Agricultural Information and IT

Proceedings of IAALD AFITA WCCA 2008

August 24 - 27, 2008 at Tokyo University of Agriculture

ISBN 978-4-931250-02-4

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Poster Presentations

Exploitation of Groundwater for Irrigation in Nganjuk District, East Java, Indonesia

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Abstract

Nganjuk District experienced fast growth in agricultural sector during 1991-1998. Cropping intensity was increasing from 2.31 crops/year in 1991 become to 2.93 crops/year in 1998. The increasing caused increasing water consumption, especially from groundwater with irrigation wells. Objective of this research is to analysis groundwater exploitation for irrigation by using GIS.

Data was collected from a government office and other studies (i.e. irrigation wells, earth shape map and hydrogeology). All hardcopy of map was transformed to digital spatial data with digitizing process. Field data were input as spatial data. Land-use/land-cover map was developed from LANDSAT data using ERDAS 8.4. Overlay analysis was used to get actual utilization of irrigation well in dry season.

The number of irrigation wells until year 2006 was more than 15,741 wells with discharge varied at 4-60 l/s. Radius influent of well in the research areas are varied at 118-348 m (Prastowo 2007 and Liyantono 2001) and these values are using as assumption for developed irrigation well density (IWD) criteria. IWD varied from 0-2.995 well/ha. Very high exploitation (IWD >1 well/ha) has conducted in 29 villages and high exploitation (IWD >0.5-1 well/ha) has conducted in 50 villages. Both areas should be integrated management of wells and pumps to reduce exploitation. Potential areas in 47 villages can be developed irrigation wells around 82-292 wells.

Based on land-use/land-cover 2004 classification (Landsat ETM^+, August 19, 2004), irrigated areas are distributed in central of Nganjuk with area around 43, 094.61 ha. Irrigated area with crop and IWD >0.05 well/ha has 82.68% of area. Irrigated with crop and IWD ≤0.05 well/ha has 17.32% of area. This state showed that irrigation wells were used in dry season. The further research will continue to estimate irrigation water requirement and groundwater withdraw to supplement the surface water irrigation in this area.

Keywords: groundwater, irrigation well, well density, GIS

Introduction

Generally, Nganjuk has 3 planting season, i.e., wet season (WS), first dry season (DS-I) and second dry season (DS-II). Paddy fields are cultivated in WS and DS-I. Secondary crops (corn, soybean, onions, chilies, melons and vegetables) are cultivated in DS-I and DS-II. Groundwater is used for irrigation in the dry season, which occurs during DS-I and DS-II. The average annual rainfall (1990-2006) was 1,722 mm/year with 82 rainfall event days/year. Based on

Oldeman classification, Nganjuk District is classified as type C3 with 6 dry months (May-October) and 5 wet months (December-April). This area can be planted rice only one time and one secondary crop (palawija) depends on the irrigation water supply.

Nganjuk District experienced fast growth in agricultural sector during 1991-1998. Agricultural area at this district was 43,000 ha in the year 1991 with average cropping intensity 2.31 crops/year. It has increased to 2.93 crops/year in 1998. The fast growth, it was caused by irrigation channel repair and development, was also caused by increasing the sources of water irrigation. It was taken from groundwater with irrigation wells. Groundwater discharge with irrigation wells can affect negatively at environmental if discharge is over exploitation.

The development of irrigation well has been conducted since 1975, through deep wells and shallow wells. The number of irrigation well in Nganjuk until year 2006 was more than 15,741 wells with discharge varied at 4-60 l/s. Radius of influent in this research area varied at 118-348 m (Prastowo 2007 and Liyantono 2001). Most of deep wells are located in northern of Nganjuk (Rejoso, Gondang, Sukomoro, Bagor, Nganjuk, Lengkong and Wilangan sub-districts). While most of shallow wells are located in southern of Nganjuk (Pace, Loceret, Bagor, Berbek, Sukomoro, Tanjunganom, Baron, Kertosono, Ngronggot and Nganjuk sub-districts). Shallow aquifer have thickness of 8.6-34 m with average depth of 9.9-22 m. Deep aquifer have thickness of 16.7-65 m with average depth of 33.75-96.25 m (Liyantono, 2001).

Centrifugal pump of deep wells have been installed 1-3 meters below ground surface to lift up groundwater in 1996 in Sukomoro and Gondang Sub-districts. Thereafter in 1998, in the same area centrifugal pump of deep wells must have been installed 1-5 meters below ground surface to lift up groundwater. These states showed that groundwater level became decreasing and affected by activity in recharge area, exploitations in discharge area or climate changes (Liyantono, 2001).

Objective of the research is to analysis groundwater exploitation for irrigation by using GIS.

Materials and Methods

Data were collected from a government office and other studies, i.e., irrigation wells, earth shape map and hydrogeology. All hardcopy of map was transformed to digital spatial data with digitizing process. Field data and GPS data were input as spatial data. Irrigation well density (IWD) was generated from number of wells at agricultural areas in each village. Criteria of IWD based on the radius influent of well in the research area. Radius influent of well in these research areas are varied at 118-348 m (Prastowo 2007 and Liyantono 2001).

