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Water management in outside irrigation areas of Tha Takiap sub-distric, Tha Takiap distric, Chachoengsao province, Thailand

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Abstract The results showed that there was a total amount of runoff was about 6,831,447.60 cubic meters, and the total water use for each activity in an area of about 6,685,449.46cubic meter. When comparing the total watery supply with the water consumption of every activity throughout the year, the water supply was sufficient to meet the demand for water. The monthly rainfall was recorded more water than in all activities in August, about 724,586.66 cubic meters. Therefore, there should be reserved more water storage for water retention during water shortages, excavation of pools and reservoirs to optimize the water capture efficiency, planting planning.

Keywords: Run off, Water management, Evapotranspiration

Introduction

Water is a resource that is extremely important for agriculture. Without water, farming is bound to fail. The amount of rainfall and its distribution occur naturally according to the seasons, with the rainy season starting from May to November, and there are usually breaks in rainfall during July almost every year. However, currently, there are longer breaks in rainfall, and precipitation does not follow the seasonal patterns (Rundawe, 2014). This is largely due to environmental changes, particularly the destruction of naturally lush forest areas near watersheds that serve as water absorption sources for agriculture. This has significantly impacted the quantity and flow of water, especially during the dry season. Additionally, the El Nino phenomenon has caused climate changes leading to higher temperatures, which in turn affects the amount of rainfall, resulting in drought conditions in Thailand. The population faces water

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shortages, both for consumption and agricultural use, causing widespread damage to crops.

Therefore, this study focused on examining community water management in areas outside the irrigation zone in Tha Takiep sub-district, Tha Takiep district, Chachoengsao province, to address drought issues and to serve as a guideline for preparing to prevent water shortages. This area often faces drought problems every year. In Tha Takiep sub-district, there are water storage sources reserved for agricultural and domestic use during the dry season. However, the existing water storage sources are not capable of adequately capturing rainfall, resulting in insufficient water availability during the dry season to meet regular water demands almost every year. Thus, this research aimed to study water management outside the irrigation zone from the available water storage sources in the area to ensure sustainable water retention.

Materials and methods

Study area

The area of Tha Takiep Subdistrict, located in Tha Takiep District of Chachoengsao Province in eastern Thailand, covers approximately 512.02 square kilometers, with 310.93 square kilometers designated for agriculture, accounting for 60.74% of the agricultural area. According to the economic development plan aimed at becoming a metropolitan hub of ASEAN, the geographical conditions are suitable for agriculture, and the terrain is mostly hilly, featuring mountain ranges and relatively intact rainforests, which are part of the national forest reserve. It is also the source of the Bang Pakong Watershed (Chachoengsao province Agriculture and Cooperatives, 2020).

Water consumption various activities

The determination of water demand for various activities consisted of the amount of water needed for consumption and agriculture (Thanapakpawin, 2008). Data on water usage across all activities were collected to find the water demand in the study area, surveying and gathering information on the total agricultural land area and categorizing it by each type of crop grown in the area. Therefore, the amount of water used for agriculture depends on the type of crop and the size of the area cultivated for each crop. The calculated water usage for agriculture is measured monthly, and the water demand for each type of crop can be calculated using Equation 1 (Boontharokul, 1983).

$$ET_c = K_c \times ET_o \quad (1)$$

NRCS Curve Number method

The NRCS-CN method is assessed the runoff volume, based on the water balance equation and two fundamental assumptions as follows:
The first hypothesis was the relation between the amout of water flow (Q), the amount of rainfall (P), the rate of water infiltration through the soil surface (F), and the maximum storage capacity (S) The second hypothesis related the initial loss rate (Ia) to the maximum storage capacity (S) The NRCS-CN model's general equation can be expressed as (USDA-NRCS, 2004) as follows:

$$Q = \frac{(P-l_a)^2}{P+(1-l_a)s} \quad (2)$$

Where Q, P, Ia, S are the quantities of water flow (mm), accumulated rainfall (mm), initial loss rate (mm), and maximum storage volume (mm). Respective, it is specified that S is related to the Curve Number (CN), which is an abstract quantity without physical meaning according to (USDA-NRCS, 2004) as follows:

$$S = 25.4\left(\frac{1000}{CN} - 10\right) \; or \; CN = \frac{25400}{254+S} \quad (3)$$

