Asian Journal of Water, Environment and Pollution, Vol. 12, No. 1 (2015), pp. 11–19.

Evaluation of Land Use Change in the Upstream of Ciliwung Watershed to Ensure Sustainability of Water Resources

Kholil* and Indarti Komala Dewi[1]

Faculty of Environment, Sahid University, Jakarta, Indonesia
Faculty of Environment, Pakuan University, Bogor, Indonesia
✉ kholil2005@yahoo.com

Received August 18, 2014; revised and accepted December 11, 2014

Abstract: The upstream of Ciliwung watershed has a very important role for the economic development in the downstream area (Jakarta as the capital of the country). One of the main functions is as water catchment areas and water reserves, as well as water management. The rapid population growth has encouraged the growth of settlements in the upstream of Ciliwung watershed, which causes the decrement of vegetation space, resulting in increment of surface water flows in the rain as potential causes of flooding in Jakarta.

This study aims to evaluate the suitability of settlements in the upstream of Ciliwung watershed area by using GIS (Geographical Information System) with over-lay system through Arc View GIS 3.3 software with geo-processing facilities.

The analysis showed that the development of existing settlements tend to be out of control, because it is not only in the corresponding region but also has entered a permanent settlement that is not suitable for residence. The area of suitable land for settlements in the upstream of Ciliwung watershed is only 19.89% but the existing settlements have reached 22.65% and even about 10-13% is in the area prone to a very dangerous landslide.

Key words: Ciliwung watershed, water infiltration, spatial plan, residential areas, non-residential areas, run off.

Background

Ciliwung watershed is one of the 5960 watersheds in Indonesia, which has been designated as a national strategic area, because it has a very important role for the development of national economy. Ciliwung watershed area spreads around 347 km^2, which flows along 117 km through two provinces which are West Java and special region of Jakarta. Ciliwung watershed is divided into three parts: the upstream, midstream and downstream of Ciliwung watershed.

The Upstream section covers an area of 14,860 hectares where it is a mountainous region with elevations between 300 metres up to 2040 metres above sea level, with an annual average rainfall of 3636 mm. In this region it is generally characterized by the fast-flowing river, especially during the rainy season, and the slope above 45% level. It is mostly used as a limited agricultural and protected area (Center for Ciliwung Watershed Management, 2003).

The main function of this upstream part is a water catchment area to protect the underneath area that is very sensitive to the changes of river flows debit that give the flooding result. Catchment area is an area that has a high ability to absorb rain water so that the water filling from the earth (aquifers) that is useful as a source of water, water reserves, and flood control. The middle section which covers 94 km^2 is an area of undulating and hilly surface with elevation variations between 100 metres and 300 metres above sea level.

*Corresponding Author

The area is dominated by the level of 2-15% slope, and an annual rainfall average of 3910 mm (Antoro and Fahmiza, 2002). While the downstream section of 82 km^2 is the widest lowland having topography ramps with elevation between 0 and 100 metres above sea level. Most of the areas are with a slope of 0-2%. The annual average rainfall is 2126 mm. The downstream is part of Jakarta area, the capital city which is the centre of the Indonesian government and business.

The watershed is an ecosystem where the organisms and environmental elements interact with the biophysical and chemical matter dynamically, constrained by the limits of natural topography and inside there are balance of inflow and outflow of material and energy (Mangundikoro, 1986; Sinukaban, 1994; Ramdhan, 1999).

Hydrological function of a watershed is related to its ability in terms of: (1) Transmission of water, (2) Buffer peak rain events, (3) Release of water slowly, (4) Maintaining water quality, (5) Reducing the land mass transfer, for example through erosion, (6) Reduce erosion, and (7) Maintain microclimate.

Utilization of upstream watershed is based on conservation function to maintain its environmental condition in order not to be degraded, which among others can be indicated by the condition of the watershed land vegetation cover, water quality, the ability to store water (discharge), and precipitation. Watershed must have an open space in the form of at least 30% vegetation (Act No. 26, 2007).

According to Eco Management Center of Java Region (2012), the use of land in Ciliwung watershed is distinguished in 11 classes, which are primary, secondary, mixed gardens, plantations, settlements, swamps, rice fields, shrubs, open land, moor/fields, and bodies of water. The land use of Ciliwung watershed is mostly paddy fields which cover an area of 56,009.44 hectares of agricultural area or covering 63.34%.

