Table 7 - The result of water flow calculated for the industrial zones in BacHungHai region

*Unit: cubicmeter per second*

| Order | Province | The water volume for industry in current | The water volume for industry in 2030 |
|---|---|---|---|
| 1 | Hai Duong | 0.89 | 2.42 |
| 2 | Hung Yen | 0.46 | 1.33 |
| 3 | BacNinh | 0.23 | 0.63 |
| 4 | Gia Lam | 0.23 | 0.59 |
| **Total** | | **1.81** | **4.97** |

Table 8 - The result calculated water volume for aquaculture

*Unit: cubic meter per hectare of water surface*

| Order | Month of water supply | Water depth for preparing pond (millimeter) | Water depth for additional replacement (millimeter) | The surface evaporation between water changes twice (millimeter) | The stable absorbed water amount between each water addition (millimeter) | Actual rainfall between water changes twice (millimeter) | The total amount of needed water (cubic meter per hectare) |
|---|---|---|---|---|---|---|---|
| 1 | Nov | 200 | | | | | **2000** |
| 2 | Dec | | 150 | 70 | 7 | 4 | **2231** |
| 3 | Jan | | 150 | 56 | 7 | 9 | **2036** |
| 4 | Feb | | 150 | 52 | 6 | 5 | **2040** |
| 5 | Mar | | 150 | 64 | 7 | 75 | **1460** |
| 6 | Apr | | 150 | 82 | 7 | 73 | **1662** |
| 7 | May | | 150 | 118 | 7 | 75 | **2000** |
| 8 | Jun | | 150 | 128 | 7 | 95 | **1897** |
| 9 | Jul | | 150 | 135 | 7 | 151 | **1408** |
| 10 | Aug | | 150 | 119 | 7 | 127 | **1489** |
| 11 | Sep | | 150 | 109 | 7 | 86 | **1797** |
| 12 | Oct | | 150 | 98 | 7 | 93 | **1621** |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Total** | **200** | **1650** | **1031** | **77** | **794** | **21641** |

Table 9 - The result calculated water flow for aquaculture

*Unit: cubic meter per second*

| **Order** | **Province** | **Nov** | **Dec** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | BacNinh | 0.36 | 0.39 | 0.36 | 0.4 | 0.26 | 0.3 | 0.35 | 0.34 | 0.25 | 0.26 | 0.33 | 0.29 |
| 2 | Hung Yen | 3.47 | 3.75 | 3.42 | 3.79 | 2.45 | 2.89 | 3.36 | 3.29 | 2.37 | 2.5 | 3.12 | 2.72 |
| 3 | Hai Duong | 5.54 | 5.98 | 5.46 | 6.05 | 3.91 | 4.6 | 5.36 | 5.25 | 3.77 | 3.99 | 4.98 | 4.35 |
| **Total** | | **9.38** | **10.12** | **9.24** | **10.25** | **6.62** | **7.79** | **9.08** | **8.89** | **6.39** | **6.75** | **8.42** | **7.35** |

Table 10 - The result calculated flow to maintain environmental flow

| **Categories** | **Required water flow (cubic meter per second)** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Environment | 13.83 | 6.95 | 7.65 | 9.74 | 4.1 | 4.65 | 2.82 | 1.92 | 2.61 | 4.37 | 3.11 | 4.41 |

Table 11 - The result calculated water flow requirement of the fields monthly in Bac Hung Hai area

| **Order** | **Categories** | **Water flow requirements of the sectors monthly (cubic meter per second)** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** |
| 1 | Industry | 1.81 | 1.81 | 1.81 | 1.81 | 1.81 | 1.81 | 1.81 | 1.81 | 1.81 | 1.81 | 1.81 | 1.81 |
| 2 | Aquatic | 9.38 | 10.12 | 9.24 | 10.25 | 6.62 | 7.79 | 9.08 | 8.89 | 6.39 | 6.75 | 8.42 | 7.35 |
| 3 | Living | 2.47 | 2.47 | 2.47 | 2.47 | 2.47 | 2.47 | 2.47 | 2.47 | 2.47 | 2.47 | 2.47 | 2.47 |
| 4 | Livestock | 2.03 | 2.03 | 2.03 | 2.03 | 2.03 | 2.03 | 2.03 | 2.03 | 2.03 | 2.03 | 2.03 | 2.03 |
| 5 | Agriculture | 122.63 | 53.04 | 60.96 | 80.88 | 28.03 | 32.39 | 12.79 | 4.04 | 13.45 | 30.61 | 16.34 | 30.39 |
| 6 | Environment | 13.83 | 6.95 | 7.65 | 9.74 | 4.1 | 4.65 | 2.82 | 1.92 | 2.61 | 4.37 | 3.11 | 4.41 |
| **Total** | | **152.15** | **152.15** | **69.47** | **76.51** | **97.44** | **40.97** | **46.49** | **28.18** | **19.25** | **26.15** | **43.68** | **31.08** |

Comment: Due to the hydro-meteorological weather in the region in recent years have many adverse developments in agricultural production. The drought in Winter-Spring crop, the rainfall reduced in dry season led to water demand for economic sectors increased, especially water requirements for agriculture.

