Aceh Int. J. Sci. Technol., 4(1): 32-40
April 2015
doi: 10.13170/aijst.4.1.2317

Aceh International Journal of Science and Technology
ISSN: 2088-9860
Journal homepage: http://jurnal.unsyiah.ac.id/aijst

Hydrological Response Unit Analysis Using AVSWAT 2000 for Keuliling Reservoir Watershed, Aceh Province, Indonesia

Azmeri [1], Alfian Yulianur,[1] Maimun Rizalihadi[1], and Shafur Bachtiar[2]
[1]Civil Engineering, Faculty of Engineering, Universitas Syiah Kuala, Banda Aceh, Indonesia; [2]General Affairs Watering Department of Pidie Jaya Regency, Aceh Province, Indonesia. Corresponding author email: azmeri73@yahoo.com

Received : February 7, 2014
Accepted : March 12, 2015
Online : April 30, 2015

Abstract - Sediments deposition derived from the erosion in upstream areas can lead to river siltation or canals downstream irrigation. According to the complexity of erosion problem at Keuliling reservoir, it is essential that topography, hydrology, soil type and land use to be analyzed comprehensively. Software used to analyze is AVSWAT 2000 (Arc View Soil and Water Assessment Tools-2000), one of the additional tool of ArcView program. The results obtained are the watershed delineation map, soil type map to produce soil erodibility factor (K) which indicates the resistance of soil particles toward exfoliation, land use map to produce crop management factor (C) and soil conservation and its management factors (P). Hydrology analysis includes soil type, land use and utility for the erosion rate analysis through Hydrologic Response Unit (HRU). The biggest HRU value of sub-basin is on area 5 and the lowest one is on area 10. All four HRU in sub-basin area 5 are potentially donating high value for HRU. In short, this area has the longest slope length so that it has a large LS factor. About 50% of the land was covered by bushes which gain higher C factor rather than forest. Moreover, it has contour crop conservation technique with 9-20 % declivity resulting in having dominant factor of P. Soil type is dominated by Meucampli Formation which has soil erodibility factor with high level of vulnerable toward the rainfall kinetic energy. All in all, the vast majority of HRU parameters in this sub-basin area obtain the highest HRU value. Hydrology analysis, soil type, and use-land are useful for land area analysis that is susceptible to erosion which was identified through Hydrologic Response Unit (HRU) using GIS. As the matter of fact, spatially studies constructed with GIS can facilitate the agency to determine critical areas which are needed to be aware or fully rehabilitated.
Key words: Hydrologic Response Unit; Keuliling Reservoir; Erosion; Soil Type; Landuse

Introduction

Keuliling Reservoir is situated in District Cot Glie, Great Aceh Regency, Aceh Province. Keuliling Reservoir is a important infrastructure to subtitute water in Krueng Aceh Extention and Krueng Jreue and the needs of rice cultivation at upstream and downstream Keuliling. Rapid change of the land use at Keuliling Reservoir watershed can result in high level of erosion and sediment level of reservoir. Therefore, this condition might affect the operational and stability processes of the reservoir in the future.

The process of soil erosion involves detachment, transport and subsequent deposition (Jain and Kothyari, 2000). Sediment is detached from the soil surface both by raindrop impact and by the shearing force of flowing water and then the detached sediment is transported downslope primarily by water flow, although there is also a small amount of downslope transport by raindrop splash (Walling, 1988). Once runoff begins over the surface areas and flows into the river, the size and quantity of material transported increases with the velocity of the runoff. At some point, the slope may decrease, resulting in a decreased velocity and hence a decreased transport capacity (Haan, 1994).

Because of erosion problem in the watershed, some actions were needed to be performed in order to analyze which watershed area is vulnerable to erosion risk (Hydrologic Response Unit (HRU)) at Keuliling Reservoir watershed. HRU analysis is performed by using some parameters in Universal Soil Loss Equation (USLE) method by running AVSWAT 2000 programme to HRU spread analysis. This programme is an extra tool from Geographical Information System (GIS)-based Arc-View programme. The use of GIS methodology is well suited for the quantification of heterogeneity in the topographic and drainage features of a catchment (Shamsi, 1996; Rodda, 1999). The use of GIS in this research were for the discretization of the catchments into small grid cells and for the computation of such physical characteristics of these cells as land use, land slope, soil type, and all of which affect the processes of soil erosion and deposition in the different sub-areas of a catchment. Further GIS methods were also used to partition the sub-areas into overland and to estimate the HRU in individual grid cells. The main objective of this research is to find HRU providing information about the erosion vulnerable land momenteous. HRU is the information used as a basis for land conservation measures due to erosion.

