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The evaluation of irrigation water requirement under climate change phenomenon in the urban area (a literature study)

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Abstract. Irrigation is important for agricultural activities because it distributes water into irrigation area and provides water for crop growth. The appropriate and effective water allocation supports agricultural productivity. Generally, irrigation activities get water from rainfall and it is very depending on several climate variables for example temperature, humidity, duration of radiation and wind velocity. Several climatic variables are important for agriculture since they affect the evapotranspiration rate that it will determine irrigation water requirement rate. Therefore, irrigation water requirement is sensitive if climate change happened. In the other hand, decreasing of agriculture area as the agricultural land conversion gradually will reduce the irrigation service area particularly in the fast-growth area in development. So that, irrigation water requirement also will be reduced. Irrigation water requirement should be evaluated simultaneously in order that it can be allocated appropriately. This paper was written to develop an evaluation method for irrigation water requirement through analysis of climate change trend, agricultural land conversion and irrigation efficiency based on the literature review. The reviews result selected method i.e. Mann Kendall Test for climate change trend analysis, spatial analysis for agricultural land conversion and comparison of inflow and outflow for irrigation efficiency analysis.

1. Introduction

The irrigated agriculture is one of the most critical human activities for sustaining civilization [1]. Irrigation system is essential to enhance crop productivity in order to meet future food needs and ensure food security [2]. Irrigated agriculture will continue to play an important role as a significant contributor to the world food supply. Thus, irrigation is a powerful mitigator of main environmental risk associated with farming [1].

Irrigation activity is very dependant on climatological variables since affect to evapotranspiration process. In several last decades, the climate change phenomenon occurred on all components of the climate system. Climate change has become a global threat which has a high potential to affect the water and agriculture sectors significantly (IPCC 2007; Molua 2009). Increasing temperatures and water deficits have been identified as the main factors influencing changes in crop growth and yield [3].

In the other hand, the fact is that today farmers are producing more food on less land than ever before [1]. Population and economic growth affect increasing of land demand for multi-purposes such as residential, commercial and industrial. So far, agricultural land has a lower economic value than non-agricultural land consequently agricultural land will continuously be converted into non-agricultural



land. The agricultural land conversion which land is converted from agricultural to urban use, is occurring at an intensive level all over the world with much higher rates in emerging economies [4]. Agricultural land conversion is a process in which land is changed from agricultural to urban uses and varies in different countries in terms of intensity, trend, and drivers. [5]. Impact directly from the conversion of agricultural land utilization form is dwindling farmland that directly affects a decrease in agricultural production [6]. That condition indicates the irrigation service area gradually will be reduced.

2. Irrigation Water Requirement (IWR)

Irrigation activities distribute water into irrigation area through the irrigation network. This water is used by the crop for growth. However, water can be lost from the soil surface and wet vegetation through a process called evaporation. And vaporization also occurs from liquid water contained in plant vegetation through the transpiration process. The combination of these two separate processes is called evapotranspiration (ET). There were several methods available to estimate evapotranspiration rates. The methods for this measurement included the Blaney-Criddle Method, Radiation Method, FAO-Modification Penman Method, Penman-Monteith Method, Thornthwaite Method, and Multiple Linear Regression Model. All these methods were used climate-related data, such as air temperature, air humidity, sunbeam length, and wind speed.

Crop water requirements (CWR) encompass the total amount of water used in evapotranspiration. Crop water requirement (CWR) value is obtained from the crop coefficient [K_c] values for the wheat crop is multiplied with the potential evapotranspiration.

$$CWR = K_c * ET_o \quad [1]$$

The crop water requirement value is subtracted by effective rainfall so that the irrigation water requirements (IWR) value will be obtained.

$$IWR = CWR - ER \quad [2]$$

Net irrigation water requirements (NIWR) is the total water to be supplied to the crops during their life cycle, considering the losses due to infiltration into the subsoil and conveyance losses.

$$NIWR = IWR + LOSSES \quad [3]$$

3. Methodology

The paper was written based on analysis of various national and international scientific publications related to climate change trend, agricultural land conversion, and irrigation efficiency analysis. The result of these analysis are used to develop evaluation method for irrigation water requirement as climate change influence in a fast growth area in development.

4. Results and Discussion

Analysis of Climate change trends is required long-term climatic data for example, precipitation and temperature. Based on a review of several papers related to the analysis of climate change trends, there are several methods used with the advantages and weakness of each which is provided by Table 1. Mann Kendal and algebraic averaging technique are widely used to analyze trend of climate change. Climate change trend analysis require long-term data and there is difficulty in obtaining long and complete data in an area.

