Global Journal of Agricultural Research
Vol.6, No.2, pp.10-20, March 2018
Published by European Centre for Research Training and Development UK (www.eajournals.org)

THE DAMAGE OF DELI RIVER WATERSHED CAUSING FLOOD, MEDAN, INDONESIA

Sumihar Hutapea

Agricultural Faculty, Medan Area University (UMA), Medan, Indonesia

ABSTRACT: *The determination of the Deli watershed, Medan, North Sumatra, Indonesia as a critical watershed is because the critical land area is almost half of the total Deli River area, which will theoretically affect the sustainability of the land and water resources of the Deli watershed area. The watershed is a land area bounded by a natural boundary of topography that serves to accommodate, store, and drain the water received to the nearest river system which further leads to reservoirs or lakes or seas. the damage to agricultural land is increasing. This may result from erosion, water logging, accumulation of salts in saline areas, the accumulation of elements or compounds that are toxic to plants due to the use of chemical fertilizers and chemical drugs continuously every year. Deli land destruction is dominated by biophysical factors, especially land use, slope, landform, and rainfall in the upstream Deli sub watershed.*

KEYWORDS: Deli River, Watershed, Flood, Restoration

INTRODUCTION

Deli watershed is one of the priority watersheds in the Medium Term Development Plan *Rencana Pembangunan Jangka Menengah* (RPJM) 2010 - 2014 according to the Ministry of Forestry decree (SK 328 / Menhut-II / 2009). This decision is based on a Joint Agreement between the Minister of Forestry, the Minister of Public Works and the Minister of Agriculture no. PKS.10 / Menhut.V / 2007 and no. 06 / PKS / M / 2007 and No. 100 / TU.210 / M / 5/2007 On May 9, 2007 About Rehabilitation The Watershed of Deli for the Conservation of Land and Water Resources. This Agreement is a follow up of the National Movement of Forest and Land Rehabilitation ***Gerakan Nasional Rehabilitasi Hutan dan Lahan*** (GN-RHL / Gerhan) January 21, 2004 and the National Water Rescue Partnership ***Gerakan Nasional Kemitraan Penyelamatan Air*** (GN-KPA) National Movement April 28, 2005 by the President and the National Declaration of Effective Water Management in Countermeasures Disaster April 23, 2004 by Menko Kesra, and based on the fact of the increased intensity of floods, landslides, and droughts. The determination of the Deli watershed as a critical watershed is because the critical land area is almost half of the total Deli River area, which will theoretically affect the sustainability of the land and water resources of the Deli watershed area. In addition, river flow is not normal due to decreased potential infiltration. The destruction of cover vegetation greatly affects infiltration, runoff, rain fall erosivitas, which ultimately affects the rate of erosion (BPDAS Wampu Sei Ular, 2003).

The deleterious condition of the Deli watershed in North Sumatra, also due to changes in watershed characteristics where the reaction or response of the watershed system to rainfall inputs is easier to cause flooding. The morphomety of the Deli watershed is characterized by a river gradient in the upper part of the Deli Basin (in particular the Sibolangit Area) averaging 3.5%, in the middle (*Sibolangit Namorambe*) averaging 1.4%, and downstream (*Namorambe-Belawan*) -1%, so the flow velocity is greater upstream while downstream is relatively slow.

ISSN 2053-5805(Print), ISSN 2053-5813(Online)

The value of river branching (Rb) is smaller than 3, so it has a tendency to increase the flood water level rapidly, and vice versa the water level is slow (BPDAS Wampu Sei Ular, 2003).

REVIEW OF LITERATURE

Definition of Watershed

The watershed (DAS), in foreign terms is called catchment area, drainage area, drainage basin, river basin, or watershed (Notohadiprawiro, 1981; Cech, 2005). Understanding that developed in Indonesia, there are three terminology in accordance with the breadth and coverage are: Catchment, Watershed and Basin. There is no standard limit, but it is understood that the catchment is smaller than watershed, and the basin is a large basin (Priyono and Savitri, 2001). The definition of a relatively diverse watershed, according to individual goals, according to Dixon and Easter (1986) DAS means an area that is topographically limited by ridges and rainwater falling by a river system. According to Wiersum (1979), and Seyhan (1990), the watershed is a land area bounded by a natural boundary of topography that serves to accommodate, store, and drain the water received to the nearest river system which further leads to reservoirs or lakes or seas. Another definition states that the watershed is a region located at a point on a river that by topographic boundaries drains water falling over it into the same river and through the same point in the river (Brooks et al., 1992; Arsyad, 2010).DAS is a complex ecological system, in which there is a dynamic equilibrium between the incoming material energy (input) and the material out (output). In natural circumstances the change in input and output balance is slow and does not pose a threat to humans and environmental sustainability, but on a watershed system with continuous land-use dynamics from dense vegetation forms to rare vegetation forms or from vegetation forms to shapes non vegetation, according to spatial land use spatial distribution, will influence fluctuation of river flow (Asdak, 2004).

