# Water Management in The Chao Phraya River Basin during Drought Crisis

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## ABSTRACT

The objectives of this Research are to analyse the minimum quantity essential for utilisation in various activities, to evaluate the satisfaction out of government relief measures to help the farmers affected by water scarcity and to offer effective water management practices and relief measures for those affected during the crisis, through the study and analysis of the processes, types and characteristics of the national strategies and policies of Thailand's water management with focuses on clarity, specificity and capability in the transformation of relevant policies into practices. The Research has gathered secondary data on water resource development plan and water management, in addition to the information received from in-depth interviews with water management experts, responses of a questionnaire from 1,025 concerned government officials and farmers in all 13 provinces under the responsibility of the Regional Irrigation Offices 10, 11 and 12 by using statistical tools in an effort to obtain the results of the Research.

The results of the study show that the minimum quantity of water needed for various activities in the Chao Phraya River Basin is 18 million cubic metres a day, in terms of 7, 8 and 3 million cubic metres respectively for public consumption, ecological balance maintenance and agricultural purposes. Therefore, the study suggests that a total of 3,258 cubic metres of water budget should be reserved for overall utilisation during the dry season while an additional quantity of 1,098 cubic metres is reserved for any dry spell during May and June, totalling 4,356 cubic metres, as in 2017.

Regarding the relief measures for the farmers affected by water scarcity in 2015, the study found that the affected farmers were very satisfied

with the measures to allow debt payment delay or payment period extension for the farmers who owe to financial institutions, to increase water budget, to increase the efficiency of water utilisation and to create jobs in order to increase the income of affected farmers. Most of the interviewed farmers believed the problems and challenges in water management were due mainly to the lack of water reserves and water budget resources, efficient water management, cooperation from the general public and farmers and effective public relations. Meanwhile they also cited the cooperation from the farmers and general public in following government regulations and advice and the integrated efforts and cooperation among concerned government agencies as the most important factors in water management during the drought crisis. In addition, 93.46 percent of the farmers said they were fairly satisfied up to most satisfied with the water management of the Royal Irrigation Department during the drought crisis in 2015.

In order to achieve good practices in water management in the Chao Phraya River Basin during the drought crisis, the study found that there should be certain preparations in four major areas. For water management policies, there should be the review and amendment of all concerned regulations and laws in relation to the reliefs and aids for crisis affected farmers so that such reliefs and aids will be in harmony with the government operations in affected areas and rendered to the affected farmers promptly. For water budget management, the drought risk management system should be developed at national and provincial levels, with an integration of a national disaster related database and the development of appropriate tools and technology for water management with a focus on information exchange and cooperation among related groups of scientists. For water utilisation demand management, there should be an agricultural zoning to be in line with projected quantity of water in the future and a promotion of less water consuming plants of agricultural areas to replace dry season rice growing. Also, for knowledge creation, public participation and public relations, the knowledge on drought crisis and relief measures and related skills, as well as a learning mechanism in all possible dimensions of crisis management systems, should be promoted; the participation of government sector, private sector and public sector should be encouraged while crisis warning systems and public information accessibility should also be made with help from information technology and the efficient public relations on drought crisis should be conducted to promote the awareness and understanding among the general public for future adjustment and readiness in the time of crisis.

## Introduction

The water management in the Chao Phraya River Basin during the drought crisis in 2015 – 2016, which was the hardest hit in the past 50 years, has been considered as the good practice worth studying in an effort to obtain relevant knowledge on water management during a crisis and related conditions which enabled the Royal Irrigation Department to effectively handle the crisis.

## Background and Significance of Problems

Water is vital to the lives of people and also helps conserve the environment of the country. In the past, Thailand faced several severe droughts and floods, with a high tendency to become more and more severe in the future due to global warming and changing land utilisation pattern, which caused extreme economic damages to agricultural and industrial areas, as well as living communities in several parts of the country. In fact, Thailand has faced droughts almost every year and the severity of their adverse effects will be related to the overall water supply – the quantity of rainfalls, water budget in the irrigation system, inland water and underground water – the water demand of agricultural, household and industrial sectors and the efforts to balance the ecosystem which also include the operations to push back seawater out of the areas in the Chao Phraya River Basin, Mae Klong River Basin and Bang Pakong River Basin.

When considering the quantity of rainwater in Thailand, which has a mean annual rainfall of 1,455 millimetres, it is found that Thailand has about 732,975 million cubic metres of rain per year and approximately 29 percent of 213,303 million cubic metres will become surface water in various resources and the remaining 71 percent or 519,672 million cubic metres will become underground water after a part of the rainwater evaporates. During 2012-2015, the quantities of water budget in large and medium-sized water resources of the nation's irrigation system on November 1 each year were 55,268, 56,872, 48,329 and 43,838 million cubic metres respectively and then offered approximate quantities of 31,469, 33,069, 24,526 and 20,035 million cubic metres of usable water for a wide range of purposes during these years.

During the dry season in 2015, the water demand for various purposes was recorded at 13,299 million cubic metres as a total of 5,003 million cubic metres or 37 percent was needed for agriculture, 5,747 million cubic metres or 43 percent for ecosystem balance maintenance, 2,348 million cubic metres or 18 percent for public consumption and 201 million cubic metres or two percent for industrial and tourism sectors. Therefore, the figures clearly show that Thailand in 2015 had more than sufficient water supply, from surface water and underground water, more than the annual demand.

However, despite having the water supply more than the demand, the fact still remains

that many parts of Thailand have faced seasonal droughts again and again. One of the most important reasons is that those areas with droughts do not have water resources to store enough water to answer the increasing demand in such areas with significant growth. Thailand has a total of 149 million rai (238,400 square kilometres), of which 30 million rai (48,000 square kilometres) are in the areas covered by the country's irrigation system while the remaining 119 million rai (190,400 square kilometres), or 80 percent of the total agricultural area, are out of the irrigation system, so the water supply cannot reach these living communities and their agricultural areas.

Eventually, whenever there has been insufficient rain during September and October, the agricultural areas out of irrigation system would face water scarcity and if there has been a dry spell since June or July, most agricultural produces would be severely affected as most plants cannot grow as they should and can only give very low amount of crops or no crops for harvesting, resulting in huge losses among the farmers and agriculturists who would have no savings for the season and might have to use their existing savings for consumption and preparation for the next growing season. For those with little or no savings, they might need to borrow some money from any available source of fund and as a result, become in debt, which would affect overall economic and social aspects of the country as well. This is one of the significant reasons why the country's water management to provide sufficient water for farmers and living communities for their efficient utilisation is so vital.

One of the past efforts in water management which is worth gathering and analysing all relevant information and thoroughly studying in order to use as a lesson for future policy and operational recommendations is the water management in the Chao Phraya River Basin in 2015 when a drought crisis occurred. From the recorded quantity of water budget in the river basin on November 1, 2015, the usable water reserved in the Bhumibol Dam for the following dry season was 1,184 million cubic metres, which was the lowest in 53 years, while the reserved water in Sirikit Dam was 2,056 million cubic metres, the lowest in 20 years, in Kwae Noi Bamrung Daen Dam 370 million cubic metres, the lowest in 6 years since its inception and in Pa Sak Cholasit Dam 637 million cubic metres, also the lowest in 17 years since its inception. In summary, the total quantity of usable water in the four major dams in the Chao Phraya River Basin in 2015 was 4,247 million cubic metres which was 2,530 million cubic metres less than the total quantity in the previous year.

From the statistics during the past five decades, Thailand had drought crises in 1967, 1968, 1972, 1977, 1979, 1986, 1987, 1990, 1994, 1999, 2002 and 2005, resulting in adverse effects on the income of the farmers and the country's overall economy, especially the agricultural and the agro-industrial sectors. Among these

occurrences, the crises in 1979, 1994 and 1999 were the most severe ones as the droughts occurred in several huge areas in almost every region of the country and repeatedly affected the previous areas of drought crisis, mainly due to little rain during the rainy season and unseasonal rains. Meanwhile, the drought risk areas were found to be in relation to their individual terrains, soil conditions and quantity of rainfalls; the highest risk areas were those with less than 1,000 millimetres of rain, soil with poor water holding capacity and the lack of reservoirs.