The second largest land use is an area of mixed farms covering 16.873.05 hectares or 19.08% of land followed with rice field area of 5,613.21 ha or 6.35 %. Among the three Ciliwung basin areas (upstream, midstream and downstream), the upstream has the most important ecological functions, because this part is a water catchment area, as well as water management (water providers, and flood control). Damage to this section will give a serious impact on the bottom, especially floods in the rainy season and drought in the dry season, so that will affect the economic and social activity, especially in the downstream (Jakarta as the capital city of the country).

Geographical condition of the majority of the upstream of Ciliwung watershed is land with a slope of above 40% and a very cool air. The width composition and slope level of Ciliwung watershed in upstream area are shown in Table 1.

Table 1: Width composition and slope level of the upstream of Ciliwung watershed

No.	*Slope level (%)*	*Width (%)*
1	0-3	8.47
2	3-8	13.91
3	8-15	11.73
4	15-25	9.78
5	25-40	25.99
6	>40	40.12

Source: Center for Ciliwung Watershed Management (2003).

Table 1 shows that the major (40.12%) area of the upstream of Ciliwung watershed is in the slope at a level above 40%. This region has a very large potential for erosion (Table 2) and the management should pay attention to the principles of land conservation, both vegetative and civil engineering.

Table 2: Level of erosion of the upstream of Ciliwung watershed

No.	*Level of erosion*	*Classifications*	*Width (acres)*	*Percentage (%)*
1	0	Not dangerous	2,983.09	20.05
2	I	Less dangerous	3,375.35	22.69
3	II	Sufficient (fairly dangerous)	4,115.37	27.66
4	III	Dangerous	1,517.54	10.21
5	IV	Very dangerous	2,884.65	19.39
	Total		14,876	100.00

Source: Center for Ciliwung Watershed Management (2000).

In accordance with the General Spatial Plan (Spatial 2005-2025), land reserved for non-agricultural cultivation, agriculture and industry in the entire area of Ciliwung watershed (upstream, midstream and downstream) is only 19,845 hectares. However, research results of the Indonesian Institute of Sciences (LIPI, 2007) showed that in the last 10 years it has increased to 22,929 hectares, or increased by more than 3,000 hectares and the settlements have increased to 20%, while the arable land decreased 37%.

Particularly in the upstream of Ciliwung watershed, the development of settlements had been increasing up to five times during 15 years, from 3.96% in 1992 to 20.17% in 2007, and the settlement also has been built in the protected area (Syartini et al., 2007), which causes shrinkage of land in the protected area by 20%, and serious degradation, as well as an increase in marginal lands (Sabar, 2008), increased erosion (Qodariah et al., 2008), increased run-off (Sawiyo, 2009) and landslides and water quality (Taufik et al., 2008; Fahrudin et al., 2009).

One of the factors causing the said degradation is the change of land use that does not fit to the upstream of Ciliwung watershed area (Irianto, 2007; Fahrudin, 2007; Arif Jaya, 2008; Lukman, 2010). Incompatible land uses according to Weng (2004) and LOI (2008) is the cause of the upstream of Ciliwung watershed degradation. Land conversion generally occurs in the use of forest land for plantation and farming areas, plantation areas into agricultural lands and settlements or agricultural areas into residential and industrial uses.

One of the indicators that gives the result of degradation in the upstream of Ciliwung watershed is the gap between the water precipitation between rainy season and dry season, and at this time the gap is expected to reach 300 times BPLHD (Environmental Management Agency of Jakarta, 2012), as it also increased the surface flow (run-off) at the time of rainy season that caused severe flooding in Jakarta (2003, 2007, 2010 and 2012) with the water's height of 50-450 cm and number of massive loss. In 2012 the total economic loss caused by the floods in Jakarta has reached to Rp 20 trillion, BPLHD (Environmental Management Agency of Jakarta, 2013).

After the implementation of regional autonomy (Regulation no 32/2000), the management of natural resources in the watershed is then done fragmented. Each of these regions manages own natural resources (NR) in respective area. Natural resources management is often not matched by conservation efforts and does not make the conservation as a priority activity (Ekawati, 2007). If this condition is allowed to continue, the upstream of Ciliwung watershed will be degraded, thus giving, as a result, more serious negative impacts such as floods and droughts in the future.

Based on the above objective condition, the main problem faced by the current upstream of Ciliwung watershed is to increase the land cover (the decrement of vegetation space) due to the growth of settlements, the flow of surface water (run off) is increased when it rains and it is the potential major flooding in the rainy season and drought in the dry season in the downstream region.