Water Conservation

Water conservation is in principle the most efficient use of water that falls to the ground and the proper flow timing, so there is no destructive flooding in the rainy season and there is enough water in the dry season. Water conservation can be carried out by: (a) improving the utilization of surface water and groundwater, and (b) increasing the efficiency of irrigation water use (Arsyad, 2010), and also the necessary measures to conserve water resources (Agus et al, 2002; Prastowo , 2008). Surface water management includes: (1) surface flow control, (2) water harvesting, (3) increasing soil infiltration capacity, (4) soil treatment, (5) use of soil clogging materials and rejection water, and (6) coating the drains. Sub surface water management can be done by: (1) drainage improvement, (2) deep percolation and sub surface flow, and (3) changes in the soil structure of the lower layers. Improved drainage will increase the efficiency of water use by plants, because excesses water loss will allow plant roots to expand to deeper layers of soil rather than confined to shallow topsoils that will dry quickly if groundwater levels decrease (Subagyono et al., 2004). Water conservation technology is designed to increase the entry of water into the soil through infiltration and filling of water pockets in the basin area and reducing water loss through evaporation. To achieve these two, water conservation efforts that can be applied are water harvesting techniques, and soil management technologies. Application of harvesting technology intended to reduce the volume of surface water flow and increase the groundwater reserves and water availability for plants

ISSN 2053-5805(Print), ISSN 2053-5813(Online)

(Irianto and Rejekiningrum, 2008).Water conservation in general is physical supervision, protecting, managing and utilizing water resources for maximum benefit for the sustainability of living creatures. The basic concept of a catchment well is a drainage system where rainwater falling on a roof or waterproof area is accommodated in a catchment system. The application of absorption wells has several functions such as flood control, protecting and improving (conserving) groundwater, and suppressing the rate of surface erosion. Theoretically the volume and efficiency of absorption wells can be calculated based on the balance of water entering wells and water that seep into the soil (Suripin, 2004).

Floods and Influential Factors

Flood is defined as an incident of overflowing river flow on the left and right of river flow either on river banks or on flood plains (Anonymous, 1999). The amount of rainfall, intensity, and distribution of rain determines the strength of rain dispersion to the soil, the amount of surface flow and the strength of erosion and flow capacity. According to PP. 38 of 2011 on the river, the definition of flooding is the event of overflowing river water over river troughs. Another definition mentions: a river is said to be flooded if there is an increase in the flow of a relatively larger flow, or when the flow of water melimpas out the river channel and cause disruption to humans (Isnugroho, 2002). Maryono (2005) states that flood events are caused by low watershed retention capability, reduced retention along the river channel, reduced absorption area, and low socio hydraulic character (water culture). According to Cech (2005) floods occur due to precipitation and runoff that exceed the capacity of the river channel. Flood is a natural occurrence that occurs due to heavy rain. The rain that falls on the earth's surface partially enters the ground, while the rest becomes the surface stream. As a result of the magnitude of the surface flow, which exceeds the capacity of natural or artificial channels, causing overflow water to flood the area around the river. If the downpour can not quickly flow into the drainage or stream, then the water causes the puddle. Flooding due to river floods or puddles will be a problem if the result of the puddle causes disruption to humans (Margianto, 2002). Factors affecting runoff are divided into two factors that are related to rainfall (duration, intensity and distribution of rain) and associated with the catchment area.

