

WATER STORAGE INDEX ESTIMATION USING GEOGRAPHIC INFORMATION SYSTEM

Estimasi Indeks Penampungan Air menggunakan Sistem Informasi Geografis

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ABSTRACT

The study aims to estimate water storage index (IPA) of six sub watersheds (Panjang, Rengas, Legi, Galeh, Parat, and Sraten) in the catchment area of Rawapening lake by using Geographic Information System. Water storage index can be calculated from average discharge (m³) divided by water requirement (m³) for each land cover/land use. Landuse information is obtained from Indonesian Topographic Map scale of 1:25.000 as updated by using SPOT image (2006), while surface water availability data was obtained from the ministry of public works. The results indicate that 1) IPA of Panjang Subwatershed was categorized as good condition with an index value of 1,49; 2) IPA of Rengas and Legi sub watersheds were categorized as moderate condition with index value 0,76 and 0,55; 3) IPA of Galeh, Parat, and Sraten sub watersheds was categorized as bad with index value of 0,3, 0,15, and 0,33, this watershed need to be improved especially an effective water resources plan, allocating and distributing of water according to priority establishment.

Keywords: water storage index/IPA, sub watershed health, Geographic Information Syatem (GIS)

ABSTRAK

Penelitian ini bertujuan untuk memperkirakan Indeks Penampungan Air (IPA) dari enam sub DAS (Panjang, Rengas, Legi, Galeh, Parat, and Sraten) di DAS Rawapening menggunakan Sistem Informasi Geografis (SIG). Perhitungan IPA didasarkan pada rerata discharge (m³) dibagi dengan jumlah kebutuhan air (m³) untuk masing-masing penggunaan lahan. Informasi penggunaan lahan diperoleh dari RBI skala 2 : 25.000 yang diupdate dengan citra SPOT (2006). Sementara ketersediaan air permukaan diperoleh dari data kementrian PU. Hasil penelitian menunjukkan bahwa berdasarkan perhitungan IPA: 1) Sub DAS Panjang termasuk kategori baik dengan indeks 1,49. 2) Sub DAS Rengas dan Legi masuk dalam kategori sedang dengan indeks 0,76 dan 0,55. 3) Sub DAS Galeh, Parat, dan Sraten termasuk dalam kategori buruk dengan indeks 0,3; 0,15; dan 0,3 sehingga perlu ditingkatkan khususnya dalam hal perencanaan SDA, aloksi, dan distribusi terkait dengan prioritas yang ditentukan.

Kata kunci: IPA, kesehatan DAS, SIG

INTRODUCTION

Watershed managements play an important role in the future in many developing countries where watershed management concepts and the supporting skills have not been well developed. Population growth and increasing demands for natural resources in these countries have exerted severe impacts on watersheds which require careful integrated watershed planning (Low, 1990). Damage to watershed areas can result to a variety of disaster such as siltation of rivers, canals, dams, and flood. The number of watersheds that require priority of management were continuously increase from 22 watersheds in 1984 to 39 and 62 watersheds in 1992 and 1998, respectively. Currently, there are about 108 watersheds need management priority. Decreasing of watershed function was because of exploitatively natural resource utilizations which was higher than its carrying capacity and capability (Paimin, et al. 2012).

Lake of Rawapening is one of the priority control of environmental issues associated with high sedimentation, resulted from high soil erosion on the catchment area. Sedimentation in Lake of Rawapening is tend to be increased from 133,75 m³ in 1993 to 149,22 m³ in 2003. However, the capacity of water of Lake of Rawapening decreased about 16 million m³ over a periode of 28 years (1976 untill 2004) from 65 million m³ to 49 million m³ (kompas, 2009). If no efforts to save, the existence of the natural lake is threatened and expected in the year of 2012 will turn into mainland. Catchment area of Lake of Rawapening is located in the upper of Tuntang watershed.

Upper watershed ecosystem is an importants part because it has a protective function of water to all part of the watershed. Land management activities in the upper watershed such as conversion of for-

est land, landuse not in accordance with the carrying capacity of land results land resources degradation. The research objective was to estimate water storage index (IPA) of six sub watersheds (Panjang, Rengas, Legi, Galeh, Parat, and Sraten) in the catchment area of lake of Rawapening by using Geographic Information System.

