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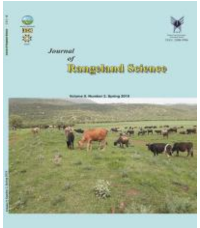

Research and Full Length Article:

Assessment of Deli Watershed Flood Causing Damage in Medan City, Indonesia

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Abstract. The watershed (DAS) Deli is one of the priority watersheds in the Medium Term Development Plan in 2010-2014 according to the Ministry of Forestry decree (SK 328/Menhut-II/2009), Indonesia. DAS is a complex ecological system in which there is a dynamic equilibrium between the incoming material energy (input) and the material out (output). Naturally, the change in input and output balance is slow and does not pose a threat to humans and environmental sustainability on a watershed system with continuous land-use dynamics from dense vegetation forms to rare vegetation forms or from vegetation forms to non-vegetation forms. It has been concluded that Deli watershed land destruction is dominated by biophysical factors, especially land use, slope, landform, and rainfall in upstream Deli sub-watershed. This is what causes flooding in Medan city, Indonesia. The cause is extreme rainfall so that a number of rivers such as Deli River and Babura River overflowed, the water level of the Deli and Babura Rivers almost reached the bridge section and this was scarce.

Key words: Deli River, Watershed, Flood, Damage, Erosion

Introduction

The Watershed Daerah Aliran Sungai(DAS) Deli is one of the priority watersheds in the Medium Term Development Plan in 2010-2014 according to the Ministry of Forestry decree (SK 328 /Menhut-II /2009), Indonesia based on a Joint Agreement among Ministry of Forestry, Ministry of Public Work and Ministry 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 Critical River Basin Rehabilitation (DAS) for the conservation of land and water resources. This agreement is a follow-up to National Movement for Forest and Land Rehabilitation (GN-RHL/Gerhan) on 21 January 2004 and National Movement for Water Rescue Partnership (GN-KPA) on 28 April 2005 by President and National Declaration on Effective Water Management in disaster management on 23 April 2004 by Coordinating Minister for People Welfare based on the fact that there are increased intensities of floods, landslides and droughts. In the Letter of Agreement, the Deli watershed is one of the critical watersheds that require priority handling as the target site for rehabilitation (www.dephut.goid/files/328.pdf). 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, rainfall erosivities, which ultimately affects the rate of erosion (BPDAS Wampu Sei Ular, 2003).

The deleterious condition of the Deli watershed in North Sumatra is due to changes in watershed characteristics where the response of the watershed system to rainfall inputs is easier to cause flooding. The morphometry of the Deli watershed is characterized by a river gradient upstream of the Deli Basin (in particular the Sibolangit Area) averaging 3.5%, in the center (Sibolangit Namorambe) averaging 1.4%, and downstream (Namorambe-Belawan) -1%, so the flow velocity is greater upstream while downstream is relatively slow. The value of branches is smaller than 3, so it has a tendency to increase the flood water level rapidly, and the water level is low (BPDAS Wampu Sei Ular, 2003).

In addition, headwater area of the watershed is dominated by the slope and mountainous plains where the majority of the population with livelihoods as farmers cultivate 82% of farmland in villages in the upstream Deli basin (BPS Karo Regency, 2009). This situation will cause vulnerability to erosion and flooding in the downstream area if land rehabilitation is not with Soil and Water Conservation (Sub-Pusat Rehabilitasi Lahan dan Konservasi Tanah / Bangun Tanah, 1998). However, as far as observations which have been conducted, there has not been an optimally integrated watershed management concept based on watershed / watershed conservation studies in order to control flooding in a region.

Deli River is one of the eight rivers in Medan, North Sumatera, Indonesia. In 19th century, Deli River is used as an artery of trade for the sultanate to other areas. The river flows in the northeastern area of Sumatra with predominantly tropical rainforest climate. The annual average temperature in the area is 24°C. The warmest month is January when the average temperature is around 26°C, and the coldest temperature is in December at 22°C. The average annual rainfall is 2862 mm. The wettest month is October with an average of 446 mm rainfall, and the driest season is in June with 129 mm rainfall.