This study aims to evaluate the deviation of alignment or changes in the use of land at the upstream of Ciliwung watershed, due to the development of settlements, agriculture and industry, using GIS approach (Geographical Information System).

Methodology

Data Collections

Analyzed data in this study is in the form of primary data, which is taken by recording the coordinates of the land cover in the field using GPS. Checking points (49) are determined by purposive. The secondary data are obtained from various official sources, especially from BIG (Geospatial Information Agency), BPDAS (Center for Ciliwung Watershed Management), and Bogor local government. Secondary data are needed such as:

1. Image data sheets 1209-141 and 1209-142 with a scale of 1:100,000
2. The scale of soil of 1:250,000
3. Spatial plan of Bogor Regency in 2005-2025 with a scale of 1:100,000
4. Citra Landsat ETM 2006 path/row 7112065-0.6520060627
5. Location permits with a scale of 1:100,000
6. Natural conservation index

Methods of Analysis

Analysis is conducted to determine: (1) the suitability of the settlement area and (2) evaluation of the settlement area. Analysis to assess the suitability of the settlement area is done by first determining: (a) The criteria for the settlements/locations that are in the cultivated region, using the Regulation No. 26/2008—the upstream Ciliwung watershed is the area of water and soil conservation that should be protected. The analysis parameters are the type of soil, rainfall, slope, river banks, altitude and status of forest; (b) Criteria for the settlements' location should

be safe from natural disasters, the parameters analyzed were prone to landslides, according to the Regulation No. 26/2008; and (c) Criteria of settlements based on residential neighbourhoods, the parameters used are the altitude (<1000 m) and slope (0-15%), according to the urban settlements planning guidelines (Ministry of Public Works, 1979). In general, there are five stages of settlement land suitability analysis, which are:

1. Phase I, using the parameters of slope, rainfall and soil type with three regional groups:
   a. Cultivation area with a score of ≤124
   b. Buffer area for cultivation non-residential or agricultural cultivation with a score of 125-175
   c. Protected area with a score above 175.
2. Phase II, using the slope parameter:
   • Cultivation area if ≤15% with soil type regosol, litosol
   • Protected area if >15% with soil type of organosol.
3. Phase III, using river banks parameter of 50 m left and right:
   • Cultivation area if ≥50 m
   • Protected area if <50 m
4. Stage IV, using forest status parameter:
   • Protected forest, conservation forest, production forest and non-forest production
5. Phase V, using the altitude parameter:
   • Cultivation area if <2000 m above sea level,
   • Protected area if ≥2000 m above sea level.

The residential area evaluation is conducted to analyze the alignment or deviations occur between: (a) the suitability of the area for settlement with RTRW (Spatial Plan), (b) the suitability of residential areas with existing land cover in 2006; (c) general spatial plan with land cover in 2006; and (d) land cover land in 2006 with Spatial Plan and suitability of the area for settlement.

Analysis method uses Arc View GIS 3.3 with the help of geoprocessing facility. The determination of the reference system (coordinate, the projection and datum) uses the Word Geodetic System (WGS) 1984 with the 48 UTM projection. The image data were classified into five types of dry lands, wet lands, tea plantations, settlements and dense vegetation. The classification method used is a supervised one using band 5 (red), band 4 (green) and band 2 (blue) (Weng, 2002).

The level of accuracy is measured using the error matrix (Lillesand and Kiefer, 2000). The level of accuracy is based on the value of overall accuracy and Khat (K) statistic as follows:

$$\text{Overall Accuracy} = \frac{\sum X_{ii}}{N} \times 100\%$$

where N is number of the whole sample and ΣX_{ii} is total of column sample diagonal.

$$\text{Khat (K) Statistics} = \frac{N(\sum X_{ii^-}(\sum X_{i+}\sum X_{+i})}{N^2 - \sum(X_{i+}\cdot\sum X_{+i})}$$

where X_{+i} is total of ith column sample; X_{i+}—total of jth column sample; N—total samples; and ΣX_{ii}—total of column sample diagonal.

Results and Discussion

Suitability Analysis Regions for Settlement

Based on the criteria given for the settlement, the result of the analysis using GIS (Geographic Information Systems) (Ligtenberg et al., 2004; Syartinilia et al., 2006) to the image data, we obtained the degree of suitability of land use in the area of the upstream of Ciliwung watershed as shown in Table 3.