In addition to the above-mentioned drought crises, the statistics of the Meteorological Department showed that in 2015, when the latest drought crisis occurred, the rainy season completely ended at the end of October and Thailand unfortunately faced with the effects from the El Nino phenomenon until the beginning of 2016 before receding. When considering the quantity of water budget for the dry season in 2016, it was quite critical, so the water management during the period from November 2015 to April 2016 required not only the knowledge of water management and irrigation engineering but also the cooperation from all concerned parties in order that the management of the available water budget would be efficient and in line with the water management plans and could help solve all the problems during the drought crisis. Therefore, it was a very important lesson on how the water management during the drought crisis in 2015-2016 was successful and there should be a thorough study and analysis in an effort to gather all useful information to be used as recommendations for mapping out related policies and operational guidelines in the future.

**Objectives of Research**

1. To study the water management in the Chao Phraya River Basin during the drought crisis in 2015-2016.

2. To evaluate the satisfaction with the relief measures for drought affected farmers.

3. To give recommendations on the water management during drought crisis and the effective relief measures for affected groups of people.

**Scope of Research**

The Research was focused on the drought crisis in the Chao Phraya River Basin during the final months of 2015 to the beginning of 2016, especially on the adverse effects on the agricultural sector and the drought relief operations through eight measures of the Ministry of Agriculture and Cooperatives to lessen the economic and social problems among the farmers.

**Research Method**

The Research included both qualitative and quantitative aspects of the studies, from analysing the process, styles and characteristics of the National Strategy and the existing water management policies of Thailand with focuses

on the clarity, specificity and the capability to transform related policies into practices within limited contents and timeframes, interviewing experts in water management, organising group discussions among water management experts and conducting questionnaire interviews with government officials and farmers to find out preferable operational practices and relief measures to lessen the economic and social impacts during the time of drought crisis in order to have a clearer picture on how to have the most feasible policies and practices for water management during the time of a drought crisis.

**Research Limitation**

The Research has used the information obtained from focus group discussions and the questionnaire interviews to sound out the opinions of two concerned groups of people as part of the efforts to analyse the effectiveness of the water management during the drought crisis. The two groups of interviewees were the government officials of the Royal Irrigation Department and the farmers who had been directly affected by the drought crisis and since there were three regional offices of the department – namely, Regional Irrigation Office 10 (Lop Buri Province), Regional Irrigation Office 11 (Nonthaburi Province) and Regional Irrigation Office 12 (Chai Nat Province) – which played the key role in handling the water management in the Chao Phraya River Basin during the drought crisis, the interviewed government officials were from these three regional offices while the interviewed farmers were from the affected areas under the responsibility of these three regional offices as well.

**Research Benefits**

1. The results of this Research are expected to directly benefit the planners, policy makers and implementers of irrigation water management, especially in the situation that there will be limited or critical quantity of water budget.

2. The policy makers and the implementers can use the useful information for planning and preparing appropriate water distribution systems for the country.

3. The policy makers, at the Ministry of Agriculture and Cooperatives, on the relief measures for drought affected farmers can decide and choose the measures which can effectively answer the needs of the affected farmers and attain their best satisfaction.

4. The ministry's policy makers will be able to identify which one of the eight relief measures for affected farmers, aimed at lessening the economic and social effects from the drought crisis, will actually yield the best results.

**Research Procedure**

The Research on "Water Management in the Chao Phraya River Basin during the Drought Crisis" comprises the study on how Thailand handled its drought crisis, with a focus on the minimum quantity of water budget for various

purposes, including public consumption, ecosystem conservation and continuing agriculture and also the evaluation of the satisfaction with relief measures among the farmers faced with water scarcity during the drought crisis in order to summarise as operational guidelines for water management during the time of crisis and effective relief measures for those affected by the drought crisis. The first part of this Research is to analyse and determine the minimum quantity of water budget to sufficiently serve various purposes during the dry season from the statistics on water utilisation, water quantity and number of water consuming population while the second part to evaluate, the satisfaction from drought relief measures by means of questionnaire interviews to gather both primary and secondary data for analysis to serve the Research objectives.

1. Data Gathering

There were two types of data gathered for this Research as follows:

1.1 Secondary Data

The secondary data for this Research contains a variety of information on drought crises and drought crisis management, collected from the official documents of several government agencies, concerned academic papers and reports, previous researches, articles and other resources from the Internet. This type of data also includes related laws and regulations and the operational guidelines of concerned government agencies during the time of drought crisis.

1.2 Primary Data

The primary data meanwhile was obtained during the field survey via questionnaire interviews as there were two groups of interviewees -- the concerned government officials in water management for the dry season in 2015-6 and the farmers affected by the drought crisis in the Chao Phraya River Basin.

1.2.1 Population and sample groups

The population and sample groups were:

1) Those in the government agencies directly involved in handling the drought crisis The question interviews were conducted and the information was gathered from the answers of a total of 259 officials of Regional Irrigation Office 10, Regional Irrigation Office 11 and Regional Irrigation Office 12 in order to get the information on water management during the time of crisis, as well as on the relief measures to lessen economic and social effects during the crisis, to find out in time and clear operations which could be used in mapping out future guidelines for effective water management operations and drought relief measures.

2) Those affected farmers in three focused areas of the Chao Phraya River Basin The interviews with the farmers who had been affected by the drought crisis during the 2015-6

Table 1: Proportion of Samples in Different Irrigation Areas

| Regional Irrigation Office | Number of Population Affected by Drought Crisis (household)1/ | Proportion (percentage) | Number of Samples in the Study (A total of 600 respondents) |
|---|---|---|---|
| Regional Irrigation Office 10 | 75,200 | 31.40 | 189 |
| Regional Irrigation Office 11 | 81,157 | 33.88 | 203 |
| Regional Irrigation Office 12 | 83,176 | 34.72 | 208 |
| TOTAL | 239,533 | 100.00 | 600 |

SOURCE: 1/ Department of Disaster Prevention and Mitigation, Ministry of Interior, 2014

dry season, also in the responsible areas of Regional Irrigation Office 10, Regional Irrigation Office 11 and Regional Irrigation Office 12. The number of the interviewed farmers in each irrigation areas was however based on the percentage of households affected by the drought crisis in 2014, recorded by Ministry of Interior's Department of Disaster Prevention and Mitigation as 31.40, 33.88 and 34.72 percent respectively in the three irrigation areas (shown in Table 1).

Then, the samples out of the total population in the three irrigation areas were determined by means of quota sampling as previously used in respectively responsible areas of the Regional Irrigation Offices 10, 11 and 12 respectively for the questionnaire interviews.

1.2.2 The tool for data collection

The questionnaire was used as the data collection instrument in this Research. The questionnaires, for the farmers who had been affected by the drought crisis in the Chao Phraya River Basin, comprised three parts:

(1) General information about the respondents;

(2) The opinions of the respondents about the relief operations, in accordance with an integrated plan initiated by the Ministry of Agriculture and Cooperatives, to aid the farmers whom had been affected by the drought crisis in 2015-6 and

(3) The opinions of the respondents about the problems and challenges of water management for the dry season in 2015-6.

2. Data Analysis

2.1 Quantitative Data

The quantitative data obtained from the survey was analysed with help from SPSS (Statistical Package for the Social Sciences) software as follows:

2.1.1 The analysis of the general information of the sample groups, such as sex, age and education, for government officials, the

number of years in civil service, types of official positions and levels of civil servants, used frequency distribution, percentage and means to describe the general characteristics of the sample groups.