RESEARCH METHOD

This research was located in catchment area of Lake of Rawapening. Administratively, most of the research area is in Semarang District Central Java Province and is geographically located at coordinate 110°17' east longitude - 110°30' east longitude dan 7°5' south latitude - 7°25' south latitude. Research location is illustrated at Figure 1.

The materials and tools used in this research were: (1) Base map: Indonesia topographic map scale 1:25.000 (digital format), Administrative map, Contour map, dan Road and river network map. (2) Sattelite image: Digital SPOT image recorded 2006. (3) Tools: Software ArcView 3.2, Erdas Imagine 8.4, computer, dan Global Positioning System (GPS).

The research was conducted with the following steps: (1) Delineating sub watershed using contour and river network map, (2) Land cover/land use information obtained from Indonesia Topographic Map (RBI) scale of 1:25.000 (digital format), updated by using SPOT image (2006 recorded), field check conducted in 2011, (3) Calculating area of land cover/land use, (4) Average discharge annually (from 2000 to 2009) was obtained from Semarang District Department of Public Works for six rivers, (5) Calculating of water requirement for each land use/land cover (base on Dumairi, 1992) presented at appendix 1. (6) Calculating of water storage index for six sub watersheds.

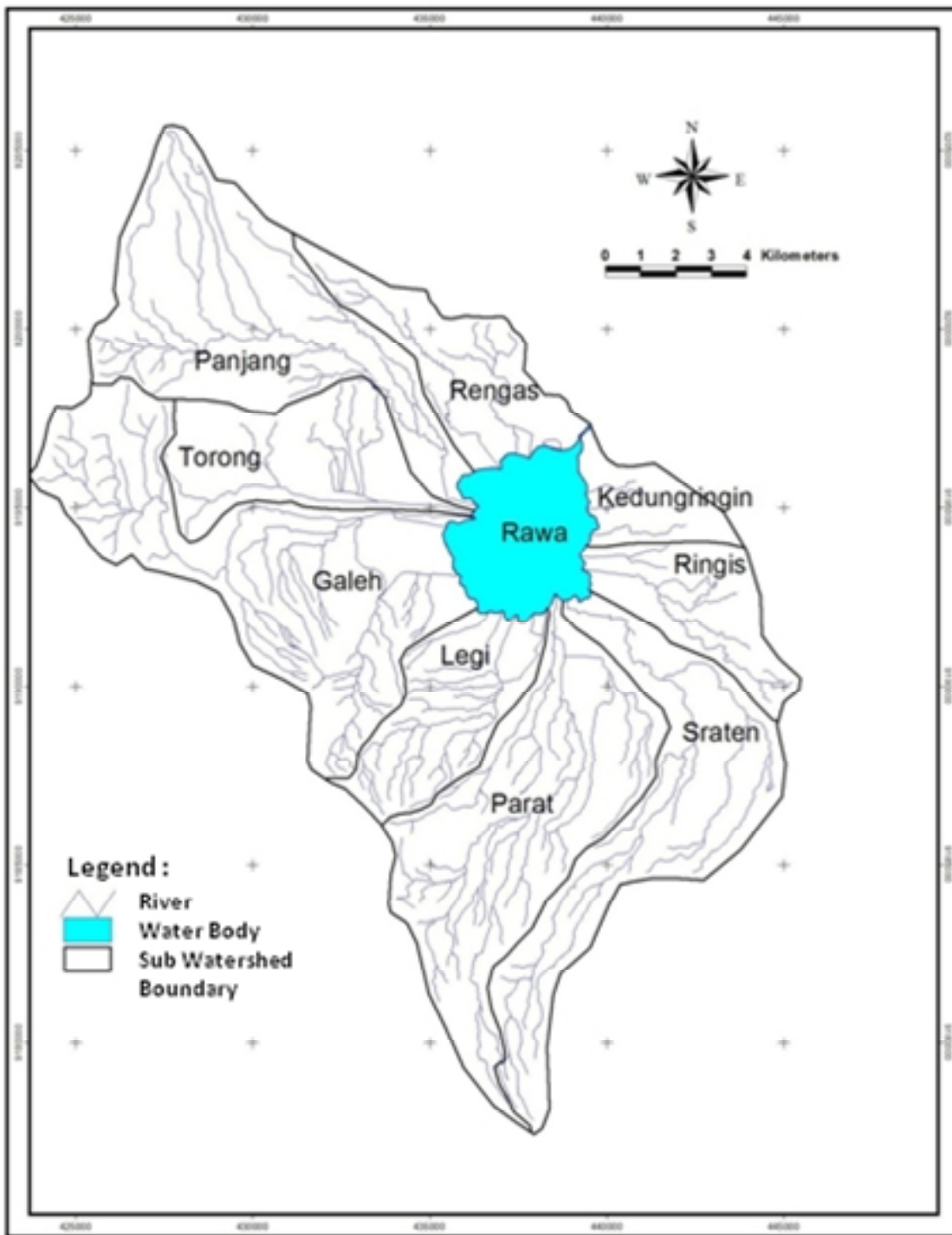


Figure 1. Map of Catchment Area of Lake of Rawapening

RESULT AND DISCUSSION

Land cover/land use information is one of the important parameter in watershed management planning. Therefore, accurate and up to date information of land cover/land use is necessary to conduct watershed management activity. Information of land cover/land use of catchment area of Lake of Rawapening was obtained from Indonesia Topographic Map scale of 1:25.000 (digital format), and has been up dated by using SPOT 2 image 2006 recorded and field check was conducted in 2011. Land cover/land use type in the study area can be divided into 12 types namely rare forest, rare private forest, dense private forest, dense forest, settlement, mix settlement with dry field, estate, dryland farming, irrigated land (paddy field), shrub, dry land/vegetable crop, and water body. The area of land use/land cover of each sub watershed was presented at table 1.

For water requirement calculation, the land cover/land use is reclassified into five main land cover/land use types namely forest, dryland farming, irrigated land/paddy field, dryland/vegetables crop, and settlement. The area of the land cover/land use (after reclassification) was presented at table 2. While water requirement of each land cover/land use of each sub watershed was presented at table 3.