Materials and Methods

Study Area

The research was conducted at Keuliling Reservoir watershed in Bak Sukon, Subdistrict of Cot Glie, Aceh Besar District, Aceh Province. The location is situated about 35 kilometres from Banda Aceh. Keuliling Reservoir is the first reservoir built in Aceh province. The construction of Keuliling Reservoir, which had been started since 2000 and finalized in 2008, was awarded as category of Construction Technology and Internal Scientific Work by Ministry of Public Works. (Figure 1).

Keuliling Reservoir water source comes from Alue Keuliling. The catchment area of Alue Keuliling is about 38.2 km^2. In one hand, the reservoir has provided irrigation water storage for 4,790 hectares of rice fields which supports the rice self-sufficiency program as well. Furthermore, it gives others great benefits for the community too, for instance as a security infrastructure against flooding, environmental conservation, tourism development, aquaculture development, and main water supply in the future. In the other hand, the increment of space requirements has caused rapid changes of land use in Keuliling Reservoir watershed. This condition increases erosion in the watershed as well as the level of sediment in the reservoir. Therefore, it is feared that the condition will disrupt the long-term process of reservoir operation. (Natural Resources Directorate General, 2010).

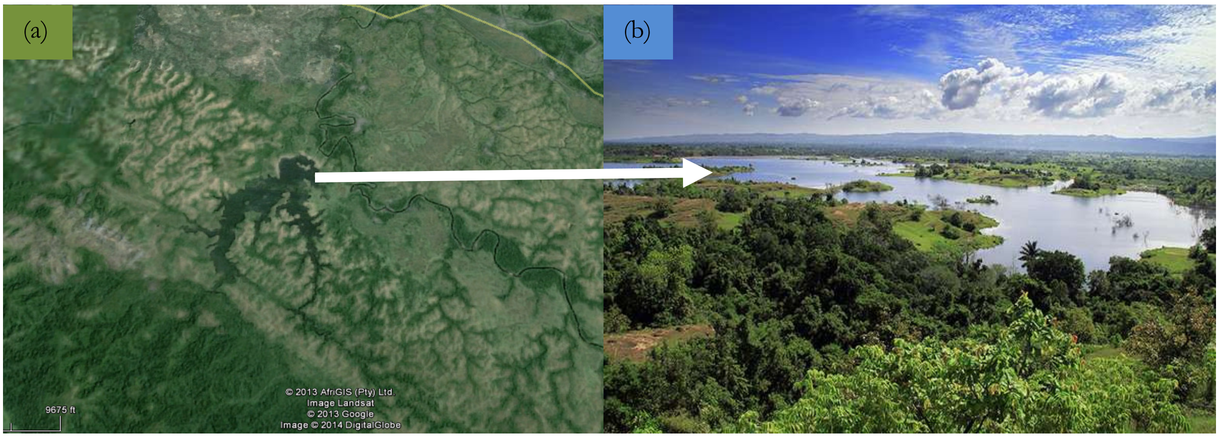

Figure 1. (a) Keuliling reservoir location (source: Google Earth Pro, 2013) (b). Inundation area of Keuliling reservoir (source: atjehpost.com)

Procedure of Hydrologic Response Unit and *Arc-View Soil and Water Assessment Tools* (AVSWAT-2000)

Keuliling Reservoir watershed needs to be discretized into smaller homogeneous units before making computations for HRU. A grid-based discretization is the most real procedure in both process-based models as well as in othersimple models (Beven, 1996; Kothyari and Jain, 1997). In this study such a differentiation was achieved by following the procedure of the channel initiation threshold given in ESRI (1994). HRU calculation in AVSWAT 2000 (Arc View Interface for SWAT 2000) is an extra feature of GSI-based Arc View using SWAT model.

Watershed delineation of grid-formatted Digital Elevation Model (DEM)

Watershed delineation begins with running ArcView 9.3 AVSWAT 2000 extension, with executing automatic delineation menu at AVSWAT 2000 toolbar to do grid-formatted DEM spatial analysis from DEM data analysis. UTM 1983 map projection was used at zone 46, and WGS 1983 was the reference datum. Creating mask grid to focus on watershed delineation process. Data structure used for modeling the surface characteristics in this study is a data structure in the form of raster data structure/grid with the cell size 25 m x 25 m. Determining stream digitation process and minimal bandwith gained catchment area. Processing DEM to eliminate sink. Synthetic river channel and each its outlet in vector format (*.shp) are earned through the process. Defining watershed main outlet from stream channel outlets. The model was processing watershed and catchment area delineation. From the process, watershed and catchment area border map in vector formatted (*.shp) are gained. The finally, calculating catchment area parameter to gain topography data consisting of statistical data about spread and elevation distribution for every watershed and catchment area.