Table 1. Researches on climate change trend analysis

Title	Author	Method	Advantages	Weakness
Trend Analysis of the Mean Annual Temperature in Rwanda during the Last Fifty Two Years	Bonfils Safari	Mann Kendall Test	appropriately applied for trend analysis	difficulty in obtaining long and complete data in an area
Long-Term Trend Analysis of Precipitation and Air Temperature for Kentucky, United States	Somsubhra Chattopadhyaya and Dwayne R. Edwards	Mann-Kendall test	appropriately applied for trend analysis	difficulty in obtaining long and complete data in an area
Analysis of climate trend and effect of land use land cover change on Harangi streamflow, South India: a case study	Ashwathi P. Anil · H. Ramesh	Mann–Kendall test	appropriately applied for trend analysis	difficulty in obtaining long and complete data in an area
Trend of Precipitation Data Analysis in East Java Using Mann-Kendal & Rank-Sum Test Method	Indarto, Budi Susanto, and Eka Mustika Diniardi	Mann-Kendal & Rank-Sum Test Method	appropriately applied for trend analysis	difficulty in obtaining long and complete data in an area
Rain Teaching Trend Analysis Of Extrim Data Distribution On River Flow Area In Ambon Island	Obednego Dominggus Nara	Mann–Kendall test	appropriately applied for trend analysis	difficulty in obtaining long and complete data in an area
Trend Analysis of Rainfall Change at Three Regions with Different Rain Pattern in Maluku Province	S. Laimeheriwa	algebraic averaging technique	easier in analysis	difficulty in obtaining long and complete data in an area
Recent Climate Change Trend Analysis and Future Prediction at Satkhira District, Bangladesh	Ruksana Haque Rimi, Syed Hafizur Rahman and Samarendra Karmakar	Analysis of average	easier in analysis	difficulty in obtaining long and complete data in an area

Agricultural land conversion gradually have been decreasing as uncontrolled population growth and economic development of sub-urban area. Several researches develop methods calculate the agricultural land conversion. Table 2 provide several related researches i.e data panel regression, spatial analytical method.

Table 2. Researches on agricultural land conversion analysis

Title	Author	Method	Advantages	Weakness
Analysis Of Causes Of Agricultural Functions To Agriculture / City In Central Java Province 2003-2013	Zara Rosalia Putri	Data Regression	Panel easier method of analysis	require a lot of secondary data

Analysis of Paddy Field Conversion: The Utilization of High Resolution Spatial Data Shows an Alarming Conversion Rate.	Anny Mulyani, Dwi Kuncoro, Dedi Nursyamsi, dan Fahmuddin Agus	spatial analytical method	provide solutions for data availability constraints	require high resolution satellite image data
Agricultural Land Conversion: Determinants And Impact For Food Sufficiency In Sleman Regency	Rika Harini, Hadi Sabari Yunus, Kasto, Slamet Harton	survey method and statistical analysis regression	primary data from the field can be directly processed	the possibility of error in filling the questionnaire
Agricultural Land Conversion In The Sub-Urban Area: A Case Study Of Rajshahi Metropolitan City	Md. Abdul Halim, Md. Mizanoor Rahman and Md. Zahidul Hassan	simple random sampling method and analyzing collected data. Excel and SPSS software were used for tabulation, analysis and graphic presentation. Arc GIS 9.3 and Arc View 3.2 software was used for mapping analysis.	primary data from focus group discussion be directly processed	the possibility of error in filling the questionnaire

Generally, the analysis of irrigation efficiency is done by comparing the outflow and inflow in the irrigation network. Several studies related to irrigation efficiency analysis can be seen in Table 3.

Table 3. Researches on irrigation efficiency analysis

Title	Author	Method	Advantages	Weakness
Efficiency Analysis Of Irrigation Network In Boro Irrigation Area, Purworejo Regency, Central Java Province	Achmad Rafi'ud Darajat, Fatchan Nurrochmad, Rachmad Jayadi	Comparing outflow and inflow	more representative because based on field measurement results	requires precision during field measurements
Water Supply Efficiency In Irrigation Channel On Karau Irrigation Area East Barito District Central Kalimantan Province	Agus Sumadiyono	Comparing outflow and inflow	more representative because based on field measurement results	requires precision during field measurements
Efficiency Of Irrigation Of Malaka Irrigation Network [Case Study Of Irrigation Irrigation Of Malaka Kiri]	Wilhelmus Bunganaen, Ruslan Ramang, Lucy L.M. Raya	Comparing outflow and inflow	more representative because based on field measurement results	requires precision during field measurements

5. Conclusion

The change of climatic data value, irrigation service area, and irrigation efficiency will change the amount of water for irrigation. So that, irrigation water requirement should be evaluated simultaneously. Evaluation should be conducted since the climate change phenomenon, agricultural land conversion was gradually happen, and change of irrigation network conditions. The trend of climate change can be analyzed by non-parametric Mann-Kendall test using long-term climatic data. While the agricultural land conversion is evaluated by converting the satellite imagery into land use map. And irrigation efficiency is calculated by comparing outflow and inflow on irrigation network.

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