## 2. Hydraulic calculation results under the regulating scenarios in Hoa Binh hydropower plant in upstream of Red River

From the results of hydraulic calculation for plan of irrigation and water supply shows:

Table 12 - Average water level at the culverts (Case 1)

*Unit: meter*

| Order | Name of culverts | From Oct 29th to Dec 31th | From Jan 1st to Jan 19th | From Jan 20th to Feb 28th | From Mar 1st to Apr 30th | From May 1st to May 31st | From Jun 1st to Jul 10th | From Jul 11th to Oct 28th |
|---|---|---|---|---|---|---|---|---|
| 1 | Upstream of culvert XuanQuan | 2.39 | 1.84 | 1.85 | 2.04 | 3.07 | 4.56 | 4.17 |
| 2 | Downstream of culvert XuanQuan | 1.8 | 1.79 | 1.82 | 1.97 | 2.1 | 2.3 | 2 |
| 3 | Upstream of culvert Bao Dap | 1.68 | 1.71 | 1.74 | 1.91 | 2 | 2.1 | 1.95 |
| 4 | Upstream of culvert KenhCau | 1.65 | 1.55 | 1.6 | 1.9 | 1.72 | 2 | 1.8 |
| 5 | Upstream of culvert Ba Thuy | 1.16 | 2.15 | 1.42 | 1.41 | 1.35 | 1.6 | 1.35 |
| 6 | Upstream of culvert Neo | 1.06 | 1.3 | 1.36 | 1.34 | 1.32 | 1.5 | 1.25 |
| 7 | Upstream of culvert CauXe | 0.7 | 1.15 | 1.17 | 0.87 | 0.71 | 0.99 | 0.94 |
| 8 | Downstream of culvert CauXe | 0.67 | 0.6 | 0.57 | 0.57 | 0.59 | 1.03 | 1.1 |

| Order | Name of culverts | From Oct 29th to Dec 31th | From Jan 1st to Jan 19th | From Jan 20th to Feb 28th | From Mar 1st to Apr 30th | From May 1st to May 31st | From Jun 1st to Jul 10th | From Jul 11th to Oct 28th |
|---|---|---|---|---|---|---|---|---|
| 9 | Upstream of culvert An Tho | 0.68 | 1.14 | 1.16 | 0.86 | 0.68 | 0.99 | 0.94 |
| 10 | Downstream of culvert An Tho | 0.71 | 0.61 | 0.58 | 0.58 | 0.98 | 1.08 | 1.2 |
| 11 | Upstream of culvert Cau Cat | 1.19 | 1.4 | 1.4 | 1.43 | 1.47 | 1.43 | 1.47 |
| 12 | Downstream of culvert Cau Cat | 1.04 | 0.81 | 0.76 | 0.76 | 1.1 | 1.52 | 1.83 |

Table 13 - Average water level at the culverts (Case 2)

*Unit: meter*

| Order | Name of culverts | From Oct 29th to Dec 31th | From Jan 1st to Jan 19th | From Jan 20th to Feb 28th | From Mar 1st to Apr 30th | From May 1st to May 31st | From Jun 1st to Jul 10th | From Jul 11th to Oct 28th |
|---|---|---|---|---|---|---|---|---|
| 1 | Upstream of culvert XuanQuan | 1.43 | 1.19 | 1.49 | 1.48 | 2.06 | 2.62 | 3.5 |
| 2 | Downstream of culvert XuanQuan | 1.23 | 1.17 | 1.4 | 1.41 | 1.86 | 2.08 | 2.29 |
| 3 | Upstream of culvert Bao Dap | 1.21 | 1.15 | 1.35 | 1.37 | 1.78 | 2.06 | 2.24 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 4 | Upstream of culvert KenhCau | 1.14 | 1.11 | 1.3 | 1.28 | 1.63 | 1.76 | 2.1 |
| 5 | Upstream of culvert Ba Thuy | 1.07 | 1.08 | 1.25 | 1.24 | 1.36 | 1.38 | 1.53 |
| 6 | Upstream of culvert Neo | 0.96 | 1.04 | 1.19 | 1.16 | 1.2 | 1.18 | 1.22 |
| 7 | Upstream of culvert CauXe | 0.65 | 0.95 | 0.94 | 0.8 | 0.81 | 0.83 | 0.99 |
| 8 | Downstream of culvert CauXe | 0.64 | 0.51 | 0.49 | 0.48 | 0.65 | 0.77 | 0.94 |
| 9 | Upstream of culvert An Tho | 0.66 | 0.94 | 0.93 | 0.77 | 0.76 | 0.79 | 1.01 |
| 10 | Downstream of culvert An Tho | 0.63 | 0.52 | 0.51 | 0.5 | 0.67 | 0.78 | 0.92 |
| 11 | Upstream of culvert Cau Cat | 1.07 | 1.11 | 1.23 | 1.25 | 1.36 | 1.39 | 1.41 |
| 12 | Downstream of culvert Cau Cat | 0.88 | 0.71 | 0.69 | 0.66 | 0.87 | 1.05 | 1.39 |

Table 14 - Average water level at the culverts (Case 3)