Table 3: Land use suitability of the upstream of Ciliwung watershed

No.	*Suitability region for settlement*	*Width (acres)*	*(%)*
1	Cultivation area (settlement and non-settlement)	6,439.89	43.29
2	Protected area	8,436.47	56.71
	Total	14,876.37	100.00

Table 3 shows that the majority (56.71%) of the upstream of Ciliwung watershed is the protected area, and the rest (43.29%) is for cultivation. By adding a safety criteria for settlements, the result of such analysis is shown in Table 4.

Table 4 shows that after the safe parameters entering the settlements, area in residential zone becomes 17.38%, the remaining 5.78% occupies less suitable zone for settlement, while area which is unsuitable for settlement becomes 76.84%, covering 20.13% in non-agricultural cultivation zone and 56.71% located in the protected zone. This shows that there is approximately 20.13% residential area that is unsuitable based on the safety criteria from disaster.

Based on the criteria, the settlement zone should lie at an altitude <1000 m above sea level and with a slope of 0-8%, while the appropriate zone rather lies at an altitude <1000 m above sea level and with a slope of 8-15%. If the criteria of settlements neighbourhood is added for the analysis in Table 4, the settlements area decreased to 3.27%, and it occurs to the increment of

Table 4: Suitability of settlement area of the upstream of Ciliwung watershed (by adding a safety criteria for settlements)

No.	*Suitability of land use for settlement*	*Width (acres)*	*(%)*
1	Settlement area		
	a. Suitable zone for settlement	2,585.30	17.38
	b. Less suitable zone for settlement	860.47	5.78
2	Non-suitable area for settlement		
	a. Non-agricultural cultivation zone	2,994.12	20.13
	b. Protected zone	8,437.47	56.71
	Total	14,876.37	100

Table 5: Suitability of settlement area of the upstream of Ciliwung watershed (by adding the criteria of settlements neighbourhood)

No.	*Suitability of land use for settlement*	*Width (acres)*	*(%)*
1	Settlement area		
	a. Suitable zone for settlement	1,580.80	10.63
	b. Less suitable zone for settlement	1,378.13	9.26
2	Non-suitable area for settlement		
	a. Agricultural cultivation zone	3,369.82	22.65
	b. Protected zone	8,547.62	57.46
	Total	14,876.37	100

settlement in the area that is unsuitable for residence in the non-residential cultivation zone at 2.52% and in the protected zone at 0.75%, as shown in Table 5.

Table 5 shows that the more stringent criteria of the settlement would be more shrinks for the suitable residential zone, and it means that the development of settlements on the non-settlement zone will increase. According to Purwanto (2008), it is estimated that there are 3000 big houses (villas) and more than 50,000 houses have been built in this region.

Based on the criteria of altitude, the upstream of Ciliwung watershed is divided into three: the upper part (>1000 m from sea level), the middle (500-1000 m above sea level) and the lower (<500 m above sea level), and so the 98.36% zone is suitable for settlement and somewhat it is more appropriate for the settlement in the middle part.

As for the area that is unsuitable for residential purpose, 75.26% is located at the top with hilly steep morphological condition, and with a very steep slope of 25-40% (>40%), with a height of 1000-2875 m above sea level, with a andosol soil type sensitive to the erosion and landslides during heavy rainfall, this is based on the analysis of Tables 4 and 5 and as a whole can be seen in Table 6.

Table 6 shows that the 98.32% area for suitable settlement is located in the middle of the upstream of Ciliwung watershed, and the remaining is located at the bottom, while the upper part is unsuitable for settlement area. On the contrary, the majority of the protected zone that is unsuitable for settlements (75.26%) is on top of upstream of Ciliwung watershed, and 23.34% located in the middle part and only 1.40% located at the bottom.

The overlay result towards the settlement area with spatial plan of Bogor regency (2005-2025) is shown in Figure 1.