Based on the result of soil watershed land delineation analysis obtained from Soil Sub Map of Land Rehabilitation and Soil /Snake Soil Conservation (1999), using ArcView GIS version 3.3 software, the spatial distribution of units of soil contained in each sub watershed Deli is listed in Table 1.

Table 1. Soil sub unit of Deli river basin

Sub watershed	Land Unit		
	Group (Asosiasi)	Wide (ha)	(%)
1	2	3	4
Petani	Dystrandept Eutrandept Dystrandept	3.865	30
	Dystropept Dystrandept Tropudult	4.491	35
	Dystropept Troporthent Tropudult	2.590	20
	Dystropept Tropudult Troporthent	563	4
	Hydrandept Eutropept Troporthent	1.313	10
Total		12.824	100
Simai-mai	Dystrandept Eutrandept Dystrandept	785	24
	Dystropept Dystrandept Haplorthox	652	20
	Dystropept Dystrandept Tropudult	1.795	55
Total		3.233	100
Babura	Andaquept Tropaquept	725	14
	Dystrandept Eutrandept Dystrandept	1.045	21
	Dystropept Dystrandept Tropudult	3.188	64
Total		4.959	100
Bekala	Dystrandept Eutrandept Dystrandept	198	4
	Dystropept Dystrandept Tropudult	4.346	95
Total		4.544	100
Deli	Andaquept Tropaquept	2.259	35
	Dystrandept Eutrandept Hydrandept	341	5
	Dystropept Dystrandept Tropudult	2.303	35
	Hydraquent Sulfaquent	751	11
	Tropaquept Fluvaquent Tropohemist	509	8
	Tropopsamment Tropaquent	282	4
Total		6.447	100
Sei Kambing	Andaquept Tropaquept	2.607	61
	Dystrandept Eutrandept Hydrandept	718	17
	Dystropept Dystrandept Tropudult	938	22
Total		4264	100
Paluh Besar	Andaquept Tropaquept	7.072	61
	Hydraquent Sulfaquent	1.382	12
	Tropaquept Fluvaquent Tropohemist	2.298	20
	Tropopsamment Tropaquent	747	6
Total		11.498	100

Table 1 shows that the soil units found in Deli watershed according to Soil Taxonomy Soil Survey Staff (1975) were classified into 5 orders as Inceptisols, Entisol, Ultisols, Oxisol, and Histosol. These five orders were grouped into 10 sub-orders and 18 soil groups. The soil unit in the Deli watershed is an association of ground map units consisting of two or three main land types at the order level with the area of each order not exceeding 75% of the land unit area (Hardjowigeno and Widiatmaka, 2007).

According to Soil Taxonomy (Keputusan Menteri Kehutanan, 2010) soil classification, 15 Inceptisol points were found, 2 Entisol order points and 1 Ultisol order point, decreasing 5 great groups. The results of the spatial distribution of the Deli River watershed are dominated by Inceptisol soil orders, i.e., young soils with moderate developmental soil pH is generally acidic to neutral, sandy soil texture, clumped earth structures and medium to very fast permeability. Considering next order Entisol land especially on the riverside, the type of soil is relatively young textured sandy loam (sandy loam). While the order of Ultisol soil and Oxisol on the upstream, generally textured silty clay loam, low organic material content developed from old parent material has a horizon of candy to order Utisol with the amount of mineral easily decayed eligible the oxic horizon for the Oxisol order (Foth, 1990; Hardjowigeno, 2007).

Definition of Watershed (DAS)

Watershed (DAS) in foreign terms is known as catchment area, drainage area, drainage basin, river basin, or watershed (Notohadiprawiro, 1999; Cech, 2005). In Indonesia, there are three terminologies in accordance with the breadth and coverage namely: 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).

Regarding the definition of a relatively diverse watershed according to individual goals, according to Dixon and Easter (1986), DAS means an area limited by ridges and rainwater falling by a river system. According to 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 that 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., 1989; 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). Naturally, 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, it will influence fluctuation of river flow (Asdak, 2004). Besides being a water system, DAS is also an ecosystem, referred to as a watershed ecosystem. The elements contained within the watershed include both natural and human resources. Natural resources act as objects consisting of land, vegetation, and water, while with respect to the human element as the subject or perpetrator of the elements of natural resources between these elements, the process of mutual relations occurs and influences each other. In the natural resources, soil, water, and vegetation are interrelated to produce a certain product and certain water conditions that ultimately affect human life. On the other hand, human as the perpetrator of the utilization of natural resources does a lot of actions or changes on land and vegetation, so it reacts to the products, participation and water results (Asdak, 2004).