Land-use/land-cover map was developed from LANDSAT data using ERDAS 8.4. LANDSAT data was acquisition in DS-II at August 19, 2004. Supervised classification method was used to classification LANDSAT image. Training sites defined by researcher using NDVI, map of Google Earth 4.0.2737 and earth shape map. Overlay analysis was used to get actual utilization of irrigation well in dry season (Fig.1).

Results and Discussion

Dinas Pertambangan Jawa Timur -East Java Mining Service- (1998) stated generally that shallow wells is scattered in central-eastern of Nganjuk District with shallow aquifer depth that is varied 5-30 m. Based on groundwater development project (P2AT) shallow wells data, shallow aquifer depth map was conducted. Around 98.1% of P2AT shallow aquifer depth is deeper than predicted shallow aquifer from Dinas Pertambangan Jawa Timur. This value shows

that the actual shallow aquifers were deeper than predicted shallow aquifer. Based on hydrogeology map (Indonesia Hydrogeology Map by R. Soekardi Poespowardoyo), P2AT shallow wells are located in the same area with medium-high productivity and scattered in wide area. Around 85.2% of P2AT shallow wells have high specific capacity (>172.8 m^2/day) and medium specific capacity (86.4-172.8 m^2/day) is around 14.8%.

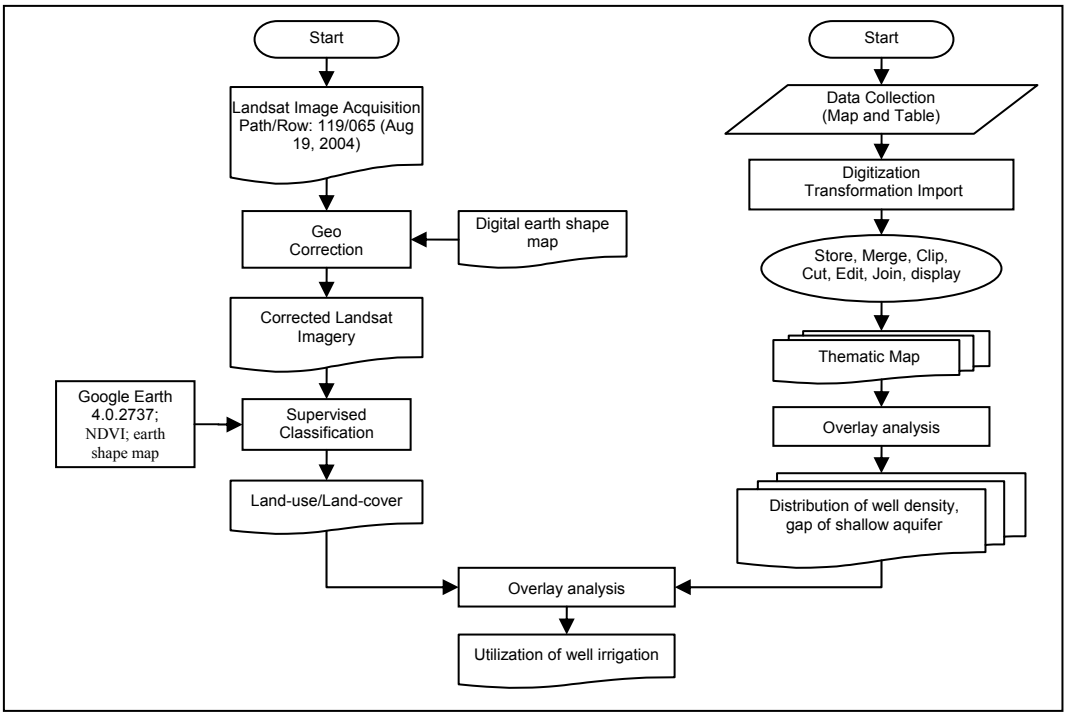

Fig.1. Flowchart of the research

Irrigation well density (IWD) varied from 0 - 2.995 wells/ha. Very high exploitation (IWD > 1 wells/ha) has conducted in 29 villages and 9 sub-districts with agricultural area of 3,703.7 ha and the number of wells was around 6,076 wells. While area with high exploitation (IWD > 0.5 and ≤ 1 well/ha) is 7,521.7 ha with around 5,259 wells and conducted in 50 villages and 13 sub-districts. Both areas should need integrated management of wells and pumps to reduce exploitation. Potential area in 47 villages and 14 sub-districts can be developed irrigation wells around 82-292 wells (IWD < 0.05 well/ha). While 20,492.5 ha of agricultural area has saturated IWD and should be managed to restricted population of irrigation well. IWD in these area is >0.05 and ≤ 0.5 well/ha and conducted in 120 villages and 17 sub-districts.