Table 6: Suitability of settlement area of the upstream of Ciliwung watershed (upper, middle and lower)

Locations	*Suitable zone for settlement*				*Unsuitable zone for settlement*			
	Suitable zone		*Less suitable zone*		*Agricultural cultivation zone*		*Protected zone*	
	acres	*%*	*acres*	*%*	*acres*	*%*	*acres*	*%*
Lower	26.58	1.68	187.93	13.64	487.16	14.46	119.53	1.40
Midlle	1,554.22	98.32	1,190.20	86.36	2,062.40	61.20	1,995.25	3.34
Upper	0.00	0.00	0.00	0.00	80.25	24.34	6,432.85	75.26
Total	1,580.80	100.00	1,378.13	100.00	3.369.82	100.00	8,547.62	100.00
% to upstream Ciliwung watersed	10.63		9.26		22.65		57.46	

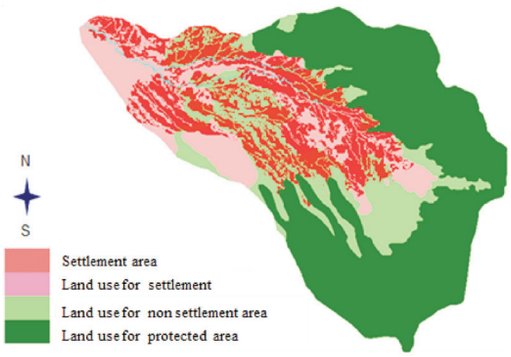

Figure 1: Suitable area for settlement based on spatial plan of Bogor Regency (2005-2025).

However, the development of the existing settlements has partially entered the protected area of the upstream of Ciliwung watershed, which means it has been occupying the forbidden region as shown in Figure 2.

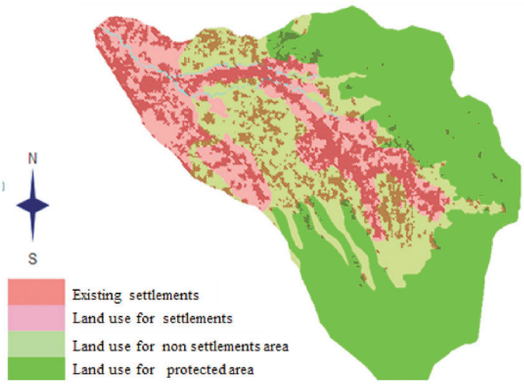

Figure 2: Existing settlements in the upstream of Ciliwung watershed.

One of the factors that encourages the development of settlements in the upstream of Ciliwung watershed is the lack of control system of licensing and law enforcement. From 3000 buildings in the form of big houses (villas) and restaurants, only 40% have the permit currently and the rest of 60% do not have the permits.

Evaluation of Settlement Region

The analysis result shows the differences in the location and allocation of the settlement area between the results of regional suitability for settlement with RTRW in Bogor Regency in 2025 as follows:

1. The allocation of settlement which is located in the residential area (suitable and less suitable) reaches 69.56% of area, and the remaining of 17.66% is in the cultivated area of non-residential and 12.78% in the protected area.
2. The designation for non-residential area is located in residential areas (appropriate and less appropriate) reaches 20.27%, and the remaining of 60.41% located in the cultivated area of non-residential and 19.32% in protected area.
3. The allocation for protected area is about 99.98% and it is suitable in the protected area.

The whole analysis result is shown in Table 7.

The results of the analysis in Table 7 show that there is an obvious discrepancy in the 2005-2025 spatial harmony between land suitability criteria based on settlements with the allotment of residential land according to the settlement criteria and the allocation area for residence which is 30.44%; even the part of 12.78% is located in protected area. This fact will encourage licensors to issue permits for settlement in non-residential area; thus many villas and restaurants are built in this non-residential zone.

The condition of land cover can be used to detect the use of space. The results of the analysis of the alignment between the existing land cover with the alignment of settlement area based on Spatial in 2005-2025 shows the classification of existing settlements as follows:

Table 7: Suitability of settlement area based on spatial plan of Bogor Regency (2005-2025) in the upstream of Ciliwung watershed

	Suitable zone for settlement		*Unsuitable zone for settlement*	
	Suitable zone (%)	*Less suitable zone (%)*	*Non-cultivation zone (%)*	*Protected zone (%)*
a. Settlement	45.08	24.48	17.66	12.78
b. Non-settlement				
1. Agricultural zone	5.11	15.16	60.41	19.32
2. Protected zone	0	0	0.02	99.98

1. In accordance with spatial plan and according to the area for settlement (25.45%).
2. In accordance with spatial plan but unsuitable for residential area (35.30%).
3. Not in accordance with spatial plan and unsuitable with the settlement area (16.75%).
4. Not in accordance with spatial but incompatible with the residential area (22.50%).

