

**CLIMATE'S ROLE IN CHANGING THE FACE OF THE EARTH
AND THE SPATIAL CONFLICT PROBLEMS:
A PRELIMINARY STUDY ON THE CIMANUK WATERSHED**

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ABSTRACT

The increased global climate directly affects the face of the earth. In addition to result in shifting of season and extreme weather, the relatively rapid change in temperature being climate element also gives impact on intensity of geomorphology process (weathering, erosion, sedimentation). This paper describes how the escalated climate affects the process of weathering and erosion as well as change in delta mainland size and its contribution to the emergence of spatial conflict. DAS Cimanuk was selected as the study case area. The escalated air temperature for a long period directly escalates the acceleration of rock weathering, which in turn accelerates the erosion of weathered rock due to rainfall to be sediment material through erosion process. During period of 1963 – 2002, Cimanuk delta area enlarged more than 350.000 m²/year. This new land, which is formed by weathering and erosion processes in the Cimanuk River Basin through peels of land surface predicted to be averagely more then 10 cm/year. In the last, the new land formed by geomorphologic processes triggering the new source of conflict potentially.

Key words: climate change, weathering, erosion, spatial conflict

INTRODUCTION

All countries in the world are now facing the impacts of climate change due to global warming. The emerged climate change is indicated by weather anomaly frequently occurs in the cycle of climatologic disaster, such as storm and hurricane creating losses of material and life. Agriculture and fishery activities are community life sectors that are mostly affected by the climate change.

The increasing temperature of earth surface is believed to have close relation with the increasingly thick of green house gas such as CO² at atmosphere.

The increasing concentration of CO² at atmosphere is contributed mostly by emission gas of burning of petroleum and coal as the main energy sources of global economic activities.

The increasingly thick and wide of area of green houses effects give impact on the increased temperature of the earth. The increasing air atmosphere will affect other elements of climate so as to form climate anomaly. In addition to the increasingly abnormality of rainfall, such condition also leads to shifting of time of dry and wet seasons. Therefore, atmosphere has dynamic nature, impacts of climate change do not only occur in green house area, but also other areas, even those areas far from the climate change source. This event called as global warming [*Harmantyo*, 2008].

In addition to give impact on human life, the climate change, mainly the increasing earth temperature, also gives impact on the natural process, such as weathering and erosion. Temperature element represents the main factor in physical weathering process, while the rainfall is one of factors determining the land surface erosion [*Lobeck*, 1939; *Strahler*, 2003].

The more rapid the weathering process, the higher level of land erosion, which will finally increase material volume of erosion being settled in the base of river, lake or sea around the river stream. Ridge, sandbar and delta as products formed by sedimentation process will exist and tend to be wider. These areas are generally fertile and contain ground water [*Sandy*, 1983 in *Harmantyo*, 2008], so that they are vulnerable to emerge conflict natural resources struggling.

This paper tries to analyze how the climate change being a global environmental issue gives impact on geomorphologic process, which in turn gives impact on spatial conflict. The result of this analysis is initial study, as such; this paper emphasizes theoretical logic in strengthening empiric analysis against data obtained from the study.

THE METHODS

This analysis uses regional analysis approach with explorative method taking study area in Cimanuk River Basin, West Java. Technique used in this study is sampling technique with systematically strata in determining climate station Indonesian Meteorological, Climatological and Geophysical Agency (BMKG) as source of temperature data and rainfall in order to know the process of climate change. Data on rock cover, slope (erosion area and sediment area), and change in land use sourced from geological map, topography map and land use map.

Data is processed with excel program, so that it can be presented in both table and graph. In addition, in order to know trend or correlation between two variables or more, a linear trend line and statistical correlation formula completed with regression equation (if R value is real) are used. In performing the analysis, based on theory of formation of meander, ridge, sandbar and delta, data of sediment area size is compared at time series. Further, spatial-temporal methodology analysis is used to answer questions on analysis, through map overlay.