Topography Index (LS)

Topography index factor L and S each represents length and slope influence toward the value of HRU. The value of LS was obtained from Suhartanto (2008):

$$LS = \left(\frac{L_{hill}}{22.1}\right)^m \cdot \left(65.41 \cdot \sin^2(\alpha_{hill}) + 4.56 \cdot \sin \alpha_{hill} + 0.065\right) \quad (1)$$

where : L_{hill} = slope length (m); m = exponential requirement; α_{hill} = slope angle

Moore and Burch (1986) in Jain and Kothyari (2000) and Moore and Wilson (1992) derived an equation based on unit stream power theory for estimating the *LS* factor in cells smaller than the plots of Wischmeier and Smith (1978).

Land Use and Soil Type

Classifying land use and soil type polygons based on SWAT classification model, with running ArcView 9.3 AVSWAT 2000 extension programme. Running Land Use and Soil Definition in Arc View 9.3. Based on the feature land use and soil type map, the land use and soil type were classified based on their categories. The finally, running reclassification to gain grid-generated land use and soil type map.

Land use (Cover and Management Factor C, *and* Support Practice Factor P)

The cover and management factor (C) indicates influence of vegetations, surface condition and land use caused the C factor equation to be different each year. However, the equation used in this research were:

$$C_{USLE} = \exp\left(\left[\ln(0.8) - \ln\left(C_{USLE,mn}\right)\right] \cdot \exp\left[-0.00115 \cdot rsd_{surf}\right] + \ln\left[C_{USLE,mn}\right]\right) \quad (2)$$

where: $C_{USLE,mn}$ = crop management minimum value. rsd_{surf} = surface residue (kg/acre)

In AVSWAT 2000, the data computation of landuse consists of land use map and factor data for every land covers. Land Use data computation was carried out using Land Use and Soil Definition menu at AVSWAT 2000 toolbar. Meanwhile, factor data were inputted in two different ways. Firstly, it was inputted in Ms. Excel then be exported to dBase IV table (*dbf) and named crop.dbf. Secondly, use the interface menu : "edit SWAT database" and named Land Cover/Crop Growth.

Soil type Condition (Soil Erodibility Factor K)

Soil erodibility factor (K) indicates soil particle resistency toward soil particle detachment and transportation by rainfall kinetics. Wischmeir (1971) in Jain and Kothyari (2000) developed matemathical equation connecting soil characteristic and soil erodibility level as follows:

$$K = \frac{0.00021 M^{1.14} \cdot (12 - OM) + 3.25 \cdot (c_{soilstr} - 2) + 2.5 \cdot (c_{perm} - 3)}{100} \tag{3}$$

where: M = particle size percentage (% dust + sand)×(100-% clayey); OM = organic substance percentage; $c_{soilstr}$ = soil structure classification code (*granular, platy, massive,*); c_{perm} = soil permeability level. The same as land use process, the data computation of soil type consists of soil type map and factor data for every kind of soil type and use the interface menu: "edit SWAT database" and named User Soils.

The values for the factors K, C and P were estimated at different grids in overland and channel regions as per Wischmeier and Smith (1978) for land cover and soil. The geo-coded scenes were masked by the boundaries of the catchments derived earlier for delineating the areas lying within the catchment. Land cover and soil maps were then generated using the supervised classification scheme (Sabins, 1997). In Keuliling catchment, three land cover categoriess and five oil type catagories were identified and mapped. Land cover information was thus available for each cell of catchments. Based on land cover categories, the attribute values for the C factor were assigned to individual cells from the tabulated values of Wischmeier and Smith (1978).

Hydrologic Response Unit (HRU)

According to Flugel (1997), HRU concept was based on system approach integration which is requirements to dynamically analyse and modelize hydrology from heterogenic basins drainage and its interaction with soil, geology and land cover. As a matter of fact, the soil, geology and land cover influnce evapotranspiration, infiltration, surface flow, interflow and ground water in all river basins. HRU analysis was able to produce fact and spacial phenomenon existed in the scope and inter catchment area. Furthermore, soil type, slope, geology and land cover were dynamic variable causing HRU changes from time to time. This HRU changes were occasionally results of area development which require more land for resident or other land cover. SWAT analysis was able to inform HRU value in watershed (MANUAL MWSWAT (Map Window Soil and Water Assessment Tool), Directorate General Watershed Management and Forestry, Indonesian Department of Forestry).