Based on table 2. Forest (consisting of rare forest, rare private forest, dense private forest and dense forest) occupies the largest area (12.120,55 ha). The largest forest area occurred at Galeh sub watershed (5.043,82 ha). While, settlement (consisting of settlement and mix settlement and dryland) occupies the smallest area (2.213,59).

Average discharge annually of six rivers (from 2000 to 2009) was obtained from Department of Public Works of Semarang

District as presented at table 4. Value of water requirement and average discharge was used to calculate water storage index (IPA). Average discharge indicates water availability of each sub watershed. IPA can be calculated by using a formula :

$$IPA = \frac{\text{Average discharge (m}^3\text{)}}{\text{Water requirement (m}^3\text{)}}$$

Water storage index (IPA) of each sub watershed in the research area was calculated and as presented at table 5. Value of water storage index (IPA) can be used to evaluate sub watershed health. Classification of IPA is presented as:

1. IPA < 0,5 (bad)
2. IPA 0,5 – 0,9 (moderate)
3. IPA > 0,9 (good)

Panjang Subwatershed was categorized as good condition with an index value (IPA) of 1,49 as indicates that water availability of the sub watershed is bigger than water requirement. Rengas and Legi sub watershed has an index value (IPA) of 0,76 and 0,55 was categorized as moderate condition. While Galeh, Parat, and Sraten sub watershed was categorized as bad condition with an IPA value of 0,33, 0,15, and 0,33. Sub watershed wich is having bad condition needs improvement especially an effective water resources plan, allocating and distributing of water according to priority establishment.

CONCLUTION

1. Panjang Subwatershed was categorized as good condition with an index value (IPA) of 1,49 as indicates that water availability of the sub watershed is bigger than water requirement.

Tabel 1. Area of Land Use/Land Cover for Each Sub Watershed

No	Land Use/Land Cover	Sub Watershed (ha)							Water Body	Total
		Galeh	Legi	Panjang	Parat	Rengas	Sraten			
1.	Rare forest	0,00	0,16	69,34	147,73	0,00	107,58	0,00	324,81	
2.	Rare private forest	4.912,82	1.127,99	958,76	1.825,86	162,19	2.018,97	0,00	11.006,58	
3.	Dense private forest	0,00	0,00	0,00	0,00	34,40	0,00	0,00	34,40	
4.	Dense forest	0,00	0,00	224,46	87,98	0,00	0,00	0,00	312,45	
5.	Settlement	281,27	78,19	343,04	47,14	101,71	210,92	0,00	1.062,27	
6.	Mix settlement and dryland	323,47	16,11	198,32	138,55	239,88	235,21	0,00	1.151,54	
7.	Estate	131,00	0,00	92,69	0,00	218,62	0,00	0,00	442,31	
8.	Dryland farming	99,70	22,58	0,00	1.549,57	0,00	745,72	0,00	2.417,58	
9.	Irrigated land/paddy field	1.018,81	421,00	444,22	604,58	377,95	240,38	0,00	3.106,94	
10.	Shrub	0,00	119,54	0,00	113,88	0,00	296,13	0,00	529,55	
11.	Dryland/vegetable crop	3,07	0,00	1.706,15	0,00	537,95	0,00	0,00	2.247,17	
12.	Water body/lake	0,00	0,00	0,00	0,00	0,00	0,00	1.517,46	1.517,46	
	Total	6.770,14	1.785,58	4.036,98	4.515,29	1.672,70	3.854,89	1.517,46	24.153,05	

