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## A DEVELOPMENT OF SOIL MOISTURE MONITORING SYSTEM FOR INCREASING IRRIGATION SUPPLY EFFICIENCY APPLIED IN THORTHONGDAENG OPERATION AND MAINTANANCE PROJECT, KAMPHANGPHET, THAILAND.

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Thorthongdaeng Operation and Maintenance Project (TTD) is an irrigation project under Royal irrigation Department (RID) initiated for allocating irrigation water to agriculture land coverage area around 550,000 rai which is the largest area of irrigation project in Thailand. TTD project delivers water supply to each water user group of agricultural area through main canals and sub-main canals by gate controlling. The quantity of water allocation according to weekly crop survey is distributed to each group of water user built on subdistrict area. During Thailand drought crisis, TTD project recently faced with confliction between operators and farmers who always asking for additional irrigation supply for their crops. It consequently causes the difficult in preserving water distribution plan due to inadequate of water supply.

This paper presents system for soil moisture monitoring linked to crop water requirement considering soil moisture capacity at real-time situation. The moisture content monitoring system and model development is used to simulate for determining crop water requirement corresponding to water content status and supply availability. Crops water demand can be calculated using traditionally reference potential evapotranspiration (ETo) factor that gives result in moderate correctness and suitable for conventional purposes. While FAO method which considers soil moisture content in various root zones and in different crop types gives crop demand estimation in more exactness on water need for planting. Thus, this research develops soil moisture monitoring system by applying sensor instrument using Time-domain reflectometry (TDR) method. The Advantage of TDR method is precisely in measuring and commonly used for quantifying soil content in both of laboratory and agricultural land. TDR principle works by transmitting and reflecting signals into the soil to analyze dielectric constant and permittivity as a water content by wave propagation. Developed soil moisture monitoring system utilizes TDR sensor together with microcontroller unit (MCU) to read output as percentage of soil content. The solar energy is connected to battery as power source to receive data from MCU and sent out to cloud server through internet 3G/4G sim card in every 3 hours. It consumes less power and beneficially can remain active status in recording data to server without sunlight continuously up to 3 days.

This study also presents a concept of rearranged irrigated area from subdistrict sectors into water user zone. Water user zone is reorganized depending on farmer's group who use same irrigation canal in crop cultivation. The position of water content sensor instrument installation is considered as four points in each water user zone to be representative station for observing soil moisture status in areas of upstream, downstream, lowland, and highland. Cropping period is also divided into four groups of all water user zone based on farmer's cropping behavior comprising of starting period on first of April, first of May, on May 4$^{th}$ and on May 7$^{th}$. The duration of receiving irrigation water in each group is of 3 to 9 days and rotates to other groups since beginning to the cropping season end.

There are 120 water content sensor stations installed coverage all 20 water user zones. All input parameters in FAO method such as soil type, field capacity and bulk density are investigated in laboratory by collecting soil sample in each sensor station. It is found that mostly TTD's irrigated area is clay soil and field capacity is between 16.4% to 48.5% by volume consistency with bulk density that is 1.0 to 1.67 g/cm$^3$.

Crop water requirement is modeled in various root zones depth and crop types by considering soil characteristics from laboratory test and moisture content data obtained from sensor monitoring. Effective rainfall is also taken as primary supply to simulate supplementary irrigation water need in cropping. Rice cultivation area is obtained from weekly surveying in record. Four cases of supply scenario during rainy season are applied in simulation period such as dry year in 2015, normal year in 2016, wet year in 2017, and present year in 2019. Crop demand is derived by FAO method and water allocation is planned afterwards to evaluate irrigation supply efficiency in using soil moisture monitoring system comparison with existing operation.

It is revealed that by using FAO method along with data from soil moisture monitoring system, the irrigation water supply for all crop types of whole TTD irrigation area is between 168.06 to 524.50 million cubic meters (MCM) that can conserve water supply up to 52.81% compared to routine operation. In the meanwhile, total demand estimation from ETo method is much more water requirement that is about 356.14 to 622.26 MCM for a season.

The recommendation of irrigation supply in relating with crop water demand is verified during dry season 2017 and 2018. The performance of water supply use for crop cultivation is assessed and compared to existing operation. In dry season 2017, observation data of rice cultivation area is around 344,948 rai and in that season TTD project has supplied water through irrigation system totally 93.62 MCM. Using the developed system, it is required only 78.20 MCM. The saving water irrigation supply is about 16.47% of the total. Additionally, data recorded of water supply in 2018, TTD project irrigated water 270.50 MCM to entirely 373,799 rai of rice cultivate area, the model suggested to supply the irrigation water of 202.33 MCM, which is about 25.20 percent of water supply saving.

The application of soil moisture monitoring system integrated with crop demand modeling using FAO method can be achieved for increasing efficiency of irrigation supply over 15%. It can be concluded that this study is matching all water demand and water irrigation supply all the time. Using soil content in root zone, amount of water irrigated can be determined to each zone area accurately with crop water need in terms of time and quantity constraint. Moreover, as a results of soil moisture sensor status can signify crop cultivation stage in relating to soil content that can use for reporting real situation in overall. This developed modeling system can be further applied into rainfed area for enhanced water use efficiency under the crisis of water supply changed circumstance that become more severity nowadays.

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