Procedure of HRU was through overlaying the grid topography map, grid-generated land use and soil type map. The result of overlaying process describes land use and soil type distribution in each catchment area. Executing HRU Distribution menu in the AVSWAT 2000 toolbar to process Hydrologic Response Unit distribution from each catchment area until Distrswat table database is earned. The database includes information regarding land use and soil type distribution in Keuliling Reservoir watershed and catchment area.

Results and Discussion

Generation of digital input maps

The border of Keuliling Reservoir watershed has been determined with Arc View GIS 9.3 through the process of analyzing several complex data on the purpose of representing the earth surface relief characteristics. Digital contour map, which is a result of digitation process in 1:50.000 from Surveys and National Mapping Organization, is used in this stage. Moreover, the grid-formatted contour and declivity map of watershed were gained through Digital Elevation Models (DEM). These DEMs were further analysed to remove pits and flat areas to maintain continuity of flow to the catchment outlets. The corrected DEMs were next used to delineate the catchment boundaries of the catchments using the eight-direction four point algorithm (ESRI, 1994). Soon afterwards, DEM analysis result was used as watershed delineation proses input in order to identify direction flow, flow accumulation and flow length from watershed outlet furthest spot, synthetic river channel, each catchment area, watershed border and catchment area border by using Arc View 9.3 extension Hydrologic Modelling. Figure 2 shows watershed delineation result meanwhile synthetic river channel, each watershed outlet, watershed and catchment area border were seen in Figure 3.