The classification of the above analysis result confirmed that the designation of settlements on spatial plan of Bogor Regency (2005-2025) has encouraged the diversion of land use in the upstream of Ciliwung watershed against land's appropriation. The impact has been felt most in the last 10 years by the increment of erosion and the surface water flows. This shows that the water discharge (debit) in Ciliwung river during rainy and dry season reaches 300 times.

The development of residential area should also regard the natural conservation index (NCI), so that the allocation of land for settlement is not located in the area which is ideal for water conservation. The analysis result using the index (NCI) shows that the majority (94.55%) of region with NCI is very high in the protected zone, while the classification of NCI is on high rate of 70% located in unsuitable zone for settlement, with the details: 40.80% is in the protected zone and the remaining of 29.12% in the cultivation area of non-residential like in the agriculture and plantation areas. While for the area suitable for residence is 2.69% with middle NCI, 14.38% with high NCI and only 0.43% located in NCI most high area, the remaining of about 82.5% located in low NCI. The analysis result also shows that the region of upstream of Ciliwung watershed, especially the top area that has very high natural conservation index, should be maintained into catchment area and water reserves, to the area underneath. The analysis results are shown in Table 8.

Table 8 shows that the region of upstream of Ciliwung watershed—both middle conservation index, high or very high—is dominated by the unsuitable zone for settlement; even with very high natural conservation index of 94.55% it is a protected zone. It is clear that the region upstream of Ciliwung watershed should be retained as a protected area and water reserves and not residential area.

Based on the criteria of landslides potential, the analysis result of spatial plan of Bogor (2005-2025) shows that there is a settlement area in the landslides hazard and very dangerous level as follows:

(a) Settlement zone located in area prone to landslide dangerous classification is 18.78%.
(b) Settlement zone located in area prone to landslides very dangerous classification is 10.82%.

Discussion

Based on the analysis result for the suitability of the region shows that for large area of ideal settlement the upstream of Ciliwung watershed is only 19.89%, and most of the rest (80.11%) is unsuitable for settlement. But in reality, there is 35.30% which is in accordance with the spatial but not according to the suitability of land for settlement.

This shows that 15.41% of settlement is out of the suitable zone for residential purpose according to the height, slope and safety zone area against the disaster. Even based on the analysis result of landslide prone settlement area in the upstream of Ciliwung watershed part, 10.82% occupies the area prone to landslides with very dangerous classification. This means that the settlement in the area prone to landslides not only violates the land use but also has a very high risk of danger.

Table 8: Appropriateness between suitable area for settlement and natural conservation index (NCI)

Suitable area for settlement	*Natural Conservation Index (NCI)*					
	Middle		*High*		*Very high*	
	acres	*%*	*acres*	*%*	*acres*	*%*
1. Suitable zone	34.26	2.69	1325.58	14.38	18.30	0.43
2. Less suitable zone	46.82	3.68	1448.33	15.70	85.64	2.00
3. Unsuitable zone						
a. Agricultural zone	473.06	37.21	2684.43	29.12	129.68	3.02
b. Protected zone	717.20	56.41	3761.35	40.80	4040.98	94.55
Total	1271.34	100.00	9219.69	100.00	4274.60	100.00

Due to the occurrence of irregularities in land use because of the lack of permits system and law enforcement, it is visible that 40% of the existing buildings (villas and restaurants) do not have permission. Besides, it is also the weakness of spatial plan of Bogor Regency (2005-2025) which has allocated part of the settlement area in the upsteam of Ciliwung watershed, particularly in the non-residential zone. Regulation No. 26 of year 2007 on spatial planning has expressly put the upstream of Ciliwung watershed as one of the strategic areas that must be protected, and land use must be in accordance with the provisions, due to very serious impact on economic growth and environmental damage to the region underneath, especially Jakarta as the capital city of Indonesia.

To restore settlement construction only in the appropriate zone, there are things that must be taken care of: (1) Law enforcement, with sealing and dismantle buildings located in non-residential areas, (2) Supervision of the construction of settlements or other buildings in the field by involving community leaders around; (3) Stop all settlement and villas construction permits in a protected zone, and (4) Review the spatial plan of Bogor Regency (2005-2025) giving the allocation of settlements in the protected zones and areas prone to landslides.

The upstream watershed ecosystem is generally seen as a rural ecosystem consisting of four major components, which are villages, rice fields, rivers and forests. The interaction of these four components will affect the output to be produced, such as water; in this case the river, in the form of discharge (water debit) and water quality. Village is a central component in watershed management, among others, due to the human factor in it. The population growth is resulting pressure in the upstream of Ciliwung watershed area. The limited job opportunities and community skills often cause encroachment in protected area in the upstream of Ciliwung watershed.