Amount of rainfall ($P>0.2S$), if the CN value is high, it indicates a greater potential for runoff. The CN value ranges from 0 (no runoff, $S=\infty$) to 100 (all rainfall becomes runoff, $S=0.0$). For watersheds without measurements, the CN value is obtained from the CN table (CNT) (Mishra *et al*., 2002), depending on soil type, ground cover, watershed management, hydrological conditions, and average soil conditions before runoff occurs (Antecedent Runoff Conditions; ARCs). CNII represents CN for average soil conditions (ARC-II), CNI represents CN for dry soil conditions (ARC-I), and CNIII represents CN for wet soil conditions (ARC-III), respectively. The values of CNII, CNI, and CNIII can be determined as follows.

$$CN_{II} = \frac{1}{A_T}\sum_{i=1}^{n}(A_i \times CN_i) \quad (4)$$

$$CN_I = \frac{4.2\,CN_{II}}{10-0.058CN_{II}} \quad (5)$$

$$CN_{III} = \frac{23\,CN_{II}}{10-0.13CN_{II}} \quad (6)$$

Water management in areas outside irrigation zones

The comparison of water demand with the available water supply aims to analyse the sufficiency of water management in the study area. This comparison was the results of the analysis of water demand across all activities in the study area and compare them with the available water supply, followed by an analysis to determine the sufficiency of water usage that occurs. This helped to identify the details of areas facing water scarcity issues. Subsequently, the sufficiency of water management in the study area was analysed as shown in Figure 1.

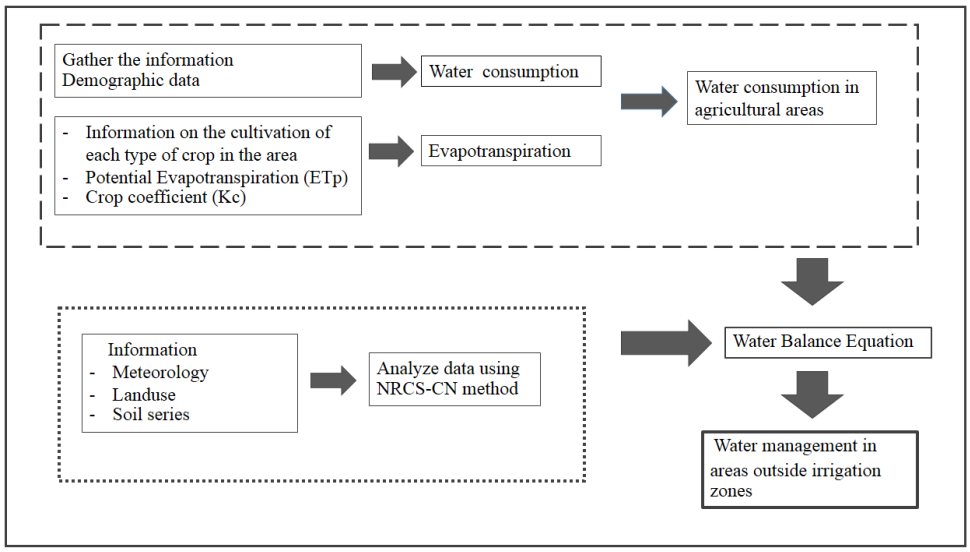

Figure 1. Procedure followed in land suitable evaluation for agricultural planning

Results

The land use

The area of Tha Takiep sub-district covers a total of 512.20 square kilometers, with agricultural land use encompassing 310.93 square kilometers, accounting for 60.74% of the total area. This is divided into crop farming areas, with cassava being the main economic crop covering 49.95 square kilometers, rice cultivation areas totaling 20.82 square kilometers, and areas for planting perennial trees such as rubber, oil palm, and eucalyptus covering 222.18 square kilometers. Additionally, there is a total of 13.06 square kilometers designated for community residential areas, as shown in Figure 2.