2.1.2 For the analysis of the opinions on the relief operations, in accordance with an integrated plan initiated by the Ministry of Agriculture and Cooperatives, to aid the farmers who had been affected by the drought crisis in 2015-6, the second part of the questionnaires were used to sound out the satisfaction among the affected farmers as the levels of satisfaction were classified into "Least Satisfied", "Little Satisfied", "Fairly Satisfied", "Very Satisfied" and "Most Satisfied", numbering 1 to 5 as an interval scale respectively. From the number of points of satisfaction, class intervals were then determined, with the following class limits:

Level of Least Satisfied = 1.00 - 1.80
Level of Little Satisfied = 1.81 - 2.60
Level of Fairly Satisfied = 2.61 - 3.40
Level of Very Satisfied = 3.41 - 4.20
Level of Most Satisfied = 4.21 - 5.00

2.2 Qualitative Data

The analysis of the answers to the third part of the questionnaires, regarding the opinions on the problems and challenges of water management for the dry season in 2015-6, was made and the results of the survey were summarised and discussed as will be presented in the following part of this Research.

**Research Results**

This Research had used the scientific and technological questionnaires, in accordance with the curriculum of the National Defence College, Batch #59, entitled the "Water Management in Chao Phraya River Basin during the Drought Crisis", to collect all essential data. The Researcher then divided the survey respondents into two groups of population – government officials and farmers – in order to find out the opinions of the government officials who were the implementers of concerned government policies and the farmers who were affected by the government policies during the drought crisis. The research area was focused on the lower part of the Chao Phraya River Basin under the responsibilities of the Regional Irrigation Offices 10, 11 and 12 (as shown in Diagram 1) which covered a total of 43 provincial irrigation projects and water supply and maintenance projects. An approximation of 20-25 samples was chosen in each of the irrigation projects, with 65-70 percent that were farmers significantly emphasised for the response while 30-35 percent were the government officials. From the inspection of all responded questionnaires, there were a total of 1,025 answered questionnaires eligible for further data interpretation, 659 responses or 64.3 percent from the farmers and 366 responses or 35.7 percent from the government officials; as the outcome and description are as follows:

**The Analysis to Determine Minimum Water Quantity Essential for Various Activities**

The water management in the Chao Phraya River Basin during the drought crisis of the 2015/2016 began from the dry season in 2015 which fell in November and December and then covered the first four months – January, February, March and April – of 2016, during which was considered to be the most critical drought period in 40 years.

Although Thailand has been considered as one of the countries with a good average rainfall, with the mean annual rainfall of more than 1,400 millimetres or having more than 730,000 million cubic metres of rain per year, only about 29 percent or 210,000 million cubic metres of the rainwater flows into rivers, canals and other sources of surface water as the rest evaporates or becomes underground water. Unfortunately, several sizes of dams in Thailand can only store about 84,000 million cubic metres only or 40 percent of all surface water as the rest or 60 percent of the water in rivers and canals flows directly into the sea.

As usual, the quantity of water budget or the quantity of water which would be taken into account for distribution for various purposes during the dry season in 2015/2016 in the Chao Phraya River Basin was stored in four main dams – the Bhumibol Dam, Sirikit Dam, Kwae Noi Bamrung Daen and the Pa Sak Cholasit Dam – at the end of October 2015. Out of the quantity of the water in these dams, the quantity of usable water for various activities was calculated in order that the water distribution could be made fairly and effectively for different purposes as follows:

Water for Public Consumption

The analysis of a minimum quantity of water for public consumption is based on the number of population during the period from 2013 to 2016 and the annual increase in population, and when the population in 2027 and 2047 were determined the future demand of water for public consumption could then be forecast by using exponential smoothing models. After that, the future demand of water for public consumption was calculated by the number of population multiplied by the number of daily consumption of 250 litres per head, as shown in Table 2 and the forecast demand in 2027 and 2047 would then be approximately 5.5 and 6.7 million cubic metres respectively. Therefore, the water demand for public consumption has been earmarked at 7 million cubic metres.

Conservation of Ecosystem

The minimum quantity for conservation of the ecosystem was determined by the results of the water management during the dry season in 2014-2016, as shown in Diagram 2 in terms of the correlation between salinity values of the water at Sam Lae water pumping station (in Pathum Thani Province) and flow rates of the water at the C29 gauge station in Bang Sai District (of Ayutthaya Province). The salinity values of the water at Sam Lae water pumping