Table1. Irrigation wells density at agriculture area in Nganjuk District

Class	Well Density (wells/ha)	Number of Villages	Number of sub-districts	Number of Wells	Area	
					ha	%
Low	0	28	13	0	3,214.29	8.02
	>0 - 0.05	25	9	127	5,167.84	12.89
Medium	>0.05 - 0.25	73	16	1,822	1,4668.4	36.58
	>0.25 - 0.5	47	15	2,175	5,824.12	14.52
High	>0.5 - 1	50	13	5,259	7,521.71	18.76
	>1	29	9	6,076	3,703.70	9.24

Based on land-use/land-cover 2004 classification (Landsat ETM^+, August 19, 2004), irrigated area are distributed in central of Nganjuk with area around 43, 094.61 ha. Irrigated

area with crop and IWD >0.05 well/ha has 82.68% of area. Irrigated area with crop and IWD ≤0.05 well/ha has 17.32% of area. This state showed that irrigation wells are used in dry season. The further research will continue to estimate irrigation water requirement and groundwater withdraw to supplement the surface water irrigation in this area.

Table2. Land-use/land-cover in Nganjuk District (Landsat ETM^{+}, August 19, 2004)

Class	Area (Ha)	Percentage
Built-up	18,369.99	14.14
Forest	3,614.76	2.78
Plantation	18,925.02	14.57
Bush, grass	20,405.61	15.71
Irrigated with crop	31,276.89	24.08
Irrigated without crop	11,817.72	9.10
Non-irrigated	16,159.23	12.44
Dry-land	7,744.50	5.96
Cloud	1,587.06	1.22

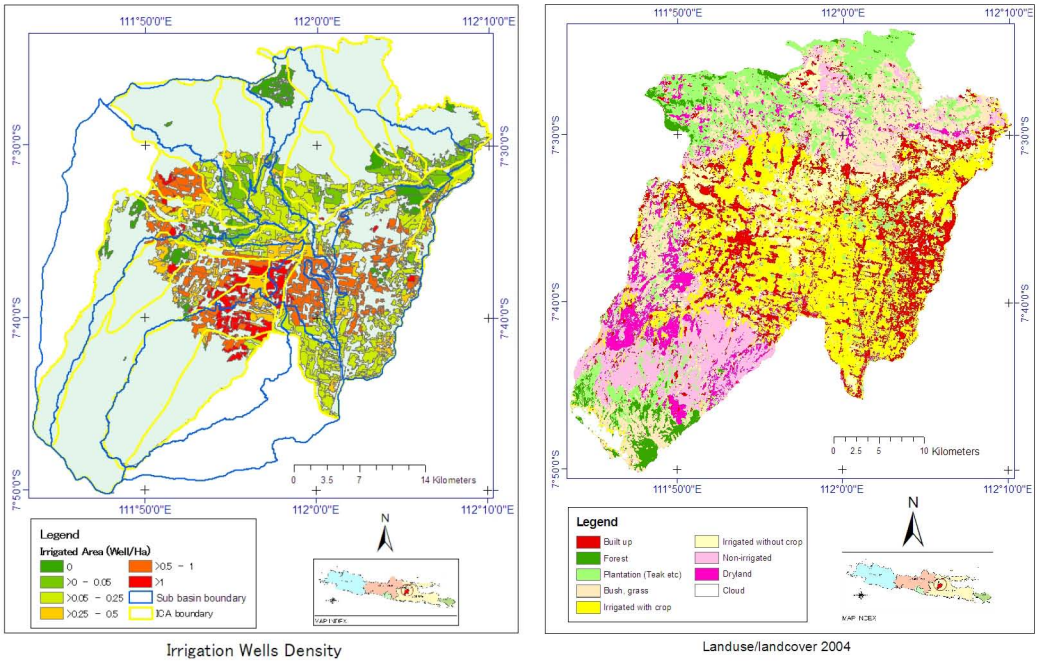

Fig.2. Irrigation wells density 2007 and land-use/land-cover 2004

Table3. Irrigation wells density at class irrigated with crop in Land-use/land-cover 2004

Class	Well Density (wells/ha)	Irrigated with crop	
		ha	%
Low	0	1,260.36	5.61
	0-0.05	2,632.05	11.71
Medium	0.05-0.25	7,882.20	35.06
	0.25-0.5	3,542.85	15.76
Hight	0.5-1	4,626.18	20.58
	>1	2,537.28	11.29
Total		22,480.92	100.00

Conclusion

- The actual shallow aquifers were deeper than predicted shallow aquifer by Dinas Pertambangan Jawa Timur.
- Very high exploitation (IWD >1 well/ha) has conducted in 29 villages and high exploitation (IWD >0.5-1 well/ha) has conducted in 50 villages. Both areas should be integrated management of wells and pumps to reduce exploitation.
- Potential areas in 47 villages can be developed irrigation wells around 82-292 wells.
- While 20,492.5 ha of agricultural area in 120 villages and 17 sub-districts have saturated IWD (>0.05 and ≤ 0.5 well/ha) and should be managed to restricted population of irrigation well.
- Irrigated areas with crop and medium-high exploitation of groundwater have 82.68% of area. This state showed that irrigation wells were used in dry season.

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