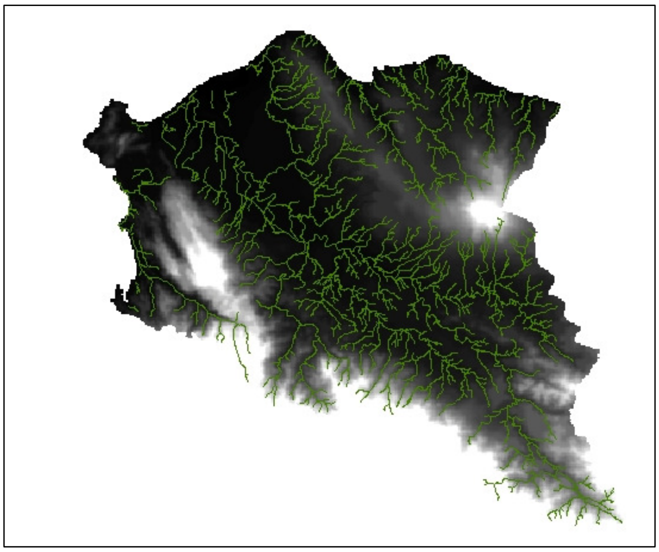

Figure 2. Keuliling Reservoir Analyzing Result DEM Map

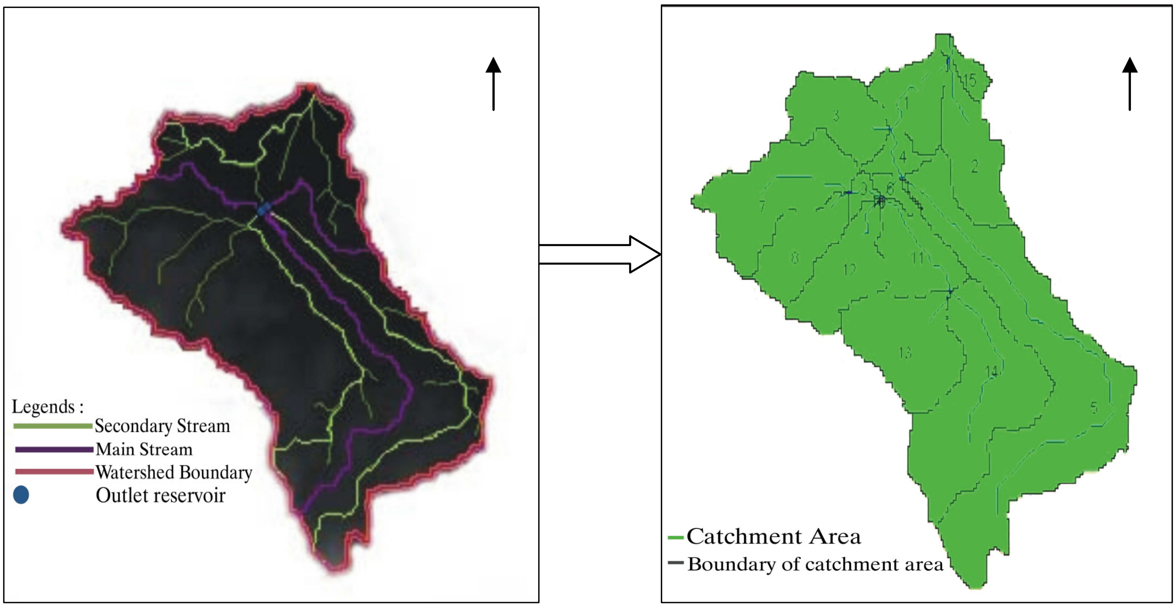

Figure 3. Process and result of Keuliling Reservoir Watershed delineation

Before defining watershed primary outlet, delineation process synthetic river channel has to be preceedingly corrected with digitation-resulted river channel from Surveys and National Mapping Organization. The correction was done by eradicating or adding outlets to each primary synthetic river in those two preceeding areas. Once this was finalized, the next step needed to be taken is defining primary outlet spot of Keuliling Reservoir watershed to get watershed and catchment area bordermap. From the watershed delineation result, it was seen that Keuliling Reservoir watershed was separated into 15 catchments area and primary synthetic river channel's and each watershed's topography parameter as presented in this following Table 1.

Assuming from Keuliling Reservoir watershed land delineation result, Catchment Area 5th has the longest land width, river length and slope length. Having dominant C and P factor, the catchment area would probably possesses highest HRU value. In contrast, Catchment Area 10th seems to be having the shortest land width, river length and slope length. As a result, it's HRU value is the lowest even when P and C factors were dominant. However, HRU analysis would be conducted more radically without putting less attention to enormous soil erodibility factors which were vulnerable to rainfall kinetics (Jain and Kothyari, 2000).

Table 1. Delineation of Keuliling Reservoir watershed

Catchment area	Area (hectare)	River Length (m)	Slope length (m)	Land declivity (%)	Elevation (metres asl*)
1	166.75	2,064.21	2,314.22	2.32	50.00
2	218.25	1,230.33	3,316.08	1.90	50.00
3	207.00	595.71	2,995.70	4.68	67.27
4	59.75	965.69	1,622.98	3.55	50.00
5	1,003.25	9,615.57	11,629.59	8.60	120.62
6	31.75	474.56	817.84	4.92	61.79
7	362.75	1,993.00	3,894.35	16.54	146.24
8	185.25	468.74	2,866.94	9.68	200.00
9	26.25	682.85	1,005.41	5.88	75.00
10	1.00	70.87	95.78	2.88	75.00
11	187.25	2,205.66	2,606.66	10.20	75.00
12	214.50	881.36	3,110.67	14.41	150.00
13	327.00	701.49	2,665.37	12.78	161.29
14	537.75	3,476.42	5,241.84	12.70	125.00
15	45.50	416.55	1,348.57	0.81	50.00

*asl = above sea level. Source: GIS analysis result based on watershed delineation

Land Use condition

The research area was mostly covered by forest and bushes. The data were used as input in this section were land use map and each land cover factor values. The data were used in Land Use and Soil Definition at AVSWAT 2000 toolbar menu. Specifically, Figure 4 illustrates soil type and land use defining map. There are 3 kinds of land-use in Keuliling Reservoir watershed; bushes, forest and cultivating area. The map depicts land management and crop type in each catchment area in Keuliling Reservoir. Crop management factor (C) and also land conservation management, which were inputted in HRU analysis, were yielded in every land use. Table 2 indicates the land C and P factor of Keuliling Reservoir Watershed.