*Unit: meter*

| Order | Name of culverts | From Oct 29th to Dec 31th | From Jan 1st to Jan 19th | From Jan 20th to Feb 28th | From Mar 1st to Apr 30th | From May 1st to May 31st | From Jun 1st to Jul 10th | From Jul 11th to Oct 28th |
|---|---|---|---|---|---|---|---|---|
| 1 | Upstream of culvert XuanQuan | 1.24 | 1.1 | 1.42 | 1.35 | 1.83 | 2.2 | 3.1 |
| 2 | Downstream of culvert XuanQuan | 1.14 | 1.09 | 1.34 | 1.3 | 1.78 | 1.9 | 1.89 |
| 3 | Upstream of culvert Bao Dap | 1.13 | 1.07 | 1.3 | 1.27 | 1.7 | 1.88 | 1.8 |
| 4 | Upstream of culvert KenhCau | 1.07 | 1.05 | 1.28 | 1.22 | 1.55 | 1.71 | 1.73 |
| 5 | Upstream of culvert Ba Thuy | 1 | 1.02 | 1.23 | 1.18 | 1.3 | 1.32 | 1.29 |
| 6 | Upstream of culvert Neo | 0.94 | 0.99 | 1.16 | 1.12 | 1.17 | 1.15 | 1.19 |
| 7 | Upstream of culvert CauXe | 0.63 | 0.9 | 0.88 | 0.76 | 0.67 | 0.81 | 0.84 |
| 8 | Downstream of culvert CauXe | 0.6 | 0.49 | 0.49 | 0.46 | 0.52 | 0.72 | 0.8 |
| 9 | Upstream of culvert An Tho | 0.65 | 0.89 | 0.87 | 0.72 | 0.64 | 0.76 | 0.95 |
| 10 | Downstream of culvert An Tho | 0.6 | 0.5 | 0.51 | 0.48 | 0.53 | 0.72 | 0.8 |

| Order | Name of culverts | From Oct 29th to Dec 31th | From Jan 1st to Jan 19th | From Jan 20th to Feb 28th | From Mar 1st to Apr 30th | From May 1st to May 31st | From Jun 1st to Jul 10th | From Jul 11th to Oct 28th |
|---|---|---|---|---|---|---|---|---|
| 11 | Upstream of culvert Cau Cat | 1.04 | 1.07 | 1.21 | 1.22 | 1.33 | 1.37 | 1.33 |
| 12 | Downstream of culvert Cau Cat | 0.87 | 0.7 | 0.69 | 0.63 | 0.83 | 0.97 | 1.3 |

## 3. Calculate and check the water level required to ensure water supply for irrigation and supply for pumping stations

To check the result of hydraulic calculation for cases of irrigation and water supply, we carried out calculation of water level be controlled at the culverts during the soil loose stage (the most intense period of irrigation water source for Bac Hung Hai area). If this period has ensured water sources, the other period will also ensure the water need of the region. Therefore, in this research we calculated the water levels required to ensure watering soil loose period (January and February annually). The regulating culverts of Bac Hung Hai area include Kenh Cau, Ba Thuy, Neo, CauXe, AnTho.

Based on data collected about the designed water level of suction tank, minimum water level of suction tank of pumping stations, channel length, the riverbed slope, we calculate the water level controlled at the culverts based on irrigation requirements for the pumping stations. Calculation results of the required water level to control at the culverts as follows:

Table 15 - Water level requirements controlled at the culverts

| Order | Name of culverts | Required water level (meter) |
|---|---|---|
| 1 | KenhCau | 1.28–1.85 |
| 2 | Ba Thuy | 0.77–1.44 |
| 3 | Neo | 0.90–1.13 |
| 4 | CauXe | 0.50–0.72 |
| 5 | An Tho | 0.50–0.72 |

The results are also the basis to harmonize water resources between the regions, norm of water use to limit the waste of water in upstream areas and set out the indicators to create favorable conditions for water users in downstream areas can negotiate effectively in demanding their water rights.

From the results calculated the average water level of the culverts and the test results of required water level conditions to ensure water for irrigation and supply for pumping stations, we launched the required water level controlled at the culverts as follows:

Table 16 - The required water level to ensure water and culvert operating mode in case 1 (the case of biggest tense on water)

*Unit: meter*

| **Order** | **Name of culverts** | **From Oct 29th to Dec 31th** | **From Jan 1st to Jan 19th** | **From Jan 20th to Feb 28th** | **From Mar 1st to Apr 30th** | **From May 1st to May 31st** | **From Jun 1st to Jul 10th** | **From Jul 11th to Oct 28th** |
|---|---|---|---|---|---|---|---|---|
| 1 | Downstream of culvert XuanQuan | 1.60 ÷ 2.20 | Open | Open | 1.80 ÷ 2.40 | 1.80 ÷ 2.20 | 2.00 ÷ 2.40 | 1.80 ÷2.20 |
| 3 | Upstream of | 1.45 ÷ | Open | Open | 1.60 ÷ | 1.60 ÷ | 1.80 ÷ | 1.60 |