Diagram 1 Responsible Areas of Different Regional Irrigation Offices

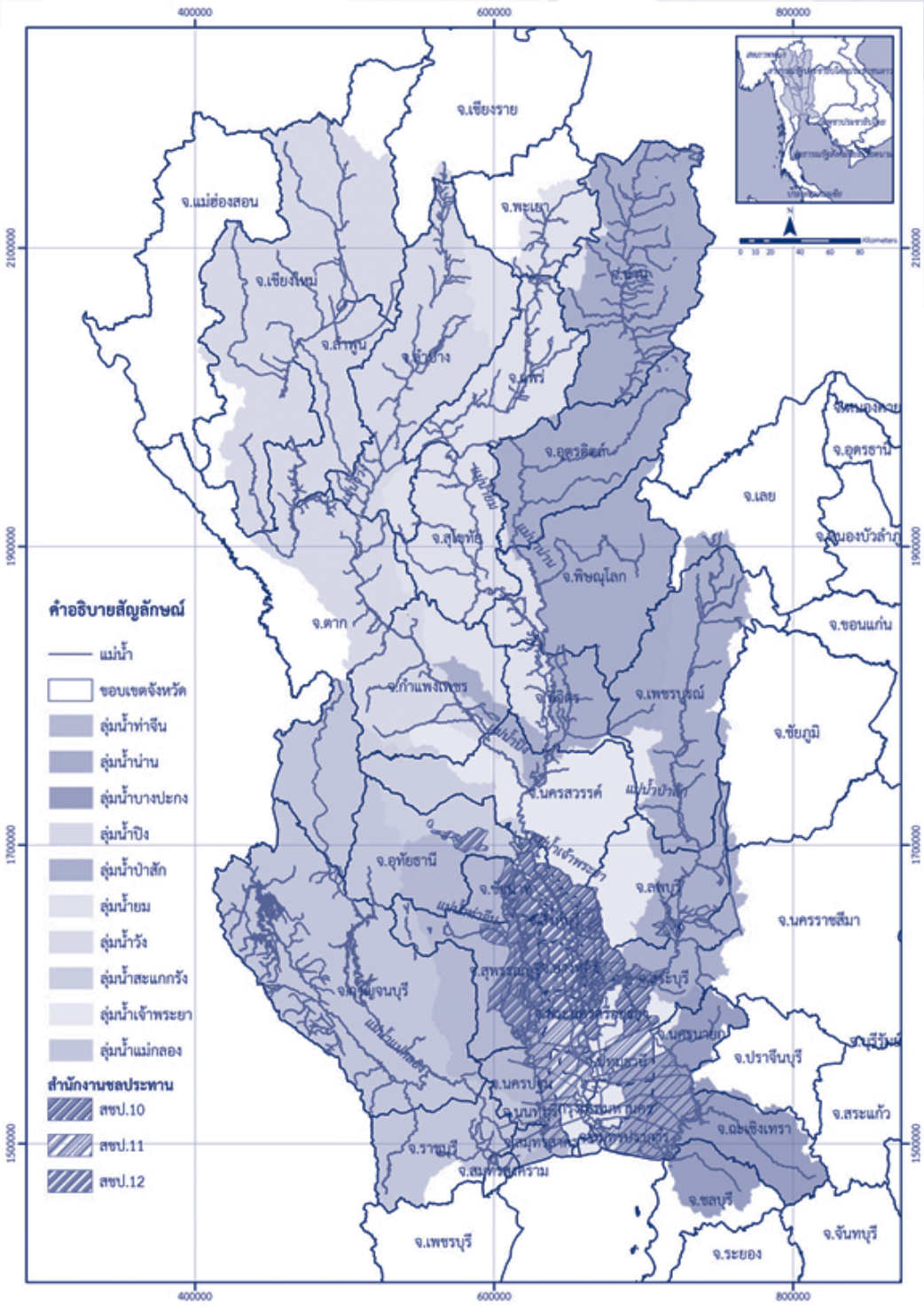

Table 2 Demand of Water for Public Consumption in Chao Phraya River Basin

| No. | Province | Population | | | Rate of Water Consumption (cu.m./day) | Projected Rate of Water Consumption (cu.m./day) | |
|---|---|---|---|---|---|---|---|
| | | Male | Female | Total | 2015 | 2027 | 2047 |
| 1 | Bangkok | 2,695,051 | 3,001,358 | 5,696,409 | 1,424,102.25 | 1,422,034.69 | 1,422,713.47 |
| 2 | Phrae | 219,342 | 233,004 | 452,346 | 113,086.50 | 106,905.09 | 97,510.54 |
| 3 | Kamphaeng Phet | 362,340 | 367,818 | 730,158 | 182,539.50 | 183,224.02 | 184,758.49 |
| 4 | Chachoengsao | 343,846 | 357,056 | 700,902 | 175,225.50 | 189,775.32 | 217,418.29 |
| 5 | Chainat | 159,876 | 171,779 | 331,655 | 82,913.75 | 80,502.36 | 76,810.89 |
| 6 | Tak | 313,179 | 305,203 | 618,382 | 154,595.50 | 307,468.50 | 1,031,715.35 |
| 7 | Nakhon Sawan | 524,682 | 547,260 | 1,071,942 | 267,985.50 | 260,585.53 | 249,972.17 |
| 8 | Nonthaburi | 559,119 | 634,592 | 1,193,711 | 298,427.75 | 360,465.89 | 494,360.51 |
| 9 | Nan | 241,282 | 238,236 | 479,518 | 119,879.50 | 121,835.85 | 125,285.87 |
| 10 | Pathum Thani | 519,952 | 574,297 | 1,094,249 | 273,562.25 | 339,048.80 | 486,927.59 |
| 11 | Ayutthaya | 389,474 | 418,886 | 808,360 | 202,090.00 | 214,350.82 | 237,532.26 |
| 12 | Phichit | 267,318 | 278,639 | 545,957 | 136,489.25 | 131,065.13 | 122,759.29 |
| 13 | Phitsanulok | 423,089 | 440,315 | 863,404 | 215,851.00 | 225,280.65 | 242,290.51 |
| 14 | Lopburi | 380,523 | 378,132 | 758,655 | 189,663.75 | 188,737.74 | 187,665.21 |
| 15 | Lampang | 369,033 | 383,323 | 752,356 | 188,089.00 | 181,812.71 | 172,390.78 |
| 16 | Samut Prakan | 613,778 | 665,532 | 1,279,310 | 319,827.50 | 376,222.50 | 495,377.90 |
| 17 | Saraburi | 315,057 | 322,616 | 637,673 | 159,418.25 | 170,399.73 | 191,035.47 |
| 18 | Sing Buri | 100,849 | 110,577 | 211,426 | 52,856.50 | 50,767.37 | 47,520.11 |
| 19 | Sukhothai | 293,158 | 308,554 | 601,712 | 150,428.00 | 147,806.48 | 143,799.43 |
| 20 | Suphan Buri | 411,295 | 438,404 | 849,699 | 212,424.75 | 212,603.08 | 213,444.43 |
| 21 | Ang Thong | 135,907 | 147,266 | 283,173 | 70,793.25 | 69,398.14 | 67,263.37 |
| 22 | Uttaradit | 225,805 | 233,963 | 459,768 | 114,942.00 | 112,023.68 | 107,573.53 |
| 23 | Uthai Thani | 162,559 | 168,347 | 330,906 | 82,726.50 | 83,279.79 | 84,577.13 |
| **Total** | | **10,026,514** | **10,725,157** | **20,751,671** | **5,187,917.75** | **5,535,593.85** | **6,700,702.58** |
| **Minimum Quantity** | | | | | | | **7,000,000** |

station in 2014 and 2016 were above the standard value of 0.25 grams per litre during March and April; but when the rate of water discharge from the Chao Phraya Dam (in Chai Nat Province) was adjusted to 90 cubic metres a second or 8 million cubic metres a day, the salinity values were effectively put under control, which such measure were in line with a study how to solve the problem of water scarcity in the Chao Phraya River Basin, conducted by Thanom Khlaikhayai and Wirat Khaouppatham in 1994.

Continuing Agriculture

For the minimum quantity for several activities of continuing agriculture – growing vegetables, fruit plants, field crop and fish farming, the statistics on the Royal Irrigation Department's water distribution for the farmers during the drought crisis in 2015 had been studied closely and found that the water supply was not sufficient for all activities, especially for off-season rice growing which would usually need a large quantity of water. Therefore, the water supply for the off-season rice growing activity had to be ceased during the dry season.

However, in the following dry season of 2015/2016 (during the period from November 2015 to April 2016), there was an effort to support the continuing agricultural activities in a total area of 700,000 rai (1,120 square kilometres) in the Chao Phraya River Basin which needs approximately 3 million cubic metres a day.

Thus, for the good practices of water distribution, it is necessary to consider both the demand for minimum quantity for different purposes, namely for public consumption, conservation of the ecosystem and continuing agriculture and the appropriate control of water discharge to be in accordance with the plans which had been calculated to be approximately 18 million cubic metres a day as it would be sufficient for the utilisation up to the end of July 2016.

**Analysis of Proportional Characteristics of the Sample Groups**

From the study of a total of 1,025 eligible questionnaires, the general information was summarised, as shown in Table 3 as follows: There were a total of 366 government officials who responded to the questionnaires, equal to 36 percent of all samples and a total of 659 farmers or 64 percent of all samples. Based on each irrigation area, a total of 369 government officials and farmers or 36 percent of all samples were in the responsibility areas of the Regional Irrigation Office 10 while 271 government officials and farmers or 26 percent in Regional Irrigation Office 11 and 385 officials and farmers or 38 percent in Regional Irrigation Office 12. For the government officials, 38 percent of them were under Regional Irrigation Office 10 while 26 percent were under Regional Irrigation Office 11 and 36 percent under Regional Irrigation Office 12. For the farmers, 35, 27 and 38 percent of them were in the responsible areas of Regional Irrigation Offices 10, 11 and 12

Table 3: Professions of Sample Groups

| Profession | Regional Irrigation Office | | | Total |
|---|---|---|---|---|
| | 10 | 11 | 12 | |
| Government officials | 138 | 95 | 133 | 366 |
| Farmers | 231 | 176 | 252 | 659 |
| **Total** | **369** | **271** | **385** | **1,025** |

respectively.

A total of 667 questionnaire respondents, or 65 percent of all respondents, were male while the remaining 358 respondents or 35 percent, were female. Most of the respondents were at the ages of 41-60, which are the age groups of Thailand's working and family caring population. Regarding the gender of the majority of the respondents who were male, it is in line with the fact that Thai society, especially in rural areas, considers a man as the head of the family. Therefore, all the samples for this survey were presumed to well represent the decision making group of the population in the Chao Phraya River Basin and eligible to answer the relevant questions.

On the education background of the samples, a total of 334 respondents, or 33 percent of all respondents, completed primary school education while 278 respondents, or 27 percent, completed bachelor's degrees.