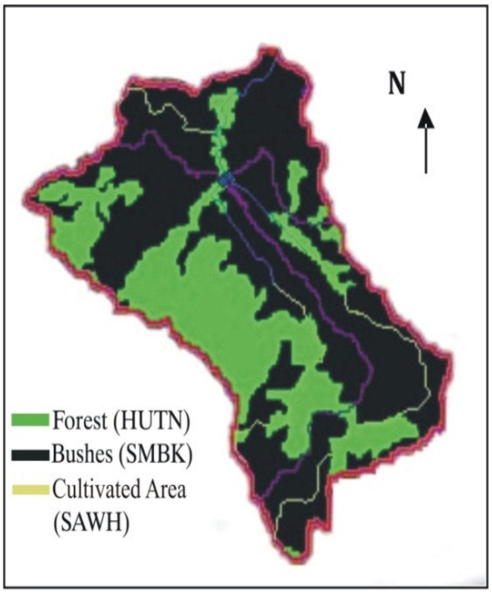

Figure 4. Keuliling reservoir land use definition

Table 2. Land use statistics for the catchments studied (Aceh Development and Planning Department, 2010)

No	Land use	Name	Area (Hectare)	C	P
1	Bushes	SMBK	2,415.152	0.010	0.50
2	Forest	HUTN	1,155.953	0.001	0.75
3	Cultivated area	SAWH	2.895	0.460	0.90

Soil Condition

The soil type initiated soil erodibility factor (K) showing the resistance of soil particle toward soil detachment. This K value was further used in HRU analysis of Keuliling Reservoir watershed. Soil type and land use definition map was presented in Figure 5. The soil consists of Alluvium Muda, Padang Tiji formation, Seulimum formation and Indrapuri formation, the latest dominates the other by occupying 35% of Keuliling Reservoir watershed. The Table 3 provides information about soil type, landwidth and soil erodibilty factors at Keuliling Reservoir watershed.

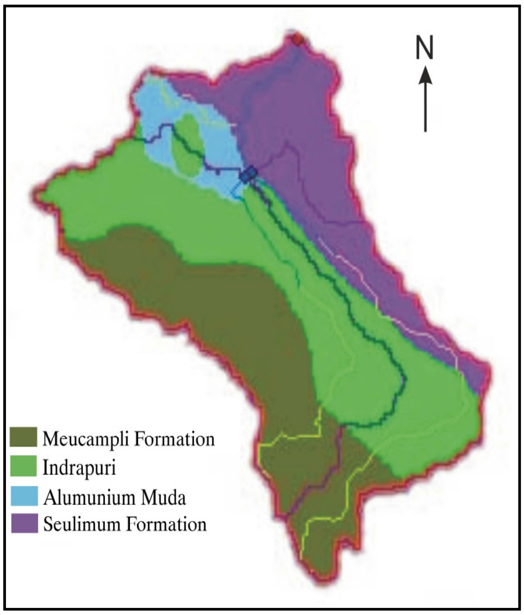

Figure 5. Soil type definition map of Keuliling Reservoir Watershed

Table 3. Soil type statistics for the catchments studied (Aceh Development and Planning Department, 2010)

No	Soil Type	Area (Hectare)	*K* factor (t ha h ha^{-1} MJ^{-1} mm^{-1})
1	Aluvium Muda	225.536	0.43
2	Padang Tidji Formation	0.211	0.32
3	Meucampli Formation	1,132.585	0.28
4	Seulimeum Formation	844.220	0.28
5	Indrapuri	1,371.448	0.24
	Total	3,574.000	

Identification of Hydrologic Response Unit (HRU)

Every HRU simultaneously brought about several infromations, such as: catchment area, HRU number, land use type, Soil type and HRU scope. HRU defining is carried out by means of AVSWAT 2000 HRU distribution menu, in Multiple Hydrologic Response Units, spesifically. The catchment bordermap organization, land use and soil type mapping yields HRU defining result; 41 units HRU terrains as stated in Table 4. Referring to Table 4, the biggest HRU value of sub-basin is on area 5 and the lowest one is on area 10. All four HRU in sub-basin area 5 are potentially donating high value for HRU. In short, this area has the longest slope length so that it has a large LS factor. About 50% of the land was covered by bushes which gain higher C factor rather than forest. Moreover, it has contour crop conservation technique with 9-20 % declivity resulting in having dominant factor of P (0.75). Soil type is dominated by Meucampli Formation which has soil erodibility factor K (0.28) with high level of vulnerable toward the rainfall kinetic energy (Jain and Kothyari, 2000). All in all, the vast majority of HRU parameters in this catchment area obtains the highest HRU value. The HRU value provides information about the erosion vulnerable land momenteous, and initializes to land conservation efforts.