According to Soerianegara (1978), the reflection or measurement of the hydrogeological conditions is determined from the ability of water supply in terms of quality and quantity and distribution by time. A good hydrogeological condition is when the watershed can ensure the provision of water of good quality, sufficient quantity and uniform discharge distribution throughout the year. Watershed ecosystems are divided into upstream, middle and downstream watersheds. Biogeophysically, the characteristics of upper watershed are:

1) It is a conservation area,
2) It has higher drainage density,
3) It is an area with a large slope (> 15%), it is not a flood zone,

4) The water used is determined by the drainage pattern, and
5) The type of vegetation is generally a forest stand (Brooks et al., 1989).
While the characteristics of downstream watershed are:
1) It is an area of exploitation, a smaller drainage density,
2) It is an area with a small to very small (<8%) slope,
3) It is in some places a flooded area,
4) The regulation of water consumption is determined by the irrigation building, and
5) The dominant type of vegetation is agricultural crops except the estuary area dominated by mangrove / peat forest.
The central watershed area is the transition region of the two bio-geophysical characteristics of different watersheds mentioned above.

Based on the point of view of the hydrological system and the ecology of the upstream roles in the watershed, the continuity of the resource economy and the conservation of biodiversity in the study of hydrological and ecological systems cannot be ignored. With these considerations, according to Pasaribu (1999), DAS can be totally used and the upstream ecosystem development can be implemented in accordance with preservation, reservation, and conservation principles. Upper and downstream areas of a watershed have a biophysical linkage represented by the hydrological cycle and nutrient cycle. The existence of biophysical linkages making the watershed can be used as a logical planning and evaluation unit for the implementation of watershed management programs.

Floods and Influential Factors

Flooding is defined as an incident of overflowing river flow on the left and right of river flow either on riverside or on flood plains (Anonymous, 1999). The amount of rainfall, intensity, and distribution of rain determine the strength of rain dispersion to the soil, the amount of surface flow and the strength of erosion and flow capacity. According to Government Regulations No. 38 in 2011 about the river, the definition of flooding is the event of overflowing river water over river troughs. 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 abundant water is out the river channel and causes 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). Cech (2005) argues that 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. Consequently, the magnitude of the surface flow, which exceeds the capacity of natural or artificial channels, caused the overflow of water to flood in the area around the river. If the downpour cannot 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). There are two factors affecting run off 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 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 become flooded. Flooding cannot be deemed as an annual routine disaster. Floods can damage various public facilities and infrastructure must be repaired after floods if there is a loss of life. At least, seven public sectors are always affected by flooding 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. Many parties have done various forms of activities to cope with flooding, but they have not shown any real results (Pssl-Ugm, 2007).

The aim of this research was to assess field survey method, and survey activity in the form of observation and verification of characterization and biophysical identification of each Deli watershed, Indonesia

Materials and Methods

A field survey method in the form of observation, verification of characterization and biophysical identification of each Deli watershed was carried out. Considering the parameters of land damage, soil observation by drilling and making minipit soil (land section or soil profile, but smaller size and more shallow), the minipit soil size of 50 x 50 x 60 cm and minipit soil samples were taken. Soil samples are analyzed for several properties of the soil in the laboratory. Field surveys were conducted by observing the types of land use, climate data and hydrology. Survey data and analysis of laboratory soil properties are used to assess land damage. The land damage assessment is based on the prediction of erosion and erosion hazard, land classification, land use classification, flood analysis, watershed conservation study /sub watershed followed by analysis of impact of conservation guidance on the decrease of flood discharge and flood volume. The database and maps of area were prepared using almost Geographic Information System (GIS).