This leads to an increase in surface run off, erosion and sediment loads that impact on the water quality and the occurrence of fluctuations in river discharge during the dry season and the rainy season. Therefore, efforts to restore the upstream of Ciliwung watershed as water catchment area cannot be separated from efforts to improve the income and welfare of the community and involve the community in its management. Besides, it is also necessary to replant in the border <50 metres either side of the forming ridges (levees) to hold water and erosion during the rainy season.

Conclusion

The development of settlements in the upstream of Ciliwung watershed that is uncontrolled has been the cause of the decrease in the water absorption capacity during the rainy season thereby increasing the potential run off into downstream flooding. Residential development has entered the unsuitable area for settlements located in the protected zone (57.46%) and cultivated zone of agriculture (22.65%) and even some have entered the region very prone to landslides. This is due to the unsuitability between spatial plan of Bogor regency (2005-2025) with settlement criteria and lack of permits system and law enforcement. To ensure the upstream of Ciliwung watershed area as water catchment field, it is necessary to do: (1) law enforcement, (2) relocation (demolition of existing buildings), (3) stop the permitting of development in the area of upstream of Ciliwung watershed, (4) increasing the income of the surrounding community by developing cottage industries based on local resources, and (5) community involvement in the management of the upstream of Ciliwung watershed.

References

Arifjaya, N.M. and dan L.B. Prasetio (2004). Impact of land use change to run off and water quality of the upstream of Ciliwung watershed. Center of Indonesian Science, Jakarta.

Anonymous (2003). Integrated management plan of Ciliwung Watershed. BPDAS, Jakarta.

Anonymous (2007). Flood management plan in Jakarta-Bogor-Tangerang and Bekasi. BPDAS, Jakarta.

Anonymous (2008). Guidance for Conservation of Ciliwung Watershed. Department of Agriculture of Republic of Indonesia, Jakarta.

Anonymous (2008). Spatial Audit in the Context of Disaster Mitigation in Indonesia. Department of Public Works, Jakarta.

Anonymous (2006). Spatial plan of Bogor Regency (2005-2025). Bapeda, Bogor.

Biswas, A.K. and C. Tortajad (2011). Water Quality Management: Challenges and Expectations. *International Journal of Water Resources Development*, **27:** 5-11.

Baird, J., Plummer, R., Morris, S., Mitchell, S. and K. Rathwell (2014). Enhancing source water protection and watershed management: Lessons from the case of the New Brunswick Water Classification Initiative. *Canadian Water Resources Journal*/*Revue canadienne des ressources hydriques*, **39(1):** 49-62.

Fahrudin (2007). Study of respon hydrology due to Land Use Changes of Upper Ciliwung Watershed using model Sedimot II. IPB, Bogor.

Gopalakrishnan, C. (2013). Water and disasters: A review and analysis of policy aspects. *International Journal of Water Resources Development*, 250-271.

Ghokan, A. (2012). Assessment of Groundwater Vulnerability Using a GIS Based DRASTIC Model (Case Study: Dehgolan Plain, Kurdistan Province). *Journal of Watershed Management Research*, **3(5):** 42-62.

Irianto (2007). Study of respon hydrology due to Land Use Changes of Upper Ciliwung Watershed using model HEC-1. IPB, Bogor.

Kartodihardjo, H. (2002). Ciliwung Watershed Management Capacity Building for Flood Control in Jakarta, the capital of Indonesia. Center of Indonesian Science, Jakarta.

Karyana (2007). Model of Sustainable reservoir management. Case study in Ciliwung watershed. IPB, Bogor.

Kumar, P.S. and S.A. Geetha (2009). A Holistic GIS-based Approach for Thematic Extraction of the Soil Erosion Estimates Using Predictors as a Function of Climate, Land Cover, Relief, Soil and Topography. *Asian Journal of Water, Environment and Pollution*, **6(3):** 73-78.

Mustafa, Y.M., Amin, M.S., Lee, T.S. and A.R.M. Shariff (2005). Evaluation of Land Development on Tropical Watershed Hydrology Using Remote Sensing and GIS. *Journal of Spatial Hydrology*, **5(2):** 16-30.

Maintindom (2005). Policy analysis of land use management in the upstream of Ciliwung watershed. IPB, Bogor.