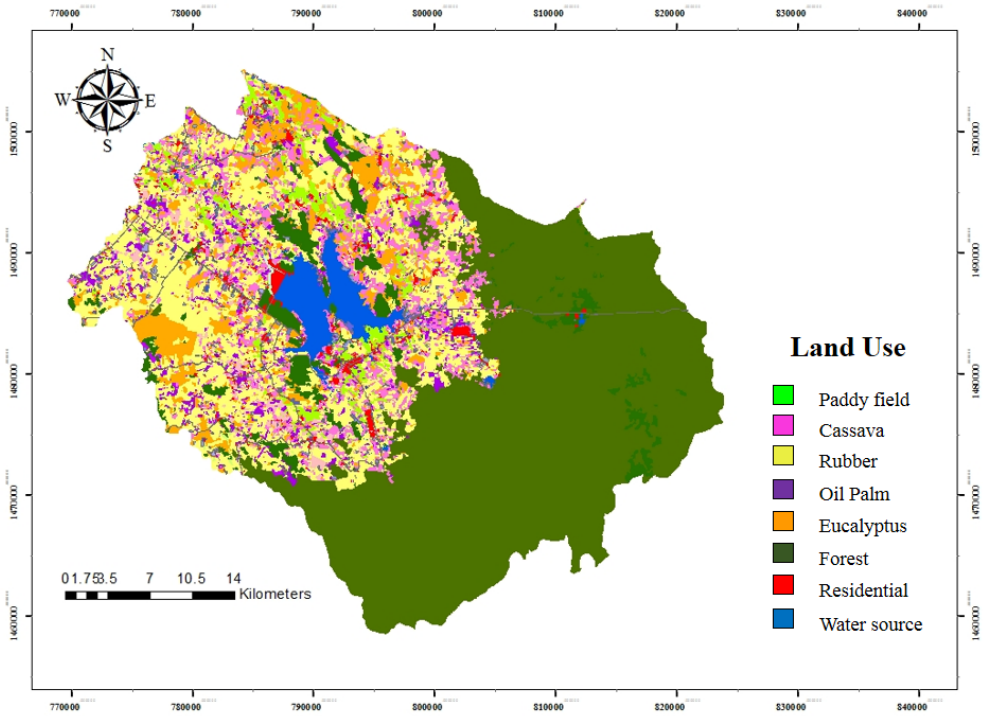

Figure 2. Land use in Tha Takiep sub-district, Tha Takiep district, Chachoengsao province, Thailand

Soil series

In the area, a total of 5 soil series can be classified, including soil series 48, soil series 46, soil series 35, soil series 49, and soil series 2, among others, in the area has soil series 48 at 30.71%, followed by soil series 46 at 28.00%, soil series 35 at 22.56%, soil series 2 at 11.00%, and soil series 49 at 7.72%, respectively, as shown in Figure 3.