Location of Study

The research was conducted at Deli Watershed located in 3 regions / cities in North Sumatera as Karo Regency, Deli Serdang and Medan City. Administratively, Deli watershed is adjacent to DAS Percut in the East and Belawan Watershed in the West. The Deli Watershed consists of 7 sub-watersheds as: 1) Farmer's DAS Sub-Waters, 2) Simai-mai Sub Watershed, 3) Deli Basin, 4) Babura Sub Watershed, 5) Sub Basin of Bekala, 6) Sub- Sei kambing and Sub DA big hammer giving the names of the sub-watershed in accordance with the names of the tributaries that flow in the area through which it passes. Based on its geographic position, the Deli watershed is located between 30 12'58 "LU - 30 47'15" LU and between 980 28'50 "BT - 980 41'50"BT. Deli River Area is 48,162 ha. The city of Medan as a downstream area is the region most affected by the management of the Deli watershed. Medan city is the capital of North Sumatera Province which is located at 030 29 '46 "LU - 030 46' 29" N and 98029'46 "BT- 980 35 '14" BT with altitude of 0-40 m above sea level. Geographically, the total area of Medan City reaches 26,510 ha; the largest landuse pattern is for settlement (80%). Field research began in February 2010 to January 2011.

Research Tools (maps)

Materials used in the study includes: earth map, geology / lithology map, topography map, soil map, Landsat digital image of 2003, land use map, vegetation density map. Single computer device, Arcview GIS Software version 3.3 and PC Software ArcGIS version 9.3 are used to make the image and MS Office word / excel software for analysis and presentation of data, Flood Assessment Software (PSSL-UGM, 2007) for flood assessment, and cameras as a survey documentation. The tools used in the study include: 1) Stationeries, 2) Work Map Scale 1: 100,000, 3) Field measuring tools (GPS Garmin, geological compass, meter roll, soil drill, drill and permeability ring), and 4) work tools in the field (scopes, hoes, fork and crowbar, plastic bags, loops, field knives).

Field Survey

Field survey aims to check the suitability between the information on the map / secondary data with existing conditions in the field. The survey is conducted to check the land characteristic data and the biophysical characteristics of the watershed / sub watershed Deli. The biophysical status of the watershed / sub watershed Deli is one of the determinants, either directly or indirectly, as one of the causes of flooding in the city of Medan. The biophysical status of the watershed / sub watershed Deli is generally reflected by the morphological conditions (slope), soil type, land use, morphometry (including broad parameters, river length, river main gradient, shape, flow density, and travel time), and other biophysical factors are vegetation and climate (especially raindrops), and hydrology in surveying field also identified flood or flood-prone locations by setting control points for inflow sources, and characteristics review of the flood hydrograph from the influence of each upstream sub-watershed, and other sub watersheds. Required hydrological data include: rainfall data (intensity, duration of rain), river flow, land use data, watershed area, length of main river, slope, high difference between upstream and downstream, concentration time, flow velocity flood average, with Rational analysis that will be obtained combined runoff coefficient. The areas affected by floods and potentially for floods are determined, and the impacts of floods on both the environment and the circumstances surrounding communities are observed.

Data Processing

The in-depth studies covered aspects of rain analysis, hydrological analysis, erosion prediction analysis, and erosion hazard, land criticality analysis, and land use capability, flood analysis including flood potential and flood-prone areas, analysis and erosion control strategies with selection of soil and water conservation models that can control flooding.

Results and Discussions

Medan City is one of the administrative areas included in the Watershed (DAS) Deli. It is 26510 ha total area of Medan City, which is included in the management of Deli watershed 53.6% (14213 ha). Therefore, the flooding in Medan City is strongly influenced by the condition of Deli watershed especially in the upstream areas where the critical land is getting wider, which can result in flooding of shipment. In addition, the reduction of the catchment area is due to the penetration process, the development of residential areas, industries and so on in the suburbs to the city center. The decline of the wet cross section of Deli and Babura River children is due to silting/ puddling, the number of slum neighborhoods around the riverbanks, and due to the very poor condition of Medan city drainage (Hasibuan, 2007). The city of Medan as the capital of North Sumatra Province is flood-prone because it is lowland, flat with a height of 2.5-40 m above sea level and a slope of 0-4%. In addition, geographically, Medan City is traversed by many rivers that divide the Medan City to Deli river, Babura river, Belawan river, Percut river, Serdang river and other small rivers such as river Batuan, Badera River and Kera river; if not managed well, they are very vulnerable to flooding (Medan City Government of Medan II Region, 2000). Based on information from various parties such as the Meteorology and