Differences in data usage on land cover, slope, and soil type will produce different patterns of HRU because it is overlapping maps of land cover, slope and soil type. This will result in spatial and temporal patterns change of HRU. Therefore, different pattern of HRU in each sub-basin in this study can affect the surface flow and discharge that will be resulted. HRU dominant and HRU wide-dominant in a sub-basin affect the accumulation of surface flow in the sub-basin (Flugel, 1997). A SWAT hydrological model was developed for analyzing effects of land use on the stream flows. The model gave satisfactory results in terms of simulating. Degradation of the catchment can affect the flow characteristics in the basin such as increasing the surface runoff and decreasing the baseflow. The main disadvantage of the SWAT model is the fact that the models have many processes and hence it has hundreds of parameters and it requires many data that can make the calibration process become monotonous. It is recommended that the use of remote sensing data should be validated to complement the ground measurement data which point to good spatial representation. Moreover, the duration of hydrological analysis should be performed longer than measurement of ground data which already have been available.

Due to the use of GIS-based spatial study is to ease the institutions in identifying vulnerable area as well as optimizing rehabilitation administration, it is suggested that the institutions improve their data inventory, due to the completeness of the data will support the research validity. (MANUAL MWSWAT (Map Window Soil and Water Assessment Tool, Directorate of Watershed Planning and Evaluation. Directorate General Watershed Management and Forestry, Indonesian Department of Forestry).

Table 4. HRU distribution result of Keuliling Reservoir watershed (Source : AVSWAT analysis results)

No	Catchment	*HRU*	Landuse	C Value	Slope	P Value	Soil type	K Value	HRU scope (Hectare)
1	1	1	SMBK	0.010	0.023	0.50	Seulimeum Form.	0.28	138.447
2	1	2	HUTN	0.001	0.023	0.50	Seulimeum Form.	0.28	28.303
3	2	1	SMBK	0.010	0.019	0.50	Seulimeum Form.	0.28	193.483
4	2	2	HUTN	0.001	0.019	0.50	Seulimeum Form.	0.28	24.767
5	3	1	SMBK	0.010	0.047	0.50	Aluvium Muda	0.43	177.137
6	3	2	SMBK	0.010	0.047	0.50	Indrapuri	0.24	29.863
7	4	1	SMBK	0.010	0.035	0.50	Aluvium Muda	0.43	41.253
8	4	2	SMBK	0.010	0.035	0.50	Indrapuri	0.24	2.082
9	4	3	HUTN	0.001	0.035	0.50	Aluvium Muda	0.43	15.160
10	4	4	HUTN	0.001	0.035	0.50	Indrapuri	0.24	1.255
11	5	1	SMBK	0.010	0.086	0.75	Seulimeum Form.	0.28	477.869
12	5	2	SMBK	0.010	0.086	0.75	Meucampli Form.	0.28	352.354
13	5	3	HUTN	0.001	0.086	0.75	Meucampli Form.	0.28	95.065
14	5	4	HUTN	0.001	0.086	0.75	Indrapuri	0.24	77.962
15	6	1	SMBK	0.010	0.049	0.50	Aluvium Muda	0.43	11.100
16	6	2	SMBK	0.010	0.049	0.50	Indrapuri	0.24	10.808
17	6	3	HUTN	0.001	0.049	0.50	Aluvium Muda	0.43	9.495
18	6	4	HUTN	0.001	0.049	0.50	Indrapuri	0.24	0.347
19	7	1	SMBK	0.010	0.165	0.75	Aluvium Muda	0.43	36.146
20	7	2	SMBK	0.010	0.165	0.75	Indrapuri	0.24	171.088
21	7	3	HUTN	0.001	0.165	0.75	Meucampli Form.	0.28	155.516
22	8	1	SMBK	0.010	0.097	0.75	Meucampli Form.	0.28	102.616
23	8	2	HUTN	0.001	0.097	0.75	Indrapuri	0.24	82.634
24	9	1	SMBK	0.010	0.059	0.50	Aluvium Muda	0.43	15.675
25	9	2	SMBK	0.010	0.059	0.50	Indrapuri	0.24	10.575
26	10	1	SMBK	0.010	0.029	0.50	Aluvium Muda	0.43	0.129
27	10	2	HUTN	0.001	0.029	0.50	Aluvium Muda	0.43	0.687
28	10	3	HUTN	0.001	0.029	0.50	Indrapuri	0.24	0.184
29	11	1	SMBK	0.010	0.102	0.75	Aluvium Muda	0.43	7.322
30	11	2	SMBK	0.010	0.102	0.75	Indrapuri	0.24	128.651
31	11	3	HUTN	0.001	0.102	0.75	Meucampli Form.	0.28	30.929
32	11	4	HUTN	0.001	0.102	0.75	Indrapuri	0.24	20.348
33	12	1	SMBK	0.010	0.144	0.75	Aluvium Muda	0.43	39.950
34	12	2	HUTN	0.001	0.144	0.75	Meucampli Form.	0.28	130.922
35	12	3	HUTN	0.001	0.144	0.75	Indrapuri	0.24	43.628
36	13	1	SMBK	0.010	0.128	0.75	Indrapuri	0.24	27.381
37	13	2	HUTN	0.001	0.128	0.75	Meucampli Form.	0.28	299.619
38	14	1	SMBK	0.010	0.127	0.75	Meucampli Form.	0.28	251.672
39	14	2	HUTN	0.001	0.127	0.75	Indrapuri	0.24	286.078
40	15	1	SMBK	0.010	0.008	0.50	Seulimeum Form.	0.28	42.605
41	15	2	SAWH	0.460	0.008	0.90	Seulimeum Form.	0.28	2.895