| Order | Name of culverts | From Oct 29th to Dec 31th | From Jan 1st to Jan 19th | From Jan 20th to Feb 28th | From Mar 1st to Apr 30th | From May 1st to May 31st | From Jun 1st to Jul 10th | From Jul 11th to Oct 28th |
|---|---|---|---|---|---|---|---|---|
| | culvert KenhCau | 1.85 | | | 2.00 | 2.00 | 2.20 | ÷2.00 |
| 4 | Upstream of culvert Ba Thuy | 1.10 ÷ 1.30 | ≤ 2.2 | ≤ 2.2 | 1.30 ÷ 1.70 | 1.20 ÷ 1.50 | 1.40 ÷ 1.80 | 1.20 ÷1.50 |
| 5 | Upstream of culvert Neo | 1.00 ÷ 1.20 | ≤ 1.80 | ≤ 1.80 | 1.20 ÷ 1.60 | 1.10 ÷ 1.40 | 1.30 ÷ 1.70 | 1.10 ÷ 1.40 |
| 6 | Upstream of culvert CauXe | 0.60 ÷ 0.8 | Get reverse water | Get reverse water | 0.80 ÷ 1.00 | 0.60 ÷ 0.8 | 0.90 ÷ 1.10 | 0.80 ÷ 1.00 |
| 7 | Upstream of culvert An Tho | 0.60 ÷ 0.8 | Get reverse water | Get reverse water | 0.80 ÷ 1.00 | 0.60 ÷ 0.8 | 0.90 ÷ 1.10 | 0.80 ÷ 1.00 |
| 8 | Upstream of culvert Cau Cat | Close | Get reverse water | Get reverse water | Close | Close | Close | Close |

In the calculation process, based on topography and water use characteristics of each region, we divide the Bac Hung Hai irrigation area into 18 sub-basins as Figure 5. Through the calculation results, comparing the amount of water and local surveys, the sub-regions were be water shortage severely when the Red River water level was low including Region 9, Region 10, Region 11, Region 12, Region 13, Region 14, Region 16.

Figure 5 - The sub-regions used water in Bac Hung Hai irrigation system


## 4. The result of water quality through the simulation process of hydraulic model

Through statistical all monitoring points and compared with water quality standard, the percentage (%) score in excess of allowing standards for some indicators as Table 17

Table 17 - The percentage (%) score in excess of allowing standards

| Period / Criteria | Year 2015 | | | | | Year 2016 | |
|---|---|---|---|---|---|---|---|
| | Mar | Apr | May | Jul | Sep | Jan | Feb |
| COD | 18.4 | 18.4 | 36.2 | 33.5 | 43.7 | 23.6 | 36.3 |
| NH4+ | 88.4 | 87.8 | 73.4 | 85.1 | 83.9 | 94.3 | 41.5 |
| NO2- | 62.8 | 68.6 | 37.4 | 18.7 | 45.2 | 9.1 | 13.7 |
| Coliform | 38.8 | 70.3 | 28.7 | 41.6 | 44.3 | 17.9 | 25.5 |

At the same time we can see the preliminary the positions of serious pollution through monitoring as follow: Culvert Bao Dap (2), culvert Xuan Thuy (3),

culvert Cau Bay (4), culvert Chua Tong (8), Binh Han pumping station (16), culvert Binh Lau (17), bridge Cat (15), end of Tu Ho SaiThi river (31), pumping station An Vu (32), culvert Hong Quang (27), culvert Tra Phuong (28), Nhu Quynh bridge (5)

Through the survey in the Commune People's Committee and Communal Health Station, the investigated results of water pollution impact on production and life as follows:

- Affect the people's lives: The survey results in Thach Khoi commune showed that many households living along the canal Thach Khoi - Doan Thuong when drilling well, they found water with foul smell and unusable, so they had to buy water from other places for living. Other places have to drill wells at a depth of 50 meter for utilization. The survey data at the local health stations on the disease related to water pollution showed that: Although the income and living level of the people is increasing highly but the rate of diseases related to pollution increased continuously over the years from 2012 to 2015. The proportion of women suffering from gynecological diseases highly such as communes of Tu Dan, Phung Hung, Dai Hung (KhoaiChau), Da Ton, Kieu Ki (Gia Lam), Hai Tan, Ngoc Chau (Hai Duong city), Tan Quang (Van Lam).

Table 18 - Synthesis of diseases statistic over the years

| No | Diseases | Prevalence rates (%) | | | |
|---|---|---|---|---|---|
| | | Year 2012 | Year 2013 | Year 2014 | Year 2015 |
| 1 | Diarrhea | 19.9 | 22.3 | 25.0 | 28.05 |
| 2 | Malnutrition in children under 5 years | 12.2 | 12.2 | 12.4 | 12.8 |
| 3 | Gynecological diseases of women | 35.5 | 36.5 | 37.6 | 38.6 |
| 4 | Skin diseases | 21.5 | 21.9 | 22.3 | 22.7 |
| 5 | Cancer | 4.0 | 4.4 | 4.7 | 5.0 |

- *Affect the agricultural production:* The survey results showed that there were 2 in 15 communes have the rice yield reduced due to contaminated irrigation water, in which: Da Ton commune has 50 hectares of rice land near pumping station, the rice yield decreased by 15 to 20 percent compared to the average yield. Hung Long commune has 200 hectares of rice land that the yield reduced 35 to 40 percent compared with the average yield. In the remaining survey communes, the rice yield remained stable from 55 to 60 quintal per hectare. The influence of water pollution into plant disease is not yet evident. According to local comments in communes of Da Ton, Hung Long, HiepCuong, the rice affected water contamination should be disproportionately and more vulnerable to pests and diseases.

- *On the impact of water pollution on aquaculture:* There are 11 in 15 survey communes suffer the water pollution impacts on aquaculture. The productivity and aquaculture production may decrease 10 to 40 percent compared with normal.