Geophysics Agency (MGA), Satkorlak of North Sumatra Disaster Management and media coverage both nationally and locally in North Sumatra, flooding incident in Medan city routinely happens every year, even according to Hasibuan (2007) Medan city on average 10-12 times / year. Therefore, the problem of flooding in Medan city is a serious problem that should be solved immediately because every flood event will threaten millions of people of Medan City, both river dwellers and other residents whose activities are disrupted by the flood. This will certainly be a bad image for the city of Medan as the capital of the province of North Sumatra, and one of the major cities in Indonesia.

The Location and Position of DAS Deli

River Basin (DAS) Deli is located in Karo Regency, Deli Serdang and Medan City, North Sumatera Province. The upstream of Deli River is located in Karo and Deli Serdang District while the middle and downstream areas are in Medan City and Deli Serdang Regency, and empties into Belawan Harbor. Deli watershed is in the east bordering with DAS Percut. Based on its geographical position, the Deli watershed is located between 30 12'58 "to 30 47'15" North Latitude and between 980 28'50 "to 980 41'50" East Longitude (Figs. 1 and 2).

Fig. 1. Location of river mouth on map of Sumatera, Indonesia

Fig. 2. The top view of Deli river

Based on the Administration of Deli Watershed, it includes 27 Subdistricts of Merdeka District and Berastagi Karo Regency. District Sibolangit, Sibiru-blue, Pancurbatu, Namorambe, Delitua, Sunggal, Patumbak, and Silver Overlay Deli Serdang District. Subdistrict Medan Tuntungan, Medan Johor, Medan

Amplas, Medan Selayang, Medan Polonia, Medan Baru, Medan City, Medan Maimun, East Medan, Medan Petisah, Medan Helvetia, Medan Barat, Medan Deli, Medan Marelan, Medan Labuhan and Medan Belawan in Medan (BPDAS Wampu Sei Ular, 2003, (BPDAS Wampu Sei Ular, 2009).

According to the Sub-Center for Land Rehabilitation and Soil / Snake Soil Conservation (1998), the Deli Watershed consists of seven Sub-Watersheds: Sub-Watershed, Simai-mai Sub-Basin, Deli Sub-Basin, Babura Sub-Basin, Bekala Sub- DAS Sei Kambing and Sub DAS big hammer.

Giving these names in accordance with the name of the tributaries that flow in the area, the location of the watershed in the watershed is as follows: The Farmers' DAS is located at the upstream, the southernmost boundary of the Deli watershed. Simai-mai Basin is located in the upper reaches of the eastern sub-watershed of Farmer, directly adjacent to DAS Percut, Belawan Watershed and Deli, Simai-mai and Babura Sub-watersheds. The Deli Watershed is located in the middle to the downstream of the Deli watershed and directly borders with almost all the sub watersheds in the Deli watersheds: Sub DAS of Farmers, Simai-mai, Kambing River, big hammer, Babura, and DAS Percut. The Babura sub watershed is located in the central part of the Deli watershed adjacent to the Farmers, Bekala, Deli and Seikambing Rivers. The Bekala River Basin is also in the center of the Deli Watershed, bordering the Babura Sub-Basin, the Seikambing, and Belawan Watershed. The Sei Kambing River Basin is located in the downstream watershed bordering the Babura sub watershed.