Flood is a natural phenomenon that occurs when the intensity of rain that falls very high, where the ability of absorption into the ground has been exceeded, resulting in runoff with the number and rate of large flow which can then become flooded. Floods can not be deemed to be an annual routine disaster. Floods can damage various public facilities and infrastructure that must be repaired after floods, plus if there is a loss of life. At least seven public sectors are always affected by floods, such as agriculture and forestry, water resources and irrigation, transportation, housing and settlements, environment and spatial planning, health and social welfare. Thus, directly or indirectly, floods can have a serious effect on the efficient use of local and national budgets. Various forms of activities to cope with flooding have been done by many parties, but have not shown any real results (PSSL UGM, 2007). Therefore, floods need to be addressed so that losses and damage and casualties can be reduced to the lowest level. Floods can occur in various places and do not always cause problems and even certain places of flood can actually bring benefits both short and long term. The phenomenon of flooding will be a problem when on the flood plain there is a disturbed human interest. The frequency and magnitude of the flood tends to increase over time. Floods are natural events that can not be avoided and eliminated but the risk of losses caused can be reduced. Flooding is a common problem that occurs in some parts of Indonesia and the world, especially densely populated areas such as urban areas, it is necessary that various parties need to pay attention to

ISSN 2053-5805(Print), ISSN 2053-5813(Online)

things that can cause floods and as anticipated as possible in order to minimize the impact of losses caused (Kodoatie and Sugiyanto, 2002). Flood handling can not be resolved conventionally by a purely localized pure hydraulic method, such as making embankments, talis, stream normalization, river basins, and other conventional hardclad construction forms. Other methods such as the eco-hydraulic method is an integral flood control concept by handling the flood-causing factors. The eco-hydraulic method develops ecological concepts by addressing environmental damage as the cause of extreme discharge (Maryono, 2005).

Land Damage

Today the damage to agricultural land is increasing. This may result from erosion, water logging, accumulation of salts in saline areas, the accumulation of elements or compounds that are toxic to plants due to the use of chemical fertilizers and chemical drugs continuously every year or every season cropping, and the absence of recycling of agricultural wastes resulting in the loss of nutrients and organic matter in root areas (Asdak, 2004). In addition, there is also a constriction of land ownership due to limited land area, while the population continues to grow. The definition of land degradation is a decrease of potential land for production and for environmental managers. In other words land degradation is a degradation of land quality both quality and quantity of land covering physical properties, chemical, biological, engineering and mineral content as well as organic material. Land damage can also be viewed from one aspect of land, water, air, forest or other resources. In terms of the causes of land damage can be caused by: (1) natural events (earthquake, landslide, climate change), (2) human actions (deforestation of vegetation in the upstream that leads to erosion and sedimentation, urban development), or (3) by human actions (Hudson, 1981; Notohadinegoro, 1999).

According to Sugandhy (1999), the destruction of natural resources, especially land resources, can be identified by the following symptoms: (1) development activities that go beyond land capability, so that productivity to produce food, raw materials of clothing and housing decreases , (2) uncontrolled land use conversion due to population pressures and development activities reducing forest and agricultural land areas followed by biodiversity depletion, and (3) less water quantity relative to the level of need, as indicated by increasing needs ratio and water reserves, the situation is exacerbated by the declining quality of water due to pollution (Irianto and Rejekiningrum, 2008). In terms of activities that cause land damage, several examples can be identified: (1) inappropriate land use resulting in degraded lands and landslides, (2) clearance of protected forests resulting in flooding and sedimentation, (3) settlement construction in the soil, (4) excessive use of groundwater resulting in soil water levels falling and subsidence, and (5) post-mining land that is not reclaimed resulting in degraded land and declining soil fertility (Anonymous, 1999). Based on Government Regulation no. 150 of 2000 on Control of Soil Damage for Biomass Production, the standard criteria for soil damage in dry land and wetlands as listed in Table1.

ISSN 2053-5805(Print), ISSN 2053-5813(Online)

Table 1: Raw Criteria of Soil Degradation on Dry Land

No	Parameter	Critical threshold	Measurement methods	Equipment
1	Thickness of solum	< 20 cm	Direct measurement	Meter
2	Unity of the surface	< 40 %	Direct measurement of rock and soil balance in unit area	Meter; counter (line or total)
3	Fraction composition	<18 % koloid; > 80 % quarsitic sand	The color of sand, gravimetric	Measuring tube; scales
4	Content weight	> 1,4 g/cm3	Gravimetric on unit volume	Candle, measuring tube; ring samples, analytic scales
5	Total porosity	< 30 %; > 70	%Calculation of Content Weight and Specific Weight	Piknometer; analytical scales
6	The degree of water grinding	<0,7 cm/hours >8,0 cm/hours	Permeability	Ring sample, double ring parameter
7	pH (H2O) 1 : 2,5	< 4,5; >8,5	Potentiometric	pH meter; pH stick skala 0,5 Unit1`
8	Power Conductivity	>4,0 mS/cm	Electric resistance	EC meter
9	Redox	< 200 mV	Electrical voltage	pH meter; elektroda platina
10	Number of microbes	<102 cfu/g land	Plating technique	Petri dish; colony counter