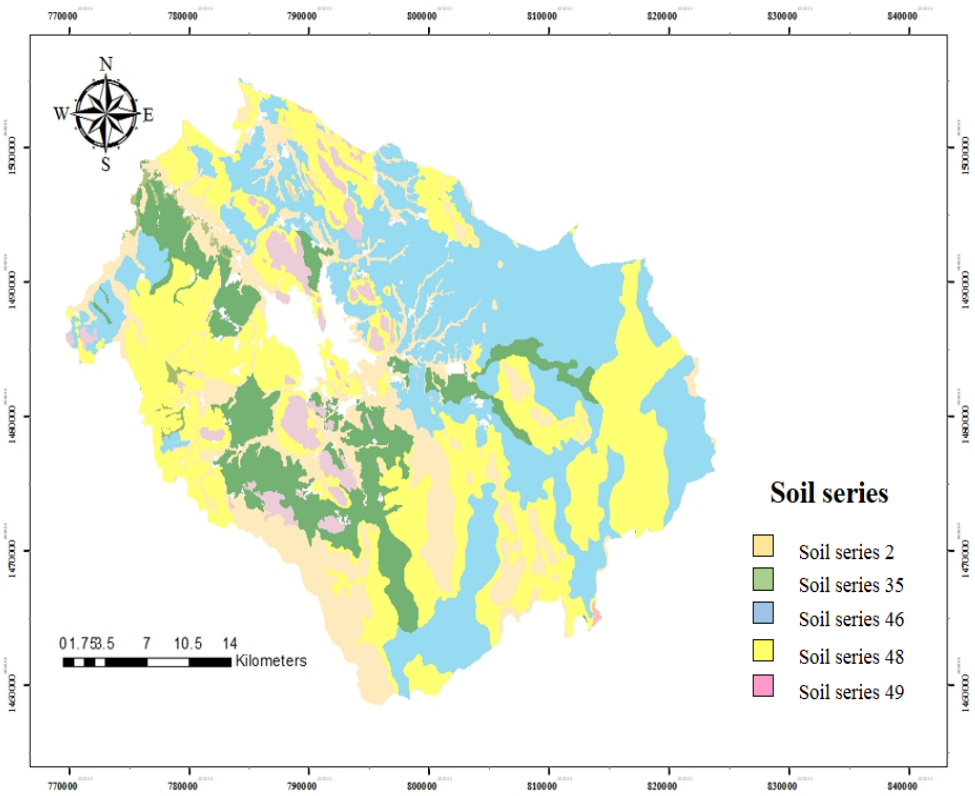

Figure 3. Soil Series in Tha Takiep sub-district, Tha Takiep district, Chachoengsao province, Thailand

Amount of water

The analysis of water content in Chachoengsao for the past 15 years from 2009 to 2023 from Meteorological Department of Thailand and Ministry of Natural Resources and Environment is rainfall data and runoff data. The average rainfall for the past 15 years from 2009 to 2023 found that an average monthly rainfall can be calculated, showing the average monthly rainfall as depicted in the figure. The data indicated that the amount of rainfall has increased in September (approximately 239.71 millimeters), and the rainfall began to decrease in November as shown in Figure 4.