Mawardi, I. (2009). Water Resource Crisis in Java and projections 2025. BPPT, Jakarta.

Mawardi, I. (2010). Decreasing of Watershed and Water Resources in Java. *Journal Hidrosfir Indonesia*, **5(2):** 1-11.

Mounir, A.M., Gao, C.S., Moustapha, A.M. and C. Ming Ma (2014). Water resources management in Sub-Saharan Africa: a status review of Niger Republic. *Int. J. of Water*, **8(3):** 275-298.

Nguyen, S. and D. Weston (2013). Dam Break for the Dalles Dam. Proceeding of American Society of Civil Engineers, 1687-1697.

Qodariah, Arifjaya, N.M. and dan I. Maryanto (2008). Rainfall Analysis, Erosion and Sedimentation due to land use changes in the upstream of Ciliwung watershed. Biology Research Center, Jakarta.

Schoeman, J., Allan, C. and C. Max Finlayson (2014). A new paradigm for water? A comparative review of integrated, adaptive and ecosystem-based water management in the Anthropocene. *International Journal of Water Resources Development*, **30(3):** 377-390.

Shrestha, S. (2014). Evaluation of sustainability of ground-water resources in a semi-arid region of the Maharashtra State. *International Journal of Water Resources and Environmental Engineering*, **6(7):** 203-211.

Suwarno, J., Kartodihardjo, H., Pramudya, B. and S. Rachman (2011). Policy Development of Sustainable Watershed Management of Upper Ciliwung, Bogor Regency. *Journal of Forest Policy Analysis*, **8(2):** 115-131.

Susilowati, W., Damianto, B., Nadjam, A. and dan I. Nurhayati (2012). Community participation in improving the environmental quality of the upstream of Ciliwung watershed. *Journal Poly Teknologi*, **11(1):** 55-63.

Unnisa, A.A. and B. Srivani (2008). Landfill Impact on Ground Water. *Asian Journal of Water, Environment and Pollution*, **5(2):** 19-22.

Asian Journal of Water, Environment and Pollution

Volume 11 Number 2 **April – June, 2014**

Contents

Editorial i

❑ *Snapshot* ii

Groundwater Arsenic in South-East Asia: Extent, Effects and Solutions
Prabhakar Sharma, Gaurav Goel, S.M. Ashekuzzaman, Gaurav Saini and Ranvir Singh 1

Assessment of Heavy Metals in Top Soil around a Proposed Uranium Tailings Pond in Southern India
K. Brindha and L. Elango 13

Assessment of the Chemical Quality of Water in the Halabja-Sulaimani, Kurdistan Region of Iraq
Dana A. Mohammed Barzinji and Dilshad G.A. Ganjo 19

Impacts of and Adaptations to Sea Level Rise in Malaysia
Md. Sujahangir Kabir Sarkar, Rawshan Ara Begum, Joy Jacqueline Pereira, Abdul Hamid Jaafar and M. Yusof Saari 29

Seasonal Variation of Phytoplankton Diversity in Relation to Eutrophication of Mathura Beel, a Floodplain Lake in West Bengal, India
Sudipta Kumar Maiti, Sarmistha Saha, Suman Adkikary Aniruddha Mukhopadhyay and Tapan Saha 37

Fuzzy and Neuro-Fuzzy Modelling for Prediction of Effluent COD for a Real Scale UASB Reactor Treating Distillery Wastewater
Ashok L. Varne and J.E.M. Macwan 45

Operation of Brick Kilns in Bangladesh—A Comparative Study
A.H. Tehzeeb and Muhammed A. Bhuiyan 55

Performance Studies on Biological Treatment of Slaughterhouse Wastewater Using Mixed Culture in Sequencing Batch Reactor
Pradyut Kundu, Anupam Debsarkar and Somnath Mukherjee 67

Studies on Physicochemical Parameters to Assess the Water Quality at Selected Sites of River Hooghly, a Tributary of the Ganges, West Bengal, India
Rajib Das, Paramita Karmakar and Susanta Nath 81

Understanding Levels and Sources of PAHs in Water of Bharalu Tributary of the Brahmaputra River
Karishma Hussain, Rajesh Rajbangshi and Raza Rafiqul Hoque 89

❑ *Short Note*

Preparation of Water Absorbing Pavement Material from Fly Ash
B.B. Kar and S.K. Dash 99

Environment News Futures 103