On the 366 respondents on the government official side, 32.79 percent of them were in the second level of operational staff (02) and 18.03 percent were in the level of senior operational staff (03), who were working in the operation fields and having direct contact with the farmers so these groups of samples would be able to know the genuine results of all operations in regard to the policies of both the Royal Irrigation Department and the Ministry of Agriculture and Cooperatives. The rest were in other levels of staff of all three Regional Irrigation Offices, about 13-18 percent per level. On the number of years in service of these respondents, about 30 percent of them were in the range of 21-30 years while the rest in other ranges of years in service were between 22-24 percent. The information on the numbers of years in service, which were quite well distributed, out of this survey was considered to be able to yield significant results of the Research.

For the proportion between the respondents within the Chao Phraya River Basin and those out of the basin, there were 72 percent of the respondents working or living within the river basin while the remaining 28 percent were out of the river basin but the majority of the latter group was in Mae Klong river basin of which the irrigation system was connected with that of the Chao Phraya River Basin and had

significant effects on the water management in the Chao Phraya River Basin. However, more than 70 percent of both the government officials and the farmers responding to the questionnaires were within the Chao Phraya River Basin so their responses could effectively yield the relevant results of the survey. Although this Research was focused on the water management in the Chao Phraya River Basin, policy makers should not ignore the impacts on and from the adjacent river basins, especially the Mae Klong river basin which also played a part in water diversion for effectively integrated water management in the Chao Phraya River Basin during the past drought crisis.

Regarding the water for public consumption during the crisis, it was found that there was a total of 152 respondents, or 14.83 percent of all respondents, having inadequate water for consumption during the crisis while the rest of 873 respondents, or 85.17 percent of all respondents, did not have such problems. On the farmer's side, the respondents who were the farmers within irrigation systems did not have any problem with water scarcity while a total of 38 farmer respondents or 5.77 percent of all farmer respondents, who were outside of the irrigation system did not have adequate water for consumption during the crisis.

**Analysis of the Causes of the Drought Crisis in 2015/2016**

On the causes of the drought crisis in 2015/2016 (Table 4), the survey found that the biggest portion of the samples, or 31.9 percent of the respondents, cited the higher water demand among relevant sectors (for consumption, agriculture and industry) was the main cause of the drought while 25.8 and 23.7 percent of the samples respectively opined that the lack of water reservoirs and the climate variation and change were the main causes of the drought.

Based on the profession of the samples, a total of 113 respondents in government sector, or 11 percent of all respondents, believed climate variation and change was the main cause of the drought, with a fewer number of fellow government officials pointed to the higher water demand among relevant sectors (for consumption, agriculture and industry) and the lack of water reservoirs to store water respectively. On the other hand, a total of 218 farmer respondents, or 21.3 percent of all respondents, believed the main cause of the drought crisis in 2015/2016 was the higher water demand among relevant sectors (for consumption, agriculture and industry) while a fewer number of fellow farmers separately cited the lack of water reservoirs and the climate variation and change.

When considering the fact about the water demand in Thailand, the demand has increased continuously. In addition to the higher demand from a growing number of population, the agricultural sector, which usually consumes approximately 70 percent of the water supply, seems to need more water for their activities

Table 4: Opinions on the most important cause of the drought crisis in 2015/16

| No. | Cause of the drought crisis in 2015/16 | Government officials | | Farmers | | TOTAL | |
|---|---|---|---|---|---|---|---|
| | | Number | % | Number | % | Number | % |
| 1 | Lack of sufficient water reservoirs | 83 | 8.1 | 181 | 17.7 | 264 | 25.8 |
| 2 | Climate variation and change | 113 | 11 | 130 | 12.7 | 243 | 23.7 |
| 3 | Change in land utilisation patterns, such as from forest areas to urban areas | 47 | 4.59 | 67 | 6.54 | 114 | 11.1 |
| 4 | Higher water demand among relevant sectors (for consumption, agriculture and industry) | 109 | 10.6 | 218 | 21.3 | 327 | 31.9 |
| 5 | No opinion / not know | 14 | 1.37 | 63 | 6.15 | 77 | 7.51 |
| Total | | 366 | | 659 | | 1,025 | 100 |

each year, especially the farmers who would like to grow rice throughout the year. The desire among the farmers has been clearly reflected when the Royal Irrigation Department announced the seasonal rice cultivation zone, based on the quantity of water reserved for agriculture, the total rice growing area would always be almost two times the announced zone. Therefore, what really happened was that some farmers would have to try to take away the water which had been reserved for public consumption and the ecosystem balance maintenance into their rice field, resulting in water scarcity in some other areas. In addition, there has also been some significantly higher demand from the industrial sector during the past years, especially in the growing tourism industry.

From the survey, more than 25 percent of all respondents agreed that there were still insufficient water reservoirs and their opinions were in line with the policies of the government and the Royal Irrigation Department in an effort to build more reservoirs wherever possible. Since the development of large reservoirs had become more and more difficult lately, the Royal Irrigation Department was determined to build small and medium sized reservoirs and has since May 2014 developed more reservoirs to increase the amount of water budget by 400 million cubic metres.

One of the interesting points from the survey was that a total of nearly 24 percent of all the respondents realised that climate variation and change had become a major cause of the drought crisis as they had experienced during the dry season of 2015/2016, which turned out to be the most severe crisis during the past 30 years in Thailand. Therefore, the water management in preparation for future crisis prevention and relief, while the crisis can occur

more often and become more severe, is the most essential. Meanwhile, public education on the impacts of climate variation and change should also be encouraged by the government in order to establish the awareness among the farmers and the public in general so that they all can help prevent any unforeseeable dangers when there is a drought crisis in the future.

As far as the gender of the respondents is concerned, there was no difference in the opinions on the main cause of the drought crisis as both genders similarly cited the higher demand of water as the biggest threat. However, the male respondents believed the climate variation and change was the second main cause while the female respondents pointed to the lack of water reservoirs. For different groups of age, most respondents in all age groups saw the higher demand of water in all three sectors was the main cause of the crisis.

On the contrary, educational background seemed to have clearly affected the opinions of the respondents as most respondents with primary school background pointed out that the higher demand of water was the main cause of the drought crisis while most of those with secondary school background saw the lack of water reservoirs as the main cause and most of those with bachelor's degrees believed the climate variation and change played the most significant role in the crisis.

**Important Factors on the Water Management during the Drought Crisis in 2015/2016**

From the survey on the important factors on the water management during the drought crisis in 2015/2016 (Table 5), almost 60 percent of all respondents agreed that the cooperation from the farmers and the public in following the regulations and recommendations from all concerned government agencies responsible for handling the drought crisis was the most important factor while two small portions of the respondents also praised the cooperation among concerned government agencies and modern equipment and technology respectively for the successful water management during the crisis.

Both the government officials and the farmers agreed with the importance of the above factor as 24.9 percent of all respondents who were in the government sector and 59.6 percent of all respondents who were the farmers agreed that the cooperation from the farmers and the public was the most important factor for the water management during the time of crisis.

As a result, this Research has pinpointed, from the opinions of the government officials and the farmers during the survey that if the government can successfully persuade the farmers and the public to follow the recommendations of the government sector, the problems of drought crisis can then be solved. In addition, the cooperation among all concerned government agencies, especially the Ministry of Agriculture and Cooperatives and the Ministry of Interior, to jointly solve the problems

Table 5: Important factors on the water management during the drought crisis in 2015/2016

| No. | Important factors | Government officials | | Farmers | | TOTAL | |
|---|---|---|---|---|---|---|---|
| | | Number | % | Number | % | Number | % |
| 1 | Knowledge and expertise of government officials | 14 | 1.37 | 55 | 5.37 | 69 | 6.73 |
| 2 | Modern equipment and technology | 22 | 2.15 | 53 | 5.17 | 75 | 7.32 |
| 3 | The cooperation from the farmers and the public in following the regulations and recommendations from all concerned government agencies | 255 | 24.9 | 356 | 34.7 | 611 | 59.6 |
| 4 | Cooperation among concerned government agencies | 58 | 5.66 | 121 | 11.8 | 179 | 17.5 |
| 5 | No opinion / not know | 17 | 1.66 | 74 | 7.22 | 91 | 8.88 |
| Total | | 366 | | 659 | | 1,025 | 100 |

during the past drought crisis, with the help from the military units which had stepped in to help control the distribution of water to be fairly made for different groups of consumers and users as planned by the Royal Irrigation Department.