Multiple Recorded Flood Events

Flooding in Medan caused hampering activities. It can be seen in the following moments: (a) on 4 November 1997, flooding in some districts of Medan from Deli River killed a person. (b) On December 2002, puddles on the runway of Polonia Airport stopped the flight for 2 days, (c) routinely happens every year, puddles in the arterial roads and collectors causing traffic congestion and (d) flooding in the Medan Belawan and Medan Labuhan Sub-districts due to high tides that cause disruption to community activities and many other cases each year, (Sub-Pusat Rehabilitasi Tanah dan Konservasi Tanah / Bangun Tanah, 1998, BPDAS, 2003). Even the information quoted from some mass media states in 2007, already 3 times (May, September, November) Medan city experiencing flood where river Deli, river of batuan and Dead river back overflow and thousands of houses along the river flooded water up to one meter. This kind of routine happens every year since 2003 in the rainy season, the river banks in the city of Medan will be flooded initially a few hours later and water will recede but since 2005, the water lasted for 1-2 days.

Then in early January 2011, precisely on January 6, 2011, a big flood also hit the city of Medan. Floods that occur cover along the rivers that cross the city of Medan, the river Deli, Babura, Bekala, Sei Kambing and big hammer. Based on field observation, the location of the floods that occurred includes 14 districts located in Medan City, and resulted in loss and misery for 49,010 people or 12,067 families who are in flooding affected areas. Inundation of floods in each location varies from 30 cm to 4m, puddles from the streets to tens of thousands of houses, especially those on the banks of the Deli, Babura, Bekala and Bedera rivers. Observations and interviews with flood-affected communities indicate that flood events begin with varying rainfall for each location from 18.00 -22.00 WIB until 03.00 - 07.00 WIB, so high rainfall lasts 5-10 hours. Flood incident shocked the people who become victims because the rise of puddle is very fast and when the people are resting, the time starts at 1.30 pm in the morning. Flood peak occurred at 06.00 WIB. It gradually receded until 17:00 pm, but there are several locations of water remaining to survive until 2 days, especially in the basin areas such as Village Sukadamai District of Polonia. High flood puddles that occur in each location also varies from 30 cm to 4 m, puddles ranging from the streets to tens of thousands of homes, especially those on the banks of the river. The location of the flood and the number of people affected and the high puddles, the flooding time can be seen in Table 2.

Table 2. Location of flood and population of victims

No.	Location of Flood (Sub-district)	The number of victims: KK (Family Card)	The number of victims: Person	Information: The High of flood (m)	Information: Time flooding (WIB)	Information: Cause
1	2	3	4	5	6	7
1.	Medan Maimun	2843	11.372			Deli river flood overflowing
	- Hamdan			2,5-3,0	02.00-16.00	
	-Kampung Aur			3,0-4,0	01.30-17.00	
	-Jati			1,0-2,0	01.30-17.00	
	-Sukaraja			1,0-2,0	01.30-17.00	
	-Badur Bawah			2,0 –2,5	04.30-17.00	
	-Badur Atas			1,0 –1,5	03.30-18.00	
	-Kampung Baru			1,0 –1,5	04.00-17.00	
	- Sungai Mati			1,0-1,5	04.00-17.00	
2.	Medan Petisah	178	712			Deli river flood overflowing
	-Silalas			0,5–1,0	05.00-16.00	
	- Petisah Hulu			0,3-0,5	05.00-16.00	
3.	Medan Tuntungan	75	300			Deli river flood overflowing
	-Mangga			1,5-2	04.00-15.00	
4.	Medan Belawan		1.232			Deli river flood overflowing
	Jl Yos Sdarso	308		1,0-1,5	05.00-17.00	
5.	Medan Sunggal	717	3.868			Deli river flood overflowing
	-Jl Abadi			1,0-1,5	02.00 –15.00	
	-Jl Pinang Baris			1,0-1,5	02.00 –15.00	
	- Jl Perjuangan			1,0-1,5	02.00 –15.00	
6.	Medan Barat	29	116			Deli river flood overflowing
7.	Medan Selayang	105	420			Deli river flood overflowing
8.	Medan Polonia	617	2.130			Deli river flood overflowing
	-Sari Rejo			1,0-2,0	02.30-18.00	
	-Polonia			1,0-2,0	02.30-18.00	
	-Suka Damai			1,0-2,0	02.30-18.00	
	-Anggrung			2,0-3,0	02.30-18.00	
	-Madras Hulu			2,0-3,5	01.00-16.00	
9.	Medan Baru	1026	4.104			Deli river flood overflowing
	-Padang Bulan			0,5-1,0	00.30-14.00	
	-Pandau Hulu			0,5-1,0	00.30-14.00	
	-Darat			1,0-1,5	00.30-14.00	
	-Titi Rantai			1,0-1,5	00.30-14.00	
	-Merdeka			1,0-2,0	00.30-14.00	
10.	Medan Helvetia	2362	9.528			Bedera rivers overflowing flood
	-Cinta Damai			1,0-2,0	4.30-17.00	
	-Kelambir V			0,5-1,0	05.00-17.00	
11.	Medan Johor	438	1.752			The Bekala River overflowed
	-Kuala Bekala			2,0-3,0	01.30- 14.00	
	-Gedung Johor			1,0-2,0	01.30-16.00	
	-Pangkalan			1,0-2,0	01.30-16.00	
	Mashyur			1,0-2,0	01.30-16.00	
12.	Medan Marelan	186	744			The Deli River is overflowing
	-Rengas			0,5-1,0	05.00-17.00	
13	Medan Deli	463	1.852	1,0-1,5	05.00-17.00	
14.	Medan Labuhan	2720	10.880			The Deli River is overflowing
	-Pekan Labuhan			1,5-2,0	05.00-16.00	
	-Martubung			1,0-2,0	05.00-16.00	
	-Jl Jermal			1,0-1,5	04.00-17.00	
				1,0-1,5	04.00-19.00	