Source: State Ministry of the Environment (2006)

DISCUSSION

Watershed in general, the factors that influence erosion are: climate, soil type, and slope (topography), as well as land cover (vegetation) and human treatment of soils. Climate determines the value of rainfall erosivity index, while the soil with its properties can determine the size of soil erosion, which is expressed as a factor of soil erodibility. Topograpi effect on the speed of the speed of water on the surface. While the cover crop factor (vegetation) has the nature of protecting the soil from hard-pressed rainwater rainfall to the surface. While the

ISSN 2053-5805(Print), ISSN 2053-5813(Online)

factors of activity or human treatment of the soil, in addition to accelerate the occurrence of soil surface erosion because the treatments are also in the effort to prevent erosion with conservation measures. Damage / degradation of land occurring in Indonesia is generally caused by rainwater erosion. This is due to the high number and intensity of rainfall, especially in western Indonesia (Abdurrahman and Sutono, 2002).

Rain Erosivity is KE> 1 or total rain kinetic power with rain intensity greater than 1 inch per hour (Hudson, 1981). Furthermore, according to Wischmeier and Smith (1978) states that rain erosivitas is E ¬ 30 or the result of total kinetic power of rain with maximum rain intensity over a period of 30 minutes. The formula used to calculate the rain erosivity factor is using the Lenvain formula (1975) in Arsyad (2010).

$$EI30= 2,21 R1,36 \qquad (4)$$

Information EI30: Rain Erosivity

R : average monthly rainfall (cm)

The rainfall data of Deli watershed was obtained from 6 rainfall station, over a period of 21 years (1989 - 2009). Data obtained from BMKG North Sumatra Medan. Based on the calculation of the average monthly rainfall, the average rainfall erosivity value in each rainwater catchment station of Deli watershed is listed in Table 2:

Tabel 2: Value of Deli River Erosivity

Erosivity	Rainfall Station					
(Ton/ha)	Togkoh	Pancur Batu	Tuntungan	Polonia	Seumayang	Belawan
January	111,9	84,8	111,3	72,0	37,4	85,1
February	103,6	59,7	59,7	41,4	35,7	34,4
March	141,0	95,6	103,3	60,8	44,3	49,4
April	182,0	104,4	90,9	85,3	52,7	53,6
Mey	79,2	176,3	186,0	135,2	94,6	108,2
June	55,9	119,3	133,3	90,3	69,7	83,3
July	52,8	111,3	100,3	88,4	68,6	100,3
August	54,6	166,8	161,0	129,4	91,7	156,4
September	102,5	284,2	320,5	228,5	234,3	185,6
October	165,5	247,1	308,7	209,6	209,1	211,1
Nopember	216,6	216,6	212,5	155,2	124,2	219,1
December	167,7	132,0	226,1	114,4	104,4	240,4
Annual Rate	116,1	149,8	167,8	117,5	97,2	127,8

Furthermore, using ArcviewGIS version 3.3 program by including rainfall erosive analysis results from six rain gauge stations (see Table 19) an isoerodent map is made. The isoerodent line is the line that connects the rainfall erosivity level with the value (Renard et al., 1997). From the Isoeroden Map it can be seen that the large rainfall erosivitas and spatial distribution of each Deli Watershed as listed in Table 19. An example of the results of annual rainfall erosive analysis of each of the Deli DAS rainfall station can be seen in Tuntungan rainfall station.