**Analysis of the Impacts of the Drought Crisis and the Satisfaction with the Water Management of the Royal Irrigation Department during the Drought Crisis in 2015/2016**

From the survey on the impacts of the drought crisis in 2015/2016 (Table 6), a total of 47.61 percent of all respondents said they had been fairly affected by the drought crisis in 2015/2016 as 17.17 percent were government officials and 30.44 percent were farmers.

For the satisfaction with the water management by the Royal Irrigation Department during the crisis (Table 7), a total of 49 percent of all respondents were fairly satisfied with the department's efforts as 13 percent were government officials and 36 percent were farmers.

In an effort to find out if the personal characteristics of the samples, such as age, gender, education and so on, would affect the satisfaction with the water management of the Royal Irrigation Department during the drought crisis in 2015/2016, the Researcher adopted T-test and F-test for the observance of sample distribution.

From the analysis of the satisfaction with the water management of the Royal Irrigation Department, it was found that the professions of the two groups of samples – the government

Table 6: The impacts of the drought crisis in 2015/2016

| Topic | Profession | | Levels of the impacts of the drought crisis | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 | TOTAL |
| The impacts of the drought crisis in 2015/2016 | Government officials | Number | 19 | 50 | 176 | 101 | 20 | 366 |
| | | % | 1.85 | 4.88 | 17.17 | 9.85 | 1.95 | |
| | Farmers | Number | 9 | 59 | 312 | 207 | 72 | 659 |
| | | % | 0.88 | 5.76 | 30.44 | 20.20 | 7.02 | |
| | TOTAL | Number | 28 | 109 | 488 | 308 | 92 | 1,025 |
| | | % | 2.73 | 10.63 | 47.61 | 30.05 | 8.98 | |

Table 7: The satisfaction with the water management by the Royal Irrigation Department during the drought crisis in 2015/16

| Topic | Profession | | Levels of the satisfaction with the water management by the Royal Irrigation Department during the crisis | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 | TOTAL |
| The satisfaction with the water management by the Royal Irrigation Department during the drought crisis in 2015/16 | Government officials | Number | 2 | 16 | 137 | 177 | 34 | 366 |
| | | % | 0.20 | 1.56 | 13.37 | 17.27 | 3.32 | |
| | Farmers | % | 6 | 43 | 366 | 191 | 53 | 659 |
| | | Number | 0.59 | 4.20 | 35.71 | 18.63 | 5.17 | |
| | TOTAL | % | 8 | 59 | 503 | 368 | 87 | 1,025 |
| | | Number | 0.78 | 5.76 | 49.07 | 35.90 | 8.49 | |

officials and the farmers – had a significant effect as much as 99.99 percent on their opinions.

However, the gender of the samples did not have any significant effects on the opinions of male and female respondents toward the satisfaction with the water management of the Royal Irrigation Department. Meanwhile, when based on the satisfaction on the working and living areas of the samples, the difference of the locations was found to have significant effects on the opinions of those working and living within irrigation systems and outside the irrigation system, as much as 95 percent. In addition, the age of sample groups was found to have significant effects on their satisfaction as much as 90 percent while the educational background of sample groups also had significant effects on their satisfaction with the

water management of the department, as much as 99.99 percent.

In summary, by using T-test and F-test statistical methods, the characteristics of the samples, except the gender of the samples, have significantly affected the satisfaction with the water management of the Royal Irrigation Department during the drought crisis, especially the profession and the educational background of the sample groups which had as much as 99.99 percent effects on the opinions of the sample groups.

**The Survey on the Satisfaction with the Relief Measures of the Ministry of Agriculture and Cooperatives for the Farmers Affected by the Drought Crisis in 2015/2016**

There was an analysis of the opinions of the farmers in relation to eights relief measures provided by the Ministry of Agriculture and Cooperatives, which are as follows:

1st Measure. Promotion of knowledge and support of production Factors to reduce household expenditure

The measure was made by providing the drought affected farmers with low water consuming plant varieties and young fowls for production and breeding in order that they can use for future household consumption or sell the excess amounts of their products. A variety of consumer products at Thong Fah (Blue Flag) shop's prices was also provided for the farmers in order to help them be able to buy several products at low prices during the crisis.

2nd Measure. Delay the payment period or extend loan payment period for the drought affected farmers who had borrowed money from Bank for Agriculture and Agricultural Cooperatives (BAAC) and local agricultural cooperatives or those who had to pay land rentals to the Agricultural Land Reform Office (ALRO).

3rd Measure. Job creation to generate income for the drought affected farmers

The Ministry of Agriculture and Agricultural Cooperatives had instructed the Royal Irrigation Department to cooperate with the Ministry of Labour and the Department of Provincial Administration and Department of Disaster Prevention and Mitigation, Ministry of Interior, in an effort to create jobs in the drought hit areas so that the affected farmers could have some income to compensate the lack of income from their agricultural production during the time of drought crisis.

4th Measure. Vocational development on the needs of each community

The fourth measure was aimed at developing additional jobs for the entire community, such as agricultural produce drying areas, community farms, canal and ditch dredging, organic fertiliser production, temporary job creation and so on, in order to help increase the income of the community members, as well as to help create the community's infrastructure in preparation for self-adjustment and relief during the time of crisis.

5th Measure. Increase water use efficiency through the education on the acknowledgment of drought situation, how to adapt and decrease the impacts of the drought crisis by using all relevant media, training, the demonstration of water saving rice production and the like.

6th Measure. Increase the quantity of water budget

The Ministry of Agriculture and Agricultural Cooperatives had instructed the Royal Irrigation Department to cooperate with Department of Royal Rainmaking and Agricultural Aviation, Department of Groundwater Resources (of the Ministry of Natural Resources and Environment), the Ministry of Defence, Department of Disaster Prevention and Mitigation (Ministry of Interior), the Provincial Waterworks Authority and the Metropolitan Waterworks Authority in order to find and develop additional water resources by means of creating water retention areas, drilling more artesian wells and finding more water reserves to maintain the water security for public consumption during the time of drought crisis.

7th Measure. Promotion of public health and life and property safety

The Ministry of Agriculture and Agricultural Cooperatives had publicised the preventive measures against the diseases which could occur during the time of drought crisis, helped the hospitals in drought affected areas to have sufficient water storage for their operations during the crisis and also asked for help from police stations in those drought affected areas in providing police patrol units to prevent the robbery of agricultural machinery and equipment as it would worsen the grievance among the drought hit farmers and the general public during the crisis.

8th Measure. Other supportive measures

The Ministry also provided the farmers with training on how to increase the productivity so that they can better adapt to the crisis and lessen the impacts of the drought crisis and suggested to them to sell their agricultural products along the available tourism routes while the ministry itself would try to closely monitor the rice growing areas and the quantity of water outside the irrigation system, via satellite image viewing and consider any possible compensation for damages during the time of crisis.

The analysis of the satisfaction with the relief operations from the government sector used the responses to the questionnaires, which had been classified into "Least Satisfied", "Little Satisfied", "Fairly Satisfied", "Very Satisfied" and "Most Satisfied", represented by number 1 to 5 respectively, as stated earlier in this Research.

Given as an example in this report, as shown in Table 9, will be the responses to the 1st Measure (of the Ministry of Agriculture and Agricultural Cooperative) while the satisfaction with all eight measures of the ministry will be discussed later.