## 5. The results of gender in participation in decisions to harmonize water resources in Bac Hung Hai region

The reality in the Bac Hung Hai area showed that little gender issues are mentioned in the developed activities by the prejudices of gender discrimination that women are not esteemed as men in social, economic and political terms. The respondents said that taking water for paddy field and for living mainly undertaken by men because one part of taking water depends on the power (digging) needs the technique (matching the job for male). Besides, if there are any disputes or conflicts occur, the male is the head of handling. Many women said that they did not dare to go get water due to fear of being beaten. Some other women said that many women must also join taking water for paddy field, sometimes have to go get water at night and this work often time consuming and strenuous.

Table 19 - Pros and cons between men and women in taking water

| | Men | Women |
|---|---|---|
| **Advantages** | - There are strength, voice and the ability of dispute highly<br>- There are techniques to lead water by pipeline, can repair plumbing when damaged and can operate water pumps. | - Understand the level of water required for paddy fields, taking water enough, do not waste or missing water.<br>- Softly in disputes and negotiations. |
| **Disadvantages** | - There're tempered, prone to dispute and conflict.<br>- Do not understand the necessary water extent for farm. | - Lack of strength, engineering, no knowledge of machinery.<br>- Risk when taking water far away, bad weather, go at night. |

This is because some households have the production land at high paddy field, so difficult to get water from canals of commune. Majority of area at high paddy fields, people have used the pump for pumping water from irrigation channels, wells or ponds, natural pools. In the dry season, these areas are also shallow and so there is no water to irrigate crops, "entrust on nature". Also, to get irrigation water for agriculture, the farmers have to operate themselves the water pump or hire the pump for about 150-200 thousand dong per pole vault and they only dare to hire 1 time for 1 crop. Because if hired pumping several times, the cost will be very high and much higher than the amount collected. Some families have to perform watering manually like carrying water from the river to irrigate crops. The irrigation manually is done by both spouses.

Through community consultation activities (both men and women) showed that people want to be involved in the management and extraction of water resources and irrigation works when there were construction investment projects. The

households petition that since the design is necessary to ask the opinion of the people concerning the actual situation of water resources as well as the best way to exploit water effectively, to avoid the situation of the construction works does not promote the effect, causing waste of resources, interrupt and difficult for people in the exploitation of water resources.

Most people who attend public consultation agreed that water for agriculture needs to be improved more. The irrigation canal system needs to be upgraded and solidified to ensure the water is clean and full. The reclamation of canal system should be implemented "as soon as possible". At the same time they also want to have drainage ditch system for waste water types of living and livestock. The existing irrigation and drainage systems are combined into one, so be a difficulty in drainage, affecting the environment and health of people. Although the communities affected on the health and environment due to cannot drainage water, but women is considered more affected because they're at home more and working agricultural production more.

Women should be encouraged to participate in the exploitation of water sources because they are knowledgeable about the cultivated land and the water demand than men. However, their involvement seems less than men due to still affected by traditional gender stereotypes. Women themselves show a lack of confidence in participating in this activity. This is shown quite clearly even with the views of staff of the local Women's Union as well as women when asked. They said that the men should participate because of strength, technical knowledge and the ability to articulate and communicate better.

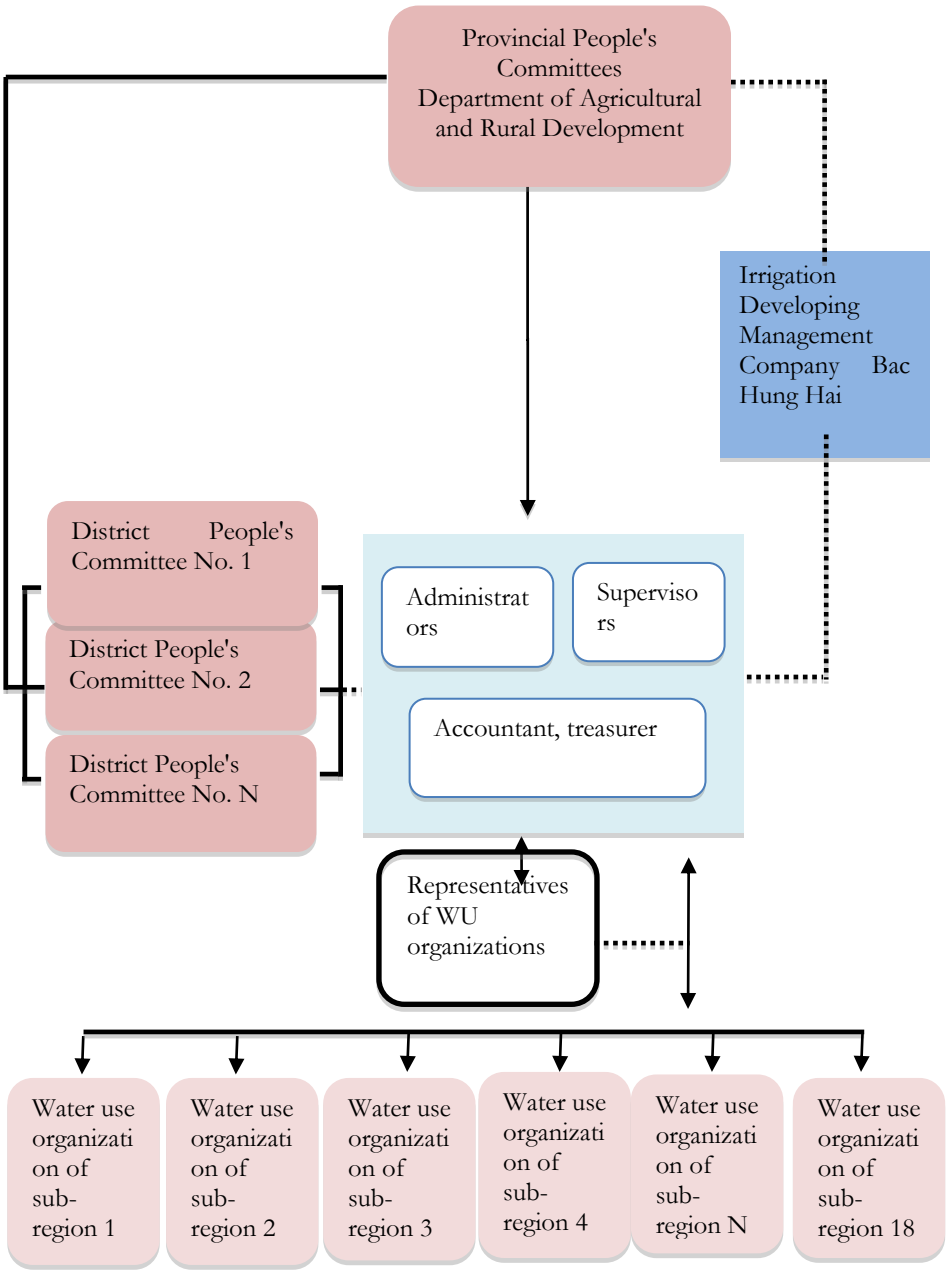
In terms of gender as mentioned above, due to the hard work, so most people engaged in irrigation and drainage were men. Especially the men also occupy majority of communal officials and company of irrigation management. Therefore, the decision in the work of irrigation and drainage are mainly from men, women have little voice or often give opinion through her husband. To enhance the participation of women, need to mitigate the heavy properties of the work by construction of works conveniently so that women can undertake the job. These are important suggestions for the development of gender action plans in order to propagate and disseminate information to raise awareness about the