ISSN 2053-5805(Print), ISSN 2053-5813(Online)

Table 3: Flood Causes Based on Priority Sequences

No.	Causes of Flood	Priority Reasons	Cause
1	Land use change	The peak discharge rises from 5 to 35 times because the water absorbed into the soil causes little runoff to become large, resulting in large discharge and erosion resulting in sedimentation.	Human
2	Trash	River or drainage is blocked and if water abounds out due to reduced channel capacity.	Human
3	Erosion and sedimentation	Due to changes in land use, erosion resulted in sedimentation into the river so that the capacity of the river is reduced	Human and nature
4	Slum areas along the river / drainage	Can be a flow inhibitor, as well as the capacity of the river. The problem of slum areas is known as an important factor to the problem of urban flooding.	Human
5	Flood control system planning is not appropriate	Flood control systems can indeed reduce damage from small to medium floods, but may add to the damage during large floods. Eg: high river embankment building. Overflow on the flood embankment beyond the plan flood caused the collapse of the embankment, the vast water velocity through the collapse of the embankment causing massive flooding.	Human
6	Rainfall	In the rainy season, high rainfall will cause flooding in the river and when exceeding river cliffs there will be floods or puddles including dike bobolnya. Rainfall data shows a maximum increase of peak discharge between 2 to 3 times.	Nuture
7	Influence of physiography	Physiography or physical geography of the river such as the shape, function and slope of the watershed, river slope, hydraulic geometric (cross-sectional shape such as width, depth, elongated section, river bed material), river location and others.	Nuture And Human

ISSN 2053-5805(Print), ISSN 2053-5813(Online)

8	River capacity	Reduced flood-flow capacity in rivers can be caused by sedimentation from watershed erosion and excessive river bank erosion and sedimentation in the river due to lack of cover vegetation and improper land use	Human and Nature
9	Inadequate drainage capacity	Due to changes in land use and reduced crop / vegetation and human actions resulted in reduced channel / river capacity as planned	Human
10	Land drainage	Urban drainage and agricultural development on the floodplain area will reduce the ability of natural banks to accommodate high water discharge	Human
11	Dams and water buildings	Dams and other buildings such as bridge pillars can increase the flood water level because of the backwater effect.	Human
12	Damage to flood control buildings	Inadequate maintenance of flood control structures that cause damage and ultimately does not work can increase the quantity of floods.	Human and Nature
13	The influence of the tide	The tide slows the flow of the river into the sea. When floods coincide with high tides, high puddles or floods become large due to backflow. Only on coastal areas like Pantura, Jakarta and Semarang.	Nature

CONCLUSION

Deli land destruction is dominated by biophysical factors, especially land use, slope, landform, and rainfall in the upstream Deli sub watershed.The damage of Deli River watershed causing flood in Medan due to some factors are: erosion, climate, soil type, and slope (topography), as well as land cover (vegetation) and human treatment of soils. Climate causes the value of rainfall erosivity index, while the soil with its properties can determine the size of soil erosion, which is expressed as a factor of soil erodibility. Topograpi effect on the speed of the speed of water on the surface. While the cover crop factor (vegetation) has the nature of protecting the soil from hard-pressed rainwater rainfall to the surface. In addition to accelerate the occurrence of soil surface erosion because the treatments are also in the effort to prevent erosion with conservation measures. Damage / degradation of land occurring in Indonesia is generally caused by rainwater erosion.

ISSN 2053-5805(Print), ISSN 2053-5813(Online)

REFERENCES

Abdrachman, A., dan S. Sutono. 2002. Teknologi Pengendalian Erosi Lahan Berlereng hlm. 103-146 *dalam* Teknologi Pengelolaan Lahan Kering Menuju Pertanian Produktif dan Ramah Lingkungan. Pusat Penelitian danPengembangan Tanah dan Agroklimat. Badan Litbang.

Abdrachman, A., S. Abuyamin, dan U. Kurnia. 1984. Pengelolaan Tanah dan Tanaman Untuk Usaha Konservasi. Pusat Penelitian Tanah. Bogor.

Anonim. 1999. Penyusunan Kriteria Kerusakan Tanah. Prosiding Seminar. Deputi Bidang Pengendalian Kerusakan Lingkungan Hidup. Badan Pengendali Dampak Lingkungan. Jakarta.

Arly. 1998. Arahan Penggunaan Lahan Daerah Aliran Sungai (DAS) Deli Bagian Hulu Ditinjau dari Aspek Fisik dan Sosial Ekonomi Wilayah. Tesis, Program Pasca Sarjana Universitas Sumatera Utara. Medan. (Tidak Dipublikasi).

Arsyad, S. 2008. Konservasi Tanah dan Air Dalam Penyelamatan Sumber Daya Tanah dan Air. *dalam* Penyelamatan Tanah, Air dan Lingkungan (Eds.) Arsyad S., dan E. Rustiadi. Yayasan Obor Indonesia. Jakarta.

Arsyad, S. 2010. Konservasi Tanah & Air. IPB Press. Bogor.