From the differences in the characteristics of the samples, such as gender, age, living/

farming location and so on, the Researcher would like to analyse if any of these characteristics would affect the satisfaction with the eight measures of the government sector, T-test and F-test were used as the statistical tools to measure the sample distribution. It was found that the professions of the two groups of samples – the government officials and the farmers – had significantly different satisfaction with the eight measures. Moreover, different educational background and different working or living locations of the samples had significant effects, as much as 99.99 percent, on their opinions toward the eight measures. However, both the gender and the age of the samples did not affect the satisfaction with the measures.

**Summary of the Satisfaction with the Eight Relief Measures for the Farmers Affected by the Drought Crisis in 2015/2016**

After the analysis of all the points received from all respondents regarding their satisfaction with the eight relief measures for the farmers affected by the drought crisis (Table 10), it was found that the 2nd, 6th, 5th and 3rd measures were the most favourable measures respectively among the respondents as the rest of the measures were "fairly satisfied". When based on the opinions of the respondents on their professions, the government officials rated all the eight measures as "very satisfied", with the 6th, 2nd and 5th measures being their most favourite measures respectively, while the farmers rated only the 2nd measure as "very satisfied" and the 6th, 5th and 3rd measures as "fairly satisfied" and less favourite respectively. In summary, since the 2nd measure (delay payment period or extend loan payment period for the drought affected farmers), 6th measure (increase the quantity of water budget), 5th measure (increase water usage efficiency) and 3rd measure (job creation to generate income for the drought affected farmers) were among the four favourable measures in terms of overall results and group results, the government should give much importance to these four measures when there would be relevant policies to aid the farmers affected by the drought crisis in the future.

**The Opinions on Problems and Challenges of the Water Management during the Drought Crisis in 2015/2016**

In response to an open-ended question on "what was the problems and challenges of the water management during the drought crisis in 2015/2016?", during which each respondent was asked to give three answers in respective order from the most important one, a total of seven topics were summarised as follows:

1. Climate change;
2. Lack of water resources/water budget;
3. Water management;
4. Higher demand of water;
5. Lack of the cooperation from the public/farmers;
6. Public relations and
7. Government policies.

Table 10: Summary of points received for the satisfaction with relief measures for the farmers affected by the drought crisis in 2015/2016

| Relief Measure | Average points received | Level of satisfaction | Rank |
|---|---|---|---|
| 2nd Measure | 3.52 | Very satisfied | 1 |
| 6th Measure | 3.48 | Very satisfied | 2 |
| 5th Measure | 3.45 | Very satisfied | 3 |
| 3rd Measure | 3.44 | Very satisfied | 4 |
| 1st Measure | 3.40 | Fairly satisfied | 5 |
| 4th Measure | 3.39 | Fairly satisfied | 6 |
| 8th Measure | 3.36 | Fairly satisfied | 7 |
| 7th Measure | 3.35 | Fairly satisfied | 8 |

From the answers of 650 respondents who opined on the problems and challenges of the water management during the drought crisis in 2015/2016, a total of 185 respondents, or 28.42 percent, cited the lack of water reservoirs or water budget sources as the most important problem and challenge while the second most important was the water management, with 19.69 percent of all responses and the third important was the lack of the cooperation from the public/farmers, with 18.15 percent of all responses.

When based on the opinions of the respondents of their professions, the government officials pointed out that the lack of the cooperation from the public/farmers was the most important problem and challenge, which was in line with the closed-ended question in the questionnaire, followed by the higher demand of water and the lack of water sources/water budget, which was in line with the fact that there had been no large size of water reservoirs to sufficiently supply the water to the farmers during the dry season. Therefore, these opinions seem to have well reflected the lack of water reservoirs as it really occurs. However, the government has a clear policy to develop more small and medium sized reservoirs since the development of large reservoirs can hardly be made, due to several laws and government regulations.

**Summary and Recommendations**

Summary

From the research method of literature review, especially on water management, in-depth interviews with decision makers or policy makers and the policy executioners, face to face questionnaire interviews with a total of 1,025 samples in the Chao Phraya River Basin,

followed by SPSS software, the results of this Research can be summarised as follows:

1. The minimum quantity of water for various activities

The water budget in the Chao Phraya River Basin during the dry season in 2015/2016 (from November 2015 to April 2016) was unable to supply sufficient water for all activities, especially for off-season rice growing which would usually need a lot of water, so it was necessary not to supply water for off-season rice growing during such period. Therefore, the water distribution must take into account the minimum quantity of water for various purposes (public consumption, ecological balance maintenance and continuing agriculture) and the water release into the irrigation system should be made in accordance with the plans at 18 million cubic metres a day.

1.1 For public consumption

With increasing water demand for public consumption, mainly from the growing number of population and related developments, the daily water demand would continuously increase; and for the Chao Phraya River Basin the appropriate quantity for public consumption will be 7 million cubic metres a day.

1.2 For ecosystem balance maintenance

The quantity of water which should be allocated for pushing back seawater at the mouths of Chao Phraya River and Tha Chin River should be 8 million cubic metres a day in order to be able to keep salinity values of the water at Sam Lae water pumping station in Pathum Thani Province under control at a standard level (0.25 gram per litre), which would continue to be at this level for some time in the future. Therefore, the water discharge rate from the Chao Phraya Dam during the dry season must be at least 8 million cubic metres a day.

1.3 For continuing agriculture

The quantity of water which would be sufficient for fruit plants, vegetable growing, field crop and fish farming should be approximately 3 million cubic metres a day.

2. The satisfaction of the relief measures for the drought affected farmers

This Research had used the scientific and technological questionnaires, in accordance with the curriculum of the National Defence College, Batch #59, entitled the "Water Management in the Chao Phraya River Basin during the Drought Crisis", for data gathering and the Researcher divided the survey respondents into two groups of population – government officials and farmers – in order to find out the opinions of the government officials who were the implementers of concerned government policies and the farmers who were affected by the government policies during the drought crisis. The research area was focused on the lower part of the Chao Phraya River Basin under the responsibilities of the Regional Irrigation Offices 10, 11 and 12, which include a total of 43 provincial irrigation projects and water supply and maintenance projects. Approximately 20-25 samples was chosen in

each of the irrigation projects, with 65-70 percent that were farmers significantly emphasised for the response while 30-35 percent were the government officials. From the inspection of all responded questionnaires, there were a total of 1,025 answered questionnaires eligible for further data interpretation, 659 responses or 64.3 percent from the farmers and 366 responses or 35.7 percent from the government officials. And the summary of the respondents' opinions on the relief measures for the drought affected farmers are as follows:

2.1 When analysing the points of overall satisfaction of all measures (by summing up the points each measure received), the 2nd measure -- delay payment period or extend loan payment period for the drought affected farmers (which received the most satisfaction), 6th measure -- increase the quantity of water budget, 5th measure -- increase water usage efficiency and 3rd measure -- job creation to generate income for the drought affected farmers – had been rated "very satisfied" and have their point averages of 3.52, 3.48, 3.45 and 3.44 respectively while the rest of the measures were "fairly satisfied".

2.2 The analysis of the points of the satisfaction based on the professions of the respondents

2.2.1 Majority of the government officials were "very satisfied" with all eight measures, with the 6th measure -- increase the quantity of water budget, the 2nd measure -- delay payment period or extend loan payment period for the drought affected farmers -- and the 5th measure -- increase water usage efficiency – receiving the average points of 3.65, 3.62 and 3.61 respectively.

2.2.2 The farmers meanwhile were "very satisfied" only with the 2nd measure and "fairly satisfied" with the 6th measure -- increase the quantity of water budget, the 5th measure -- increase water usage efficiency – and the 3rd measure --job creation to generate income for the drought affected farmers – respectively.

The interesting point in this criteria is that the 2nd measure -- delay payment period or extend loan payment period for the drought affected farmers, 6th measure -- increase the quantity of water budget, the 5th measure -- increase water usage efficiency, and the 3rd measure -- job creation to generate income for the drought affected farmers -- were among the four favourable measures in terms of overall results and group results, so whenever the government would map out relevant policies to aid the farmers affected by the drought crisis in the future it should give much importance to these four measures.