role and position of women, and there are plans for training, retraining and capacity building of women in the activities of exploit water resources participatory of this group.

## 6. The results of the management model proposed to apply for Bac Hung Hai irrigation system

From the analysis of the advantages and disadvantages described above, this study aims to suggest a change process in which a number of functions of management, operation or maintenance of previously made by state agencies, today transferred to the management organization of the users. After being transferred, local or any organization that will have full responsibility and powers as well as interests in operation, management, maintenance and promote effective for assigned projects. If lack of water at the end of the system due to the above people use all, the solution to this problem is merge the water users at the top and end of systems together into a management organization, this organization will have responsible for all water users.

Figure 6 - The organizational chart proposed for Bac Hung Hai irrigation system



***Details related tothe management model for a water user organization:***

- *There are 18 water use organizations corresponding to 18 sub-regions as divided.*
- *Legal status of WUOs: There are seals, accounts, business registration license. There are rules and operational regulations, there are own headquarters.*
- *The scale and scope of operation: the water use organizations are in charge of managing entire inter-communal channels, the interior canals and culvert systems within their catchment. Also each organization appointed a representative to oversee mutual the neighboring basins.*
- *Organizational structure: There are 18 members of the representative board of water use organizations. Each water use organization has 6 members evenly distributed in each sub-region (including 3 males and 3 females).*
- *Operational characteristics of water use organization:*

*+ Operating and distribution of water in the large channel and the interior channel.*