Source: Satkorlak data of north sumatra disaster management (2011), field data

Interviews and field observations indicate that flooding and flooding times vary widely due to floods occurring at night when people are at rest, and the high pools are strongly influenced by the distance of houses from riverbanks. In addition to causing harm to the urban population, this flood also damages several hectares of agricultural land, especially those located along the Bekala, Babura, Deli and Bedera rivers for the second time in the same year, floods struck Medan City on April 1, 2011 just as January's high rainfall in Medan City caused the Deli, Belawan and Babura Rivers to overflow. Almost all areas in Medan City are flooded. The cause is extreme rainfall so that a number of rivers such as Deli river and Babura river overflowed, the water level of the Deli and Babura rivers almost reached the bridge section and this is scarce.

Conclusion

Deli land destruction is dominated by biophysical factors, especially land use, slope, landform, and rainfall in upstream Deli sub watershed. This is what causes flooding in Medan. The cause is extreme rainfall, so that a number of rivers such as Deli River and Babura River overflowed, the water level of the Deli and Babura Rivers almost reached the bridge section and this is scarce.

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ارزیابی خسارت ناشی از سیل حوزه آبخیز دلی شهر مدان در اندونزی

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چکیده: حوزه آبخیز دلی یک از حوزه‌های دارای اولویت در طرح توسعه‌ای میان مدت (DAS) در میان سال‌های ۱۳۹۳ الی ۱۳۸۹، طبق دستور وزارت جنگلداری (SK 328/Menhut-II/2009) اندونزی است. DAS یک سیستم زیست محیطی پیچیده است که در آن تعادل پویایی بین انرژی مواد ورودی و خروجی وجود دارد. بطور طبیعی تغییر تعادل بین مواد ورودی و خروجی آهسته است و این وضعیت تهدیدی برای پایداری تعادل بین انسان و محیط زیست نیست اما وقتی پویایی کاربری اراضی از شکل‌های پوشش گیاهی متراکم به شکل‌های نادر یا به شکل‌های فاقد پوشش گیاهی ادامه دارد در نتیجه تخریب اراضی حوزه آبریز دلی تحت تاثیر عوامل بیوفیزیکی، به ویژه استفاده از زمین، شیب، شکل زمین و بارندگی در رودخانه‌های زیرحوزه‌های بالادست قرار می‌گیرد. این تغییر کاربری اراضی دلیلی است که باعث سیل در شهر مدان اندونزی می‌شود. باران‌های شدید باعث طغیان تعدادی از رودخانه‌ها از جمله رودخانه دلی و بابرا می‌شود که سبب می‌شود سطح آب رودخانه‌های مذکور تقریباً به سطح پل برسد و این یک اتفاق نادر است.

کلمات کلیدی: رودخانه دلی، حوزه آبخیز، سیل، خسارت، فرسایش