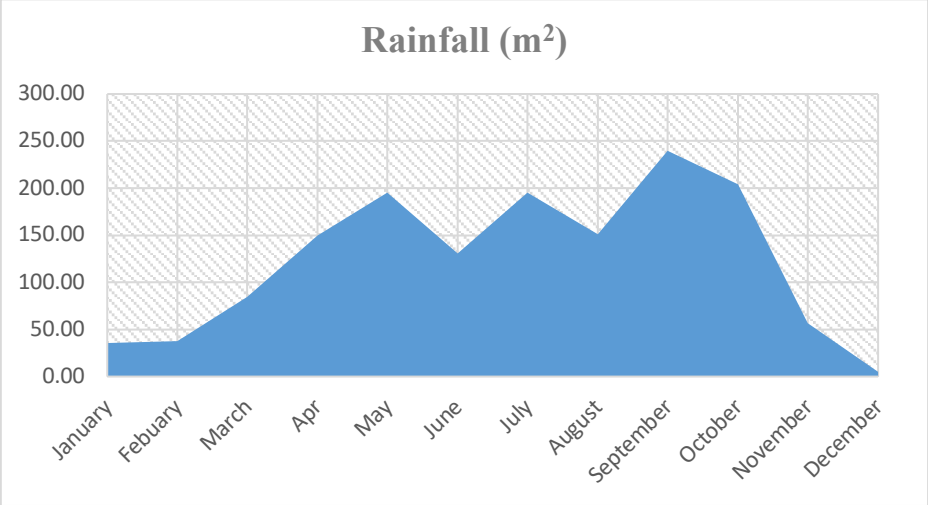

Figure 4. Amount of rainfall

The average monthly rainfall data, the surface runoff was using the NRCS-CN method. According to the soil series data from the Department of Land Development, the soil characteristics in the area of Tha Takiep sub-district, Tha Takiep district, Chachoengsao province, fall into five soil series: Soil series 2, Soil series 35, Soil series 46, Soil series 48, and Soil series 49.

The comparison of data from the soil group selected using Hydrologic soil group C in agricultural areas and vacant land under Fair Hydrologic conditions, it calculated the average monthly runoff as shown in the Figure 5.

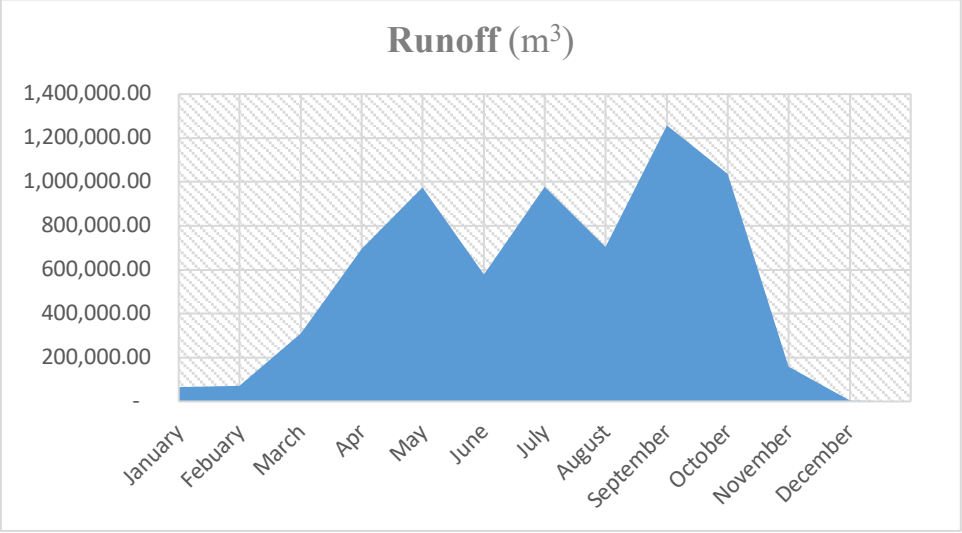

Figure 5. Amount of runoff

Analysis of water consumption in agricultural area

Water consumption

According to the population data, there are 19,482 people. The water demand equation for consumption, the water usage for consumption of the population in Tha Takiep sub-district is calculated to be 974.10 cubic meters per day (assuming an average water usage rate in rural areas of approximately 50 liters per person per day), as shown in the Figure 6.