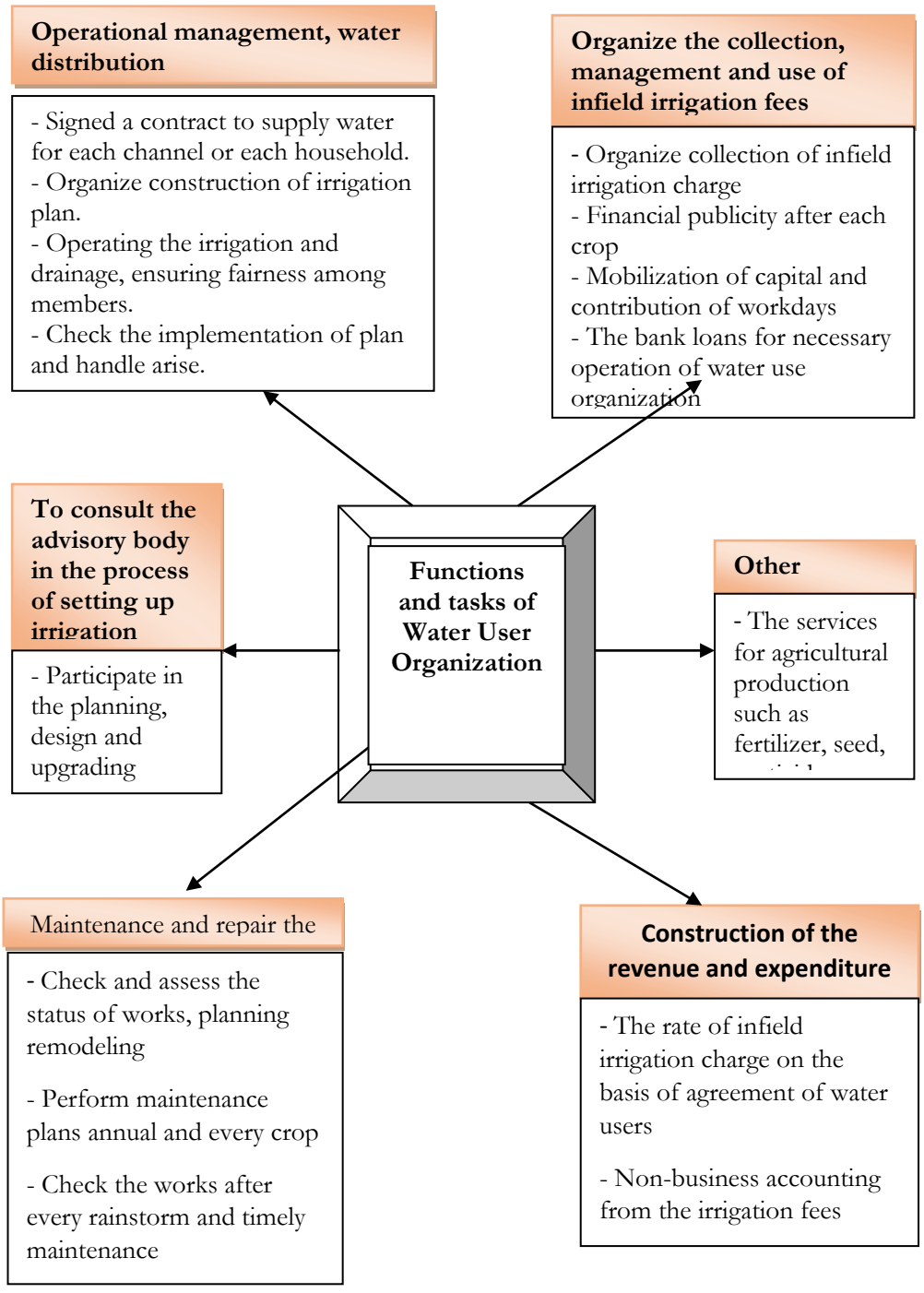
*+ Maintenance, repair and protection of works: carried out maintenance and protection of the channel and works on the channel. The Bac Hung Hai Company will repair the works only in case of any damage caused by the flood disaster, or have the large damage. For infield canals, the head of the water use organization will conduct maintenance and protection of the channel, the works on infield channel.*

- *Finance of water use organization:*

*+ Revenues: There are the shared irrigation charges of state subsidies to Bac Hung Hai Company (12% funding subsidies) and the infield irrigation charges get from water users (3 hundred thousand VND per hectare per crop).*

*+ Cost: the irrigation charge shared by state subsidy only spending for the management, operation, water distribution, regular repair and protection on the channel route (remuneration ratio: Company Bac Hung Hai 25%, water use organization 41%, regular repairs 26% and administrative expenses 8%). The infield irrigation charges used for management, operation, maintenance and regular repair of canals and the works on infield channel (cost ratio for water use organization is 71% and for maintenance is 29%).*

- *The management of irrigation schemes should be proposed in the form of co-operation of those who benefit from the irrigation works, duty to exploit and protect the works for productions and living in a certain locality. Namely to ensure the irrigation works especially communal and village level have actual managers to perform operation, maintenance and repair works aims to protect and promote well the works efficiency. Moreover the knowledge of farmers is increasingly raised and they will have the ability to manage projects if they are organized and trained appropriately. From there, the proposed water user organizations can ensure consistency and closely on management, do well the function of bridge between State enterprises exploiting irrigation works and the involved services to help farmer households use water efficiently.*


Operational management, water distribution
- Signed a contract to supply water for each channel or each household.
- Organize construction of irrigation plan.
- Operating the irrigation and drainage, ensuring fairness among members.
- Check the implementation of plan and handle arise.
Organize the collection, management and use of infield irrigation fees
- Organize collection of infield irrigation charge
- Financial publicity after each crop
- Mobilization of capital and contribution of workdays
- The bank loans for necessary operation of water use organization
To consult the advisory body in the process of setting up irrigation
- Participate in the planning, design and upgrading
Functions and tasks of Water User Organization
Other
- The services for agricultural production such as fertilizer, seed,
Maintenance and repair the
- Check and assess the status of works, planning remodeling
- Perform maintenance plans annual and every crop
- Check the works after every rainstorm and timely maintenance
Construction of the revenue and expenditure
- The rate of infield irrigation charge on the basis of agreement of water users
- Non-business accounting from the irrigation fees

## Discussion

According to calculations of population growth, the world annual increase of 90 million people, expected by 2020 will reach 8.1 billion people (World Population Prospects of the United Nations). In this level the developing countries accounted for 93%, of which Asia accounted for 60%. From the result of population growth led to food production of the world needs to double by 2020. Of the total more increased food to meet that population increase, there're 80% must be created from the area of agricultural land is irrigated. According to the Food and Agriculture Organization (FAO), which is only about 12% has no water stress condition. So the basic challenge for irrigated agriculture today is how to produce more food and increase income for farmers but uses amount of water lesser?

In the past in the world as well as in the region have a common status is the State guaranteed and met all requirements of irrigated areas including both construction investment and management cost. The management method based on this planed targets has created dependence and expectation of water users into the state. Especially since the late 70s of the 20th century, the program of development and expansion of irrigation systems on a large scale has revealed many weaknesses. The construction quality is not up to standards, the inefficient management method besides the difficult economic condition and the government began to cut subsidized financing have led to the result that where is the management not suitable, the works system are not be maintenance on demand and the irrigation efficiency is very low compared to the potential of the system. This situation was exacerbated when people are not involved in the operation and maintenance activities and involuntary paying the water service charge.