Sumber: hasil analisis

Tabel 2. The Area of The Land Cover/Land Use (After Reclassification)

No	Land Cover/Land Use	Sub Watershed (ha)						Total
		Galeh	Legi	Panjang	Parat	Rengas	Sraten	
1.	Forest	5.043,82	1.128,15	1.345,26	2.061,57	415,21	2.126,54	12.120,55
2.	Dryland farming	99,70	22,58	0,00	1.549,57	0,00	745,72	2.417,58
3.	Irrigated Land/paddy field	1.018,81	421,00	444,22	604,58	377,95	240,38	3.106,94
4.	Dryland/vegetables Crop	3,07	119,54	1.706,15	113,88	537,95	296,13	2.776,72
5.	Settlement	604,74	94,31	541,36	185,69	341,59	446,13	2.213,81
Total		6.770,14	1.785,58	4.036,98	4.515,29	1.672,70	3.854,89	22.635,59

Sumber: hasil analisis

Tabel 3. Water Requirement of Each Land Cover/Land Use of Each Sub Watershed

No.	Land Cover /Land Use	Sub Watershed (m ³)						Total
		Galeh	Legi	Panjang	Parat	Rengas	Sraten	
1.	Forest	50438182	11281528	13452558,6	20615697	4152088,8	21265428,5	121.205.478,44
2.	Dryland farming	1196436,5	270964,81	0	18594895	0	8948617,64	29.012.569,44
3.	Irrigated land/paddy field	14513720	2263379,6	12992554,8	4456558,1	8198049,12	10707150,7	53.131.660,40
4.	Dryland/vegetables crop	41462,78	1613854,2	23032976,8	1537340,6	7262364,15	3997704,51	37.485.703,07
5.	Settlement	7256860,2	1131689,8	6496277,4	2228279,1	4099024,56	5353575,36	26.566.497,01
Total		73446662	16561417	55974367,6	47432770	23711521,6	50272476,8	267.401.908,37

Sumber: hasil analisis

Tabel 4. Water Requirement of Each Land Cover/Land Use of Each Sub Watershed

No.	River	Average discharge (l/dt)										Total	Average	Average discharge (m3)
		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009			
1.	Panjang	1902	2010	1280	811	466	822	696	562	339	356	9244	924,4	79868160
2.	Rengas	424	324	245	142	167	276	172	154	124	125	2153	215,3	18601920
3.	Galeh	411	428	407	293	206	160	267	256	260	214	2902	290,2	25073280
4.	Legi	297	183	128	274	87	140	103	92	126	132	1562	156,2	13495680
5.	Parat	212	145	122		93	121	98	97	137		1025	102,5	8856000
6.	Sraten	397	158	192	190	134	123	177	91	82	186	1730	173	14947200

Sumber: hasil analisis

Tabel 5. IPA Value of Each Sub Watershed and Its Category

No.	Sub Watershed	Average discharge (m3)	Water requirement (m3)	IP.A	Category
1.	Panjang	79.868.160,00	53.643.144,02	1,49	Good
2.	Rengas	18.601.920,00	24.584.318,34	0,76	Moderate
3.	Galeh	25.073.280,00	83.384.311,65	0,30	Bad
4.	Legi	13.495.680,00	24.402.015,35	0,55	Moderate
5.	Parat	8.856.000,00	57.486.167,02	0,15	Bad
6.	Sraten	14.947.200,00	45.334.349,08	0,33	Bad

Sumber: hasil analisis

2. Rengas and Legi sub watershed has an index value (IPA) of 0,76 and 0,55 was categorized as moderate condition
3. Galeh, Parat, and Sragen sub watershed was categorized as bad condition with an IPA value of 0,33, 0,15, and 0,33

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