Asdak, C. 2004. Hidrologi dan Pengelolaan Daerah Aliran Sungai. Gadjah Mada University Press.Yogyakarta.

Badan Pusat Statistik Kabupaten Karo. 2009. Kabupaten Karo dalam Angka. Koordinator Statistik Kabupaten Karo.

Bakosurtanal. 1979. Peta Rupa Bumi Indonesia Skala 1 : 50.000 Lembar 0619 – 61 Medan ; 0619 – 63 Belawan dan 0619 – 33 Pancurbatu. Edisi I.

Baronsono, J.M. 1998. Erosi Permukaan dan Arahan Konservasi di Daerah Sentani Kabupaten Jayapura. Disertasi Progam Studi Geografi, Sekolah Pasca Sarjana Universitas Gadjah Mada (Tidak dipublikasi)

Bedient, P. B. and W. C. Huber. 1992. *Hydrology and Floodplan Analysis.* Addison-Wesley Publishing Company. USA.

Black, P.E. 1991. Watershed Hydrologi. Prentice Hall, Engleewood Cliffs, New Jersey. 408 p.

BPDAS Wampu Sei Ular. 2003. Rencana Pengelolaan Daerah Aliran Sungai Terpadu Deli. Direktorat Jenderal Rehabilitasi Lahan dan Perhutanan Sosial. Departemen Kehutanan.

BPDAS Wampu Sei Ular. 2009. Kajian Banjir Kota Medan Distribusi Faktor Penyebab dan Arahan Penanganannya. Direktorat Jenderal Rehabilitasi Lahan dan Perhutanan Sosial. Departemen Kehutanan.

BPDAS Wampu Sei Ular. 2011. Pemantauan Tata Air dengan Pendekatan Mdel Hidrologi. Direktorat Jenderal Rehabilitasi Lahan dan Perhutanan Sosial. Departemen Kehutanan.

Brooks, K. N. 1989. Watershed Management Project Planning, Monitoring, and Minnesota Evaluation : A Manual for The ASEAN Region. University of Minnesota, St Paul, Minnesota.

Kurnia, U., Sudirman, dan Kusnadi. 2002. Teknologi Rehabilitasi dan Reklamasi

Lahan Kering. Hlm 147-182. *dalam* Teknologi Pengelolaan Lahan Kering Menuju Pertanian Produktif dan Ramah Lingkungan. Pusat Penelitian dan Pengembangan Tanah dan Agroklimat. Badan Litbang Pertanian.

Linsley. R.K., M. A.Kohler, and J.L.H.Paulus. 1983. Hydrology for Engineering. New York, Third Edition McGraw-Hill Book Co.

Maas, A. 2001. Pengelolaan Sumber DayaLahan BerwawasanLingkungan untuk

ISSN 2053-5805(Print), ISSN 2053-5813(Online)