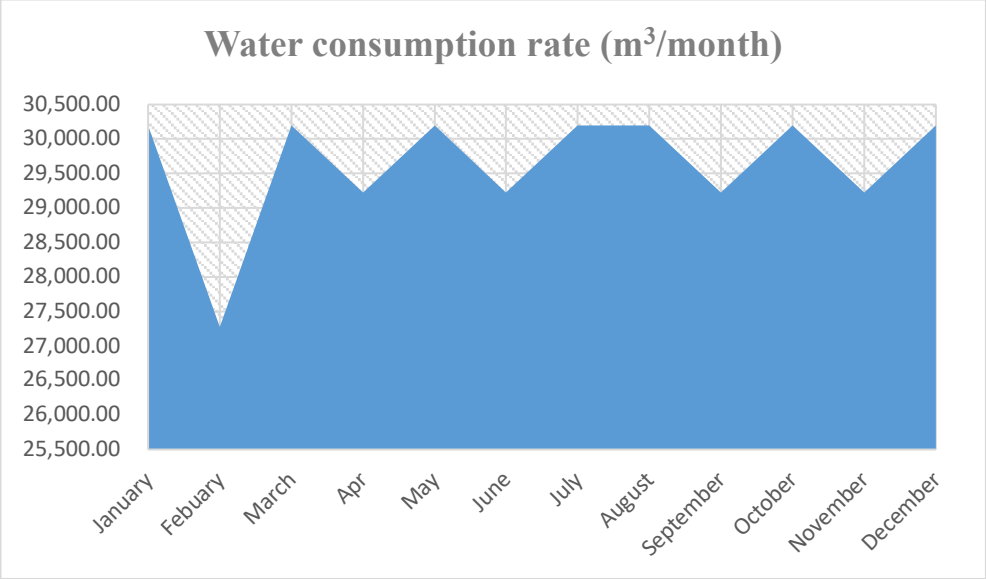

Figure 6. Water consumption

Water consumption in agricultural areas

In the agricultural area of Tha Takiep sub-district, Tha Takiep district, Chachoengsao province, Thailand. As shown in Figure 7. Amount of water for agriculture. that rubber is predominantly cultivated (with a cultivation area of approximately 139.06 square meters).In addition to rubber trees, farmers in the area also commonly grow other crops such as paddy fields, cassava, oil palm plantations and eucalyptus, etc.

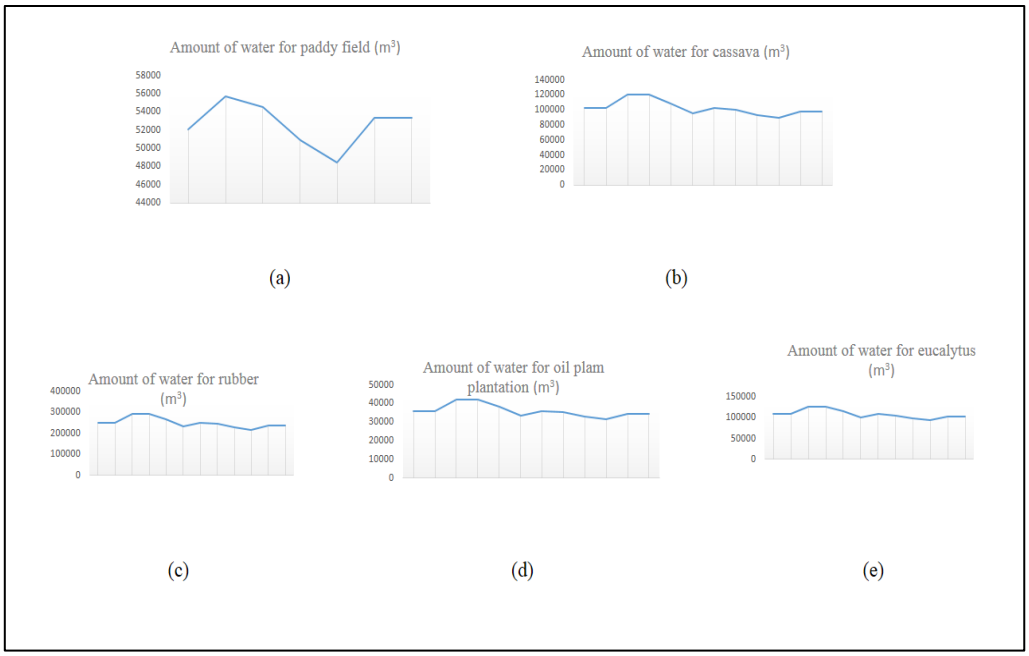

Figure 7. Water consumption in agricultural areas

Water balance analysis

The water usage in the entire area revealed the water consumption in agricultural areas. It provides the water consumption in the area when compared with the monthly water usage for water uses. According to the data on overall water use, the biggest demand for water consumption in March and April, when there are roughly 612,338.73 and 611,364.63 cubic meters, respectively.