After a long period under the management of state agencies, many irrigation systems are not concerned repairing properly leads to the works seriously degraded, there are always phenomenon to wait state allocated funds for repair and maintenance works, so although enormous capital for repairs but irrigation efficiency increasingly diminished. About 60% of water for irrigation is lost

which is caused by the lax management (evaluation of FAO, 1990). The government budget for operation and maintenance of work systems is declining while this works often need large amounts of investment. The system by management of state agencies can't fully collect water fees from users lead to can't complete the plans laid out. The final result showed that efficiency serve of irrigation systems controlled by state enterprises is still low.

Comes from the management status of irrigation systems, the study aims proposed in the organizational management structure that the water user representatives and the state body representative together attend and keep important role in all aspects and all levels in irrigation management. Every aspect includes from planning, design, construction, operation and maintenance, financial contributions, set the rules, monitor and evaluate the operation of irrigation systems. This contributes to enhance responsibilities and powers of the people in management process, not only creates production capital (repairs and maintenance of the works better) but participatory irrigation management also creates social capital (the newly formed organization, the skills of leadership, ability attract the community activities, etc.). For water users, participatory irrigation management can bring a lot of benefits:

- When the people involved directly in the design process both the construction of new systems and system upgrade repaired, they will provide useful information for the design and understand the system that they will manage. During the construction process, the people participate in monitoring quality to ensure the design standard, cost savings through eliminating unnecessary expenditures, contributing labor, knowledge and experience to build. Also when understand about the system will more favorable to manage and fix later.
- The systems managed and operated by organizations of government often lack of funds for maintenance lead to the system degraded and the operation becomes difficult. Transferring management of most system for the people will help the managing irrigation organizations of government avoid this situation. Therefore, both the government and the people will benefit from the cost savings, people can get irrigation service

better and saving costs, the government lesser costly for management and likely cover to improve services for the main works. When the water users in the system must also be responsible for maintenance, they have the motivation of promptly repair, monitor the quality of work and protect the works against acts of infringement. When the people are owners actually of the works system, it means that maintenance costs is their own responsibility, they will have a very clear motive to protect the works and find solutions to reduce general expenses. When the people participate in management of systems, they will better understand the use of funds, means that the sense to pay for irrigation services they receive will also be enhanced.

- The unfair water supply make up the contradictions, because the users in downstream always get water lesser than in upstream. If the people know that in the coming period will continue to supply watering, the water use is normal, but if they know that it can take a longer time, they will get more irrigated water to limit risks caused by lack of water. When the farmers participate in decisions that affect them, a lot of trouble on water problem can be solved friendly and quickly. Even when one of parties did not achieve what they want, the participation in decision also makes them easy to accept the results. If the people see water shortage as the overall situation and will inevitably lead to the unfair distribution of water, they will restrict the use of water by using water lesser than needs.

## Conclusion

This study evaluated the impact of water usage is not harmonized between the sub-regions onto production and people life in Bac Hung Hai irrigation system. The results of this study showed that there are many inconsistencies in the management and distribution of water resources in a smaller scale in Bac Hung Hai system.

The impact analysis has proven that the management of Bac Hung Hai irrigation system under a state enterprise manages the whole have not been able to solve thoroughly the arising problems on water resources and irrigation works at the infield level. Under the management of the Irrigation and Drainage Management Company Bac Hung Hai, only the large sluices and main channels supplied from clue system are closely managed, but at a smaller scale, there also arises much problems. Some locations use excessive water than water demand is modeled as communes in two districts of An Thi and Van Giang (Hung Yen province). These districts controlled 3 large culverts upstream are Bao Dap, KenhCau, Luc Dien, so the water amount was abundant. Meanwhile, through simulation on water stress period in January and February, there were many areas of water shortage due to the inconsistent regime of water regulation through the sluices as Region 9, Region 10, Region 11, Region 12, Region 13, Region 14, Region 16. These regions are located in the downstream and depend heavily on water regulatory regime in the big drains above.

Parallel to that, the issue of wasted discharge directly into the canal system has not been closely monitored under the current management model. Through the statistic at 32 monitoring sites of water quality in the months of 2015 and 2016, the majority of positions are exceeding the allowed target for the parameters COD, NH4 +, NO2 -, Coliform. Thereby, there are many areas which are severely polluted water sources such as Gia Lam district (Hanoi city), Tu Son district (BacNinh province), Yen My district (Hung Yen province), Cam Giang district (Hai Duong province ), etc. This has led to a decline in productivity in agriculture and fisheries of many households in this area. At the same time it also increases the epidemic. According to statistics of the Centers for Health and

Population of communes were surveyed from 2012 to 2015, the rate of diseases has been increasing, especially women's gynecological disease led many people in these areas extremely indignant.

Therefore, the management model of irrigation system need to be adjusted in order to consider the shortcomings more detail and the people who use water directly have a legal status to raise voices in solving the problems that arise within the irrigation system, especially emphasized the participation of women. A new management model proposed in this study is the result of the consideration of issues on technical indicators and social factors, thereby to provide an insight on the infield issues of farmers.

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