Conclusions

Land management in Keuliling Reservoir watershed consists of 3 landuses: bushes, forest and cultivating area. Land cover values (C) to each land cover were: 0.01; 0.001 and 0.46. Meanwhile, land management value (P) were: 0.5 ; 0.75 and 0.9. The soil type consists of 5 formations, which is Alluvium Muda, padang Tiji Formation, Meucampli formation, Seulimum formation and Indrapuri. Furthermore, the soil erodibility value (K) in each soil type were: 0.43; 0.32 ; 0.28 ; 0.28 and 0.24. The value of C, P, K factors were issued in erosion vulnerable land width study by using GIS. A GIS-based methodology has been proposed and validated for the identification of sediment source areas and prediction of storm sediment yield from catchment areas. Grid cell drainage directions and catchment boundaries were generated by forming the DEM using a pour point model. The DEM was further analysed to classify grid cells into overland region cells and channel region cells by using the concept of a channel initiation threshold area. The land cover affect the spatial patterns of HRU. It is identified by changes in number and extent of each HRU. The change of HRU spatially also influenced by how detailed land cover information is used. Therefore, it is suggested that the institutions improve their data inventory on the purpose of supporting erosion study and sediments land which will be done. The result of the HRU can ease the institutions to identify vulnerable areas which will be needed to be rehabilitated optimally.

References

Beven, K. J. (1996). A discussion of distributed modelling. In: Distributed Hydrological Modelling (edition by M. B. Abbott and J. C. Refsgaard): 255-278. Kluwer, Dordrecht, The Netherlands.

ESRI (Environmental Systems Research Institute). (1994). Cell based modelling with GRID, Environmental Systems Research Institute Inc., Redlands, California, USA.

Flugel, W. A. (1997). Combining GIS with regional hydrological modeling using hydrological response unit (HRUs): An application from Germany, Mathematics and Computers in Simulation 43: 297-304.

Haan, C. T., Barfield, B. J. and Hayes, J. C. (1994). Design hydrology and sedimentology for small catchments. Academic Press, New York.

Jain, K. M. and Kothyari, C. U. (2000). Estimation of soil erosion and sediment yield using GIS. Hydrological Sciences-]ournal-des Sciences Hydrologiques, 45(5): 771-786.

Kothyari, U. C. and Jain, S. K. (1997). Sediment yield estimation using GIS. Hydrology Science Journal, 42(6): 833-843.

Moore, I. D. and Wilson, J. P. (1992). Length slope factor for the Revised Universal Soil Loss equation: simplified method of solution. Journal of Soil and Water Conservation, 47(5): 423-428.

Panuska, J. C, Moore, I. D. and Kramer, L. A. (1991). Terrain analysis: integration into the agricultural nonpoint source (AGNPS) pollution model. Journal of Soil and Water Conservation, 46(1): 59-64.

Rodda, H. J. E., Demuth, S. and Shankar, U. (1999). The application of a GIS based decision support system to predict nitrate leaching to ground water in south Germany. Hydrology Science Journal, 44(2): 221-236.

Sabins, F. S. (1997). Remote sensing: Principles and interpretations (third edition), W.H. Freeman and Company, New York.

Shamsi, U. M. (1996). Storm-water management implementation through modeling and GIS, Journal of Water Résource Plan Manage. ASCE 122(2): 114-127.

Suhartanto, E. (2008). AVSWAT 2000 manual and applied to water resources field. CV. ASRORI, Malang.

Walling, D. E. (1988). Erosion and sediment yield research-some recent perspectives. Journal of Hydrology, 100: 113-141.

Wischmeier, W. H. and Smith, D. D. (1978). Predicting rainfall erosion losses. Agriculture Handbook no. 537, USDA Science and Education Administration.