GIS Based Water Management Approach for Sustainable Groundwater Use

-Case Study: Nganjuk District, East Java, Indonesia-

○ Liyantono[1], 黒田久雄[2], 加藤亮[2]
○ Liyantono[1], , Hisao KURODA[2] Tasuku KATO[2]

1. Introduction

In Indonesia, rice production in dry season is still important for regional sustainable development. This research was conducted in Nganjuk district, East Java province, Indonesia. Objectives of the research are to develop spatial database for distribution wells and to analyze water balance.

The Approach of this research was conducted in two steps. First step was to analyze annual recharge and withdrawal of groundwater by estimation of water balance. Second step was to develop a spatial database for distribution wells and to analyze groundwater exploitation for irrigation in dry season.

2. Study Area

The Nganjuk District lies in a climatic regime characterized by the annual progress of rainy and dry seasons, and receives roughly 80% of precipitation within the 5 to 6 months of the rainy season (December-May). Nganjuk area has flat area in central and eastern of Nganjuk with altitude ranging from 30 to 100 m above sea level. Mountains area is located at southern and northern area.

In Nganjuk area, there are 3 planting season, wet season (WS), first dry season (DS1), and second dry season (DS2). Paddy fields are cultivated in WS and DS1. Secondary crops (corn, soybean, onions, chilies, melons and vegetables) are cultivated in DS1 and DS2. Cropping intensity in Nganjuk district is high varied 2-4 crops yr^{-1} with average 2.83 crops yr^{-1} (BPS Nganjuk, 2007).

There are three main sub-basins in Nganjuk area, Widas, Kuncir, and Bodor sub-basins. Kedungsoko River is for Kuncir and Bodor sub-basins, Widas River is for Widas sub-basin and those rivers were merged into Brantas River.

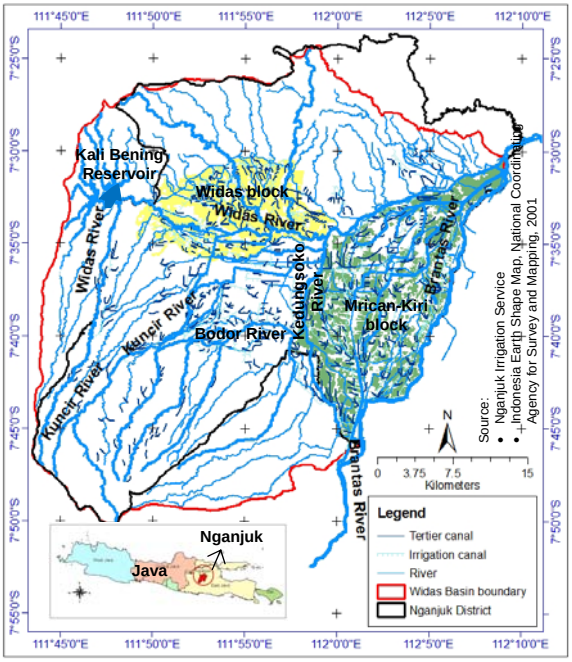

Fig.1. Nganjuk District and Widas Basin

In Nganjuk area, there are two surface irrigation systems, Widas block and Mrican-Kiri block.

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[1] *United Graduate School of Agricultural Science, Tokyo University of Agriculture and Technology*
[2] *Faculty of Agriculture, Ibaraki University*

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The Widas block has irrigation command area in north western area of Nganjuk. The Mrican-Kiri block has irrigation command area in south eastern area of Nganjuk. In Widas block a reservoir is constructed in west of Nganjuk, and in Mrican-Kiri block, irrigation water is uptake from Brantas River (Fig.1). The surface irrigation system in Nganjuk area can supply irrigation water in DS1, however, it is not enough to supply water in DS2. Therefore, groundwater is used for conjunction irrigation with surface irrigation in the DS2.

3. Water Balance and GIS Database

In analysis of this research, GIS and remote sensing were used to analysis land use, digital elevation model (DEM) and hydrological data. And water balance analysis was used to analyze groundwater recharge and withdrawal.

First, water balance analysis was conducted in wet and dry seasons, respectively (Fig.2). Precipitation and irrigation data was supplied from local offices. Evapotranspiration was estimated using Penman Monteith method. Surface runoff was estimated using SCS-CN method. Subsurface flow and base flow were estimated from change of water storage (ΔS). ΔS' was replaced ΔS subtracted subsurface and base flows. Withdrawal was assumed same to ΔS'.

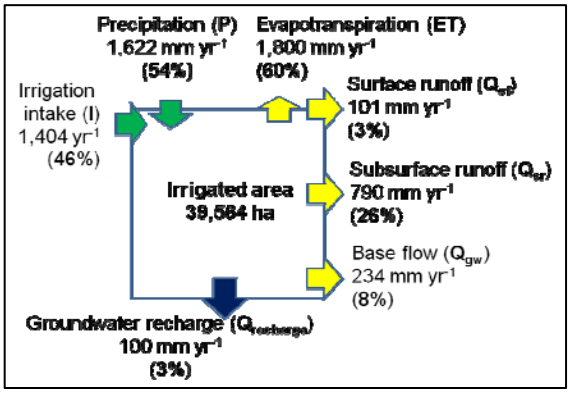

Fig.2. Flowchart of water balance in irrigated area

Second, irrigation well density (IWD) was estimated by cropping area and number of irrigation wells. The spatial distribution of groundwater withdrawal was analyzed using IWD. The IWD was varied 0-3 well ha^{-1} in Nganjuk in 2006. High exploitation (IWD >0.5 well ha^{-1}) has conducted in 79 villages. These villages are located at south and central of Nganjuk area (Fig.3). Based on land-use/land-cover 2004 classification in DS2 and IWD map, irrigated area with crop and IWD >0.05 well ha^{-1} has 82% of cultivated area.

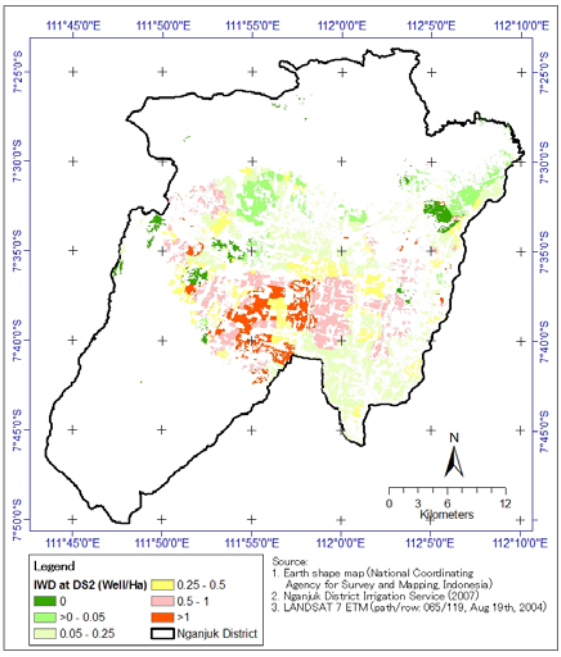

Fig.3. Irrigation well density at irrigated area with crop

4. Conclusion

The research showed as following. The estimation groundwater recharge showed the irrigated area has surplus recharge shallow groundwater. The spatial database for distribution of wells was developed. The IWD analysis showed that irrigation wells were used in DS2.