3. Effective guidelines for the water management during the time of crisis and the relief measures for those affected by the drought crisis

In order to be able to manage the water supply in the Chao Phraya River Basin during the dry season in 2015/2016 in accordance with the plans, several water management measures

were implemented as follows:

3.1 The water gates which would derive the water from the rivers in the Chao Phraya River Basin had to be opened to receive the water for public consumption from time to time only. For any connected building, under the supervision of a local government administration, a calendar for receiving and discharging water supply must be made and submitted to the Royal Irrigation Department for further planning;

3.2 For any waterway or irrigation canal which might need water to strengthen the stability of its banks, the minimum quantity of water, as determined by the Royal Irrigation Department, can be obtained for such purpose;

3.3 No water pumping station for agriculture was allowed to take the water into any agricultural areas and the farmers were not allowed to close the waterways or pump the water from the waterways into their fields. In the case of urgent need of water for consumption, a calendar for water pumping must be made and submitted to the Royal Irrigation Department for approval;

3.4 The water pumping stations of the Metropolitan Waterworks Authority, the Provincial Waterworks Authority and local administration organisations however, could operate the water pumping stations as usual, but the calendar for water pumping must be made and submitted to the Royal Irrigation Department for further acknowledgement for agriculture was allowed to take the water into any agricultural areas and the farmers were not allowed to close the waterways or pump the water from the waterways into their fields. In the case of urgent need of water for consumption, a calendar for water pumping must be made and submitted to the Royal Irrigation Department for approval;

3.5 Fish cage culture should be curbed to be in line with the quantity of water in the Ping River, Nan River, Chao Phraya River, Noi River, Tha Chin River and all irrigation systems during the period from October 1, 2015, to April 30, 2016, as the Royal Irrigation Department would provide the data on water quantity and the level of water at checkpoints, as well as monitor the water situation and inform the Fishery Department to convey all relevant information to the fish farmers later on and

3.6 All concerned government agencies must closely monitor and control the release of polluted water into rivers, canals and waterways as it would cause the discharge of water from connected reservoirs to dilute the polluted water and eventually cause the water reserve to become less or insufficient for public consumption and ecosystem balance maintenance.

4. Problems and Challenges of the Water Management

From the study of the answers of 650 respondents who opined on the problems and challenges of the water management during the drought crisis in 2015/2016, a total of 185 respondents, or 28.42 percent, cited the lack of water reservoirs or water budget resources as

the most important problem and challenge while the second most important was the water management, with 19.69 percent of all responses and the third most important was the lack of cooperation from the public/farmers, with 18.15 percent of all responses. When considering the opinions of the respondents in different professions, the government officials opined that the lack of cooperation from the public/farmers was the most important problem and challenge, which was in line with the closed-ended question in the questionnaire, followed by the higher demand of water and the lack of water sources/water budget, which was in line with the fact that there had been no large water reservoirs to sufficiently supply the water to the farmers during the dry season. Therefore, these opinions seem to have well reflected the lack of water reservoirs as it really occurs. However, the government has a clear policy to develop more small and medium sized reservoirs since the development of large reservoirs can hardly be made, due to several laws and government regulations.

**Recommendations**

1. Recommendations on water management policies

1.1 There should be a review of all government regulations and laws related to the relief measures for the farmers who are faced with agricultural disaster in order that the related regulations and laws will be in harmony with the government operation in the field and those affected farmers can be helped in time.

1.2 There should be a single command operation centre to handle all types of disaster effectively, with certain operational guidelines for the policy executioners and the operational staff which would enable substantial and immediate operations in the disaster affected areas, also based on the participation of all concerned parties, in the same direction and all operations can be evaluated by such a single command centre.

2. Recommendations on budget water management

2.1 There should be an integrated database of natural disasters of which all essential information has been systematically analysed to become the most up-to-date and harmonised in order to be widely accepted by all concerned parties, so that the data can be effectively used for future disaster management, risk assessment, public warnings and related operations with future risk assessment being taken into account.

2.2 The risk management for natural disaster at the national level and provincial level should be developed into a harmonised system in order to be able to effectively assess any future disaster situation and also to effectively manage operational command at all levels, by increasing the efficiency and effectiveness in management task while reducing any overlapping use of resources with

an aim to be able to identify and tackle the problems promptly. The unity of management and command systems must also be equipped with effective data gathering and storage and accurate situation assessment.

2.3 There should be a continuous development of all possible tools and technologies for water management through the continuous exchange of information and the cooperation among scientists and technologists, stakeholders and policy makers in order to establish a linkage between the science and technology and the policies, so that there will be choices for appropriate options in water management which would lead to effective decision making for disaster risk management to be correctly, promptly and precisely.

3. Recommendations on water demand management

3.1 For the agricultural sector, there must be an agricultural zoning to be in line with the availability of the water supply in the future. The zoning can be effectively made by using the analysis of the relations between each agricultural product, land utilisation and water demand in conducting a feasibility study on appropriate production technologies, which would also need the knowledge on natural science, geosocial conditions and environments in each area. The decision to choose certain agricultural products for any particular zone must be equipped with the study on production technology, marketing, finance, economy, environment and management, as well as risk and impact assessment during the production process, cost accounting, the water demand for production and so on.

3.2 This study was aimed at providing guidelines for water management in the Chao Phraya River Basin which would be able to help solve any problems and challenges in any drought crisis in the future, when there will be more water usage in rapidly growing communities but gradually decreasing amounts of water budget in the river basin, both in the reservoirs and other natural resources. Therefore, all concerned parties should start planning for a more appropriate water utilisation in advance, especially by trying to find less water consuming crops to replace off-season rice growing. At the same time, water saving measures should be mapped out and publicised to the residents in all drought risk areas while more water resources be developed.

4. Recommendations on knowledge establishment, public participation and public relations

4.1 The knowledge establishment and knowledge management skills on disaster prevention and reliefs, preparations, confrontation and risk and impact management should be promoted among the general public and the farmers in risk areas in order to help them be aware of and understand the natural disaster, as well as be able to protect themselves and their property in the first stage.

4.2 There should be an effective mechanism to promote the knowledge and understanding on all dimensions of disaster management, especially on risk management, disaster prevention and impact reduction, for operational staff who would have to take part in mapping out vision, plans, operational practices and mechanisms within their own units and with other units to be as clear as possible and also in line with their mission in the operational fields sustainably.

4.3 The participation of all concerned parties in government, private and public sectors and the establishment of knowledge on disaster management should be encouraged, especially on disaster prevention, risk reduction and disaster confrontation preparations, environment restoration, should be promoted, along with the development of public potentials for effective disaster confrontation.

4.4 The substantial disaster warning channels and the accessibility of disaster related information should be established with the help from information technology in order to provide the general public with the knowledge on drought crisis threats, disaster prevention and reliefs, preparations, disaster confrontation, post-crisis restoration and refurbishment, so that the public can learn how to reduce the risks from natural disasters. Therefore, there should also be more information, especially the knowledge on disaster risk reduction in the database, for online public relations and campaigns for public awareness and unity in each community.

4.5 There should be continuous communication with the general public in order to help them learn and understand natural disasters, have awareness, realise their role and duty in preparation for the crisis and the confrontation with the crisis and be able to adapt themselves during the crisis to lessen the impacts of the disasters. In addition, the understanding among the mass media on disaster situations, the causes, risks and impacts of such disasters, the adaption and impact reduction during the crisis should be established in order that the media would be able to also play a part in solving the drought crisis together with other concerned parties, in the same direction which would finally benefit the nation as a whole.

5. Recommendations on translational research

The results of this Research can be applied into further studies on the minimum quantity of water for various activities and the appropriate measures to effectively solve the problems from the drought crisis in other river basins in order that the overall water management in Thailand can be made efficiently.