Margianto, T. D. S. 2002. Penanganan Fisik Penanggulangan Banjir. Alami. JurnalAir, Lahan, Lingkungan dan Mitigasi Bencana. Vol. 7 No. 2. Jakarta. p. 40 – 45.
Maryono, A. 2005. Menangani Banjir Kekeringan dan Lingkungan. Gadjah Mada University Press.
Menyongsong Otonomi Daerah. Makalah pada Seminar Nasional Ilmu Tanah. Peran Manajemen Sumber Daya Lahan Terhadap Pengembangan Wilayah 12 Mei 2001, KMIT UGM Yogyakarta.
Notohadiprawiro, T., Rachman S., Azwar M., dan S. Yasni. 1999. Kebutuhan Riset, Inventarisasi dan Koordinasi Pengelolaan Sumber Daya Tanah di Indonesia. Kantor Menteri Negara Riset dan Teknologi dan Dewan Riset Nasional. Jakarta. 169 hal.
Predicting Soil Erosion by Water: A Guide to Conservation Planning With The Rivesed Universal Soil Loss Equation (RUSLE). USDA Agriculture Hand Book (703).
Publishers.
Rahayu, K. 2005. Tingkat Bahaya Erosi Tanah di Kecamatan Bulu Kabupaten Temanggung. Skripsi Fakultas Geografi Universitas Gadjah Mada (Tidak dipublikas).
Rahim, E.S. 2006. Pegendalian Erosi Tanah. Edisi 3. Aksara. Jakarta pp 106.
Reimold, J. K. Robert. 1998. *Watershed Management: Practice, Policies, and Coordination*. The McGraw-Hill Companies, Inc.
Renard, K.G, G.R Foster, G.A. Weeisies, D.K. Mc. Cool, and D.C. Yoder. 1997.
Riebe, C.S. , J.W. Kirchner, D.E. Granger, and R.C. Finkel. 2001. Minimal Climatic Control on Erosion Rates in The Sierra Nevada, California. *Geology*, v. 29, no. 5, p. 447–450.
River Basin, Makalah pada Linggarjati Enviromental Meeting, 9 – 13 November 2000. Suripin. 2004. Pelestarian Sumber Daya Tanah dan Air. Andi. Yogyakarta
Santoso, D., J. Purnomo, IG.P Wigena, dan E. Tuherkih. 2004. Teknologi Konservasi Tanah Pada Lahan Kering Berlereng. (Eds) Kurnia, U. *dkk.,* Pusat Penelitian dan Pengembangan Tanah dan Agroklimat Badan Penelitian dan Pengembangan Pertanian.
Sastrodihardjo, S. 2012. Upaya Mengatasi Masalah Banjir Secara Menyeluruh. PT. Mediatama Saptakarya. Jakarta.
Schmidt, F.H. and J.H.A. Ferguson, 1951. Rainfall Type Base on Wet and Dry Period Ratios for Indonesia and Western. New Guinea. Verb. 42 Jawatan Meteorologi dan Geofisika. Jakarta.
Schwab, G. O., D. F. Delmar, D. F., J. E. William, and K. F. Richard. 1993. Soil and Water Conservation Engineering (Fourth Edition). John Wiley and Sons, Inc.New York.
Seta, A. K. 1991. Konservasi Sumber Daya Tanah dan Air. Kalam Mulia. Jakarta.
Seyhan. 1990. Dasar-dasar Hidrologi. Yogyakarta: Gadjah Mada University Press Yogyakarta.
SPLaSH. 2007. *Software* Sistem Penilaian Lahan Sesuai Harkat. Balai Penelitian Tanah dan Agroklimat. Bogor. Supriadi, D. 2000. Up Land Management : Cases of Cimanuk and Cisanggarung
Suryani dan Agus. 2005. Perubahan Penggunaan Lahan dan Dampaknya terhadap Karakteristik Hidrologi: Suatu Studi DAS Cijalupang, Bandung, Jawa Barat. Prosiding Seminar Nasional Multifungsi Pertanian dan Ketahanan Pangan. Pusat Penelitian dan Pengembangan Tanah dan Agroklimat. Bogor. hal 83-106.
Svendsen, M. 2004. Irigation River Basin Management Option for Governance and Institutions. USA.
The World Commission on Dams. 2000. Dams and Development.
Triatmodjo, B. 2008. Hidrologi Terapan. Beta Offset. Yogyakarta. Undang-undang No. 7. 2004. Tentang Sumber Daya Air.

ISSN 2053-5805(Print), ISSN 2053-5813(Online)

U S S C S (Unitet State Soil Conservation Service). 1971. Hydrology. Washington DC : National Engineering Handbook.

Utomo, W. H. 1983. Pengawetan Tanah. Fakultas Pertanian Universitas Brawijaya. Malang.

Vadari, T., K. Subagyono, dan N. Sutrisno. 2004. Model Prediksi Erosi Prinsip Keunggulan dan Keterbatasan. *dalam* TeknologiKonservasiTanah pada Lahan Kering Berlereng. (Eds) Kurnia, U., A. Rahman, dan A. Dariah. Pusat Penelitian dan Pengembangan Tanah dan Agroklimat Badan Penelitian dan Pengembangan Pertanian. p. 35 – 71.

Veiche, A. 2002. The Spatial Variability of Erodibility and Its Relation to Soil Types: A Study From Northen Ghana. Geoderma 106: 110 – 120.

Viesmann. J. W. 1989. Introduction to Hydrology. New York: Harper and Row

Wanielista M.P. 1990. Hydrology and Water Quality Control. Florida-USA : John Wiley & sons.

Ward, A.D., and W. J. Elliot,. 1995. Environmental Hydrology. Lewis Publishers. New York.

Wiersum, K. F. 1979. Introduction to Principles of Forest Hydrology and Erosion. Institute of Ecology. Bandung: Universitas Pajajaran.

ISSN 2053-5805(Print), ISSN 2053-5813(Online)