The total average rainfall in the area allows us to determine the total inflow of water to the area on a monthly basis. The average monthly water data show that in September, the runoff in the area (inflow) was the highest, approximately 1,257,475.76 cubic meters.

Comparing the monthly amount of water demand with the monthly amount of available water balance in the area (Table 1). According to the data, the area's water input is adequate to meet demand between April and October. However, there is insufficient water inflow to meet needs during the months of January through March, as well as in November and December. This is due to the fact that some agricultural regions have shallow water reservoirs or are remote from water sources.

Table 1. Water balance in the area

Month	Water balance (m^3)		Amount of water (m^3)	
	Runoff in the area (Inflow)	Water consumption in agricultural area (Outflow)	Excess Water volume	Lack of Water
January	64,233.96	526,095.53	0	-461,861.57
Febuary	71,718.16	523,173.23	0	-451,455.07
March	310,431.60	612,338.73	0	-301,907.13
Apr	695,054.40	611,364.63	83,689.77	0
May	976,200.00	558,436.73	417,763.27	0
June	577,910.40	544,881.15	33,029.25	0
July	978,607.96	581,831.40	396,776.56	0
August	702,798.92	569,839.35	132,959.57	0
September	1,257,475.76	532,889.10	724,586.66	0
October	1,034,902.16	509,879.10	525,023.06	0
November	159,250.76	556,873.20	0	-397,622.44
December	2,863.52	557,847.30	0	-554,983.78
Total	**6,831,447.60**	**6,685,449.46**	**2,313,828.14**	**-2,167,829.99**

Results of the consideration for finding solutions to the problems

According to the water inflow and demand calculations, which were broken down into categories such as residential use, horticulture, cash crops, and rice, there is a 2,167,829.99 cubic meter water deficit from January to March and November to December. On the other hand, there is an excess of 2,313,828.14 cubic meters of water from April to October. As a result, increasing the effectiveness of pond water retention should solve the problem of water scarcity in the area. By using a clay material (montmorillonite/betonies/synthesized clay sheet). In addition, adjusting irrigation methods and planning crop cultivation according to the available water supply will enhance water usage efficiency. Soil maintenance before planting and improving water delivery methods to reduce loss of water, seeping, and evaporation.

Discussion

The study of water management outside the irrigation area in Tha Takiep sub-district, Tha Takiep district, Chachoengsao Province, to compare the amount of water demand and the available water resources in the area to determine whether they are sufficient to meet the water needs for all activities taking place in the area. The survey of the study area found that there are insufficient water sources for agriculture during the dry season. Some ponds and waterways in the area are shallow, resulting in inadequate water storage to meet the demand.

The calculation of water balance in the area shows a total runoff of approximately 6,831,447.60 cubic meters, while the total water usage for all activities in the area is about 6,685,449.46 cubic meters. When comparing the total surface water volume with the water usage for all activities throughout the year, it is evident that the surface water is sufficient to meet the water demand. Analysing the monthly rainfall reveals that September has a higher surface water volume than the water usage for all activities. However, it is not possible to store water for use during periods of water scarcity to a significant extent. This analysis of water volume serves as a guideline for water management in areas outside irrigation zones, such as adjusting irrigation methods and planning crop cultivation to align with the available water volume in the area to enhance water use efficiency, soil maintenance before planting, and improving water delivery methods to reduce water loss through evaporation and seepage. (Sangchan and Tarakultip, 2016).

The found that the ponds and waterways in certain sections of the area face issues with insufficient water supply due to the shallow nature of the ponds or waterways, which limits their capacity to store enough water to meet demand. Additionally, the soil conditions retain moisture poorly.

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