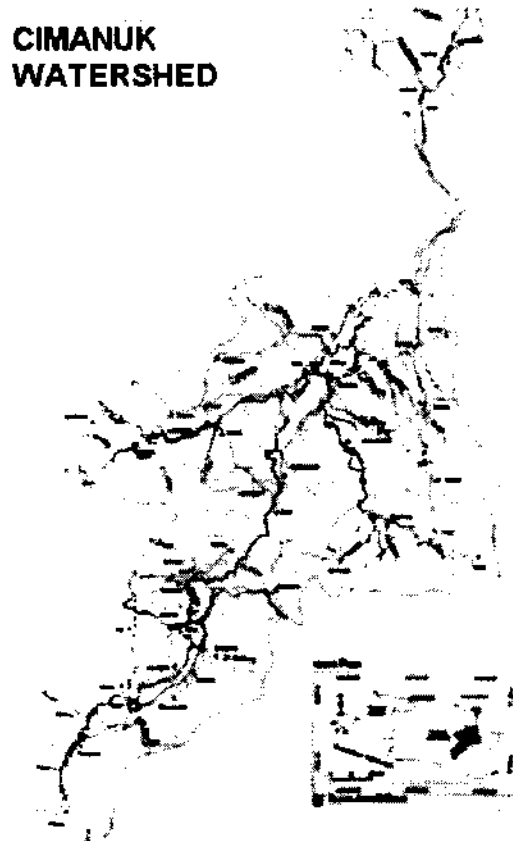


Figure 1. The Cimanuk Watershed

The term climate means condition of climate in relative wide area for a long period. While weather means atmosphere condition in a given place (not wide) and at given time (short time). Conditions of climate/weather are formed by integration of elements of temperature, pressure, moisture, rainfall and wind. Data of temperature and rainfall for a long period, at least 30 years, is two elements of climate mostly used to make classification of climate, such as Koppen, Oldeman, Thornthawaite and others [Linacre, 1997].

Change in temperature and rainfall for a period of 30 years from normal condition may result in climate change such as shifting of duration of the coming of wet and dry seasons. The change in surface air temperature can be measured from the changes in maximum, average, and minimum temperatures. In the context of weathering, the difference of value between minimum and maximum temperatures becomes crucial factor of identifying their intensity. This means that the higher difference the more intensity of weathering. As the higher power being resulted at the time of expansion and reduction of rock surface layer.

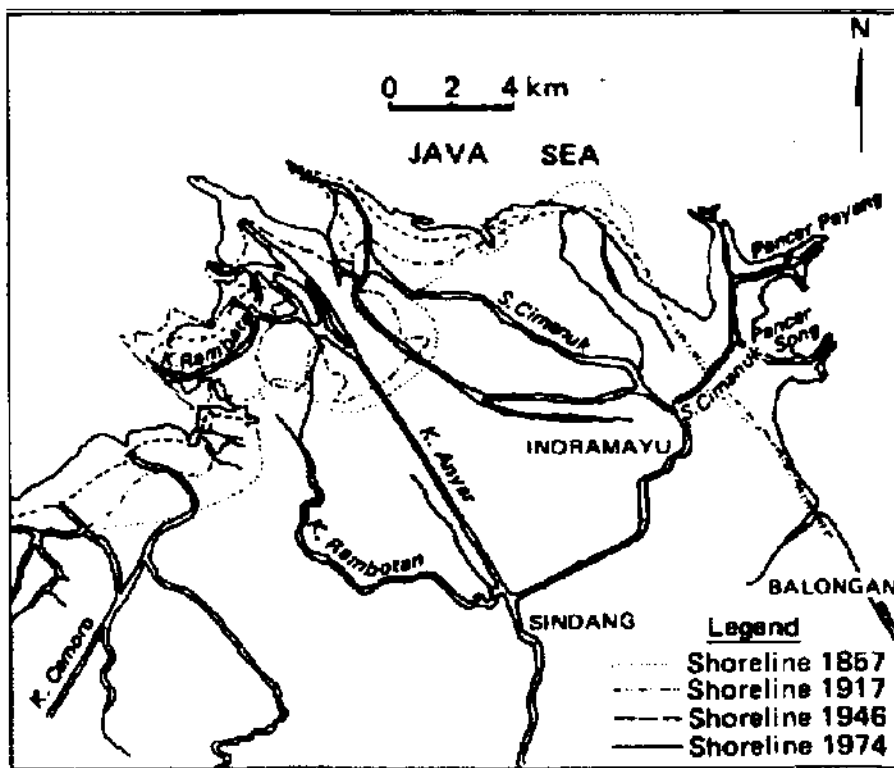


Figure 2. The Development of Cimanuk Delta (UNU, 1980)

According to *Strahler* [2003], mechanical weathering is categorized as physical weathering. Formation of mineral from weathering is resulted from heating (extension) at light days and cooling (reducing) process at night days. These processes occur continually as from the formation of the earth. Furthermore, it is stated that decomposition of rocks due to hydrolysis and oxidation processes taking place for thousands of year's changes hard rocks into soft rocks up to 100m thickness. These processes occur simultaneously with the process of biological and chemical weathering. Weathering process can be defined as the process of disintegration and decomposition of rocks.

At least there are three factors obviously affect the weathering process, namely: (1) rock type, in this case is structure and composition of mineral, (2) climate condition, such as hot or cool or stable climate or climate change, (3) vegetation existence [Lobeck, 1939]. Further, it is said that slope, sunbeam, and rainfall become supporting factors of the process. Materials of rocks undergoing weathering due to washing process will be separated from their master rocks, called as basic materials of soil surface. In some cases, the separated layer of decayed rock is caused by water power. On the other side, the weathering process may be deemed as adjustment process toward climate change [Lobeck, 1939].

Weathering is an initial phase of destructive process of the face of the earth by climate factor. Further process is erosion, transportation of erosion and sedimentation results at lower areas. In addition to rainfall factor, there are many other factors that affect the intensity of erosion, such as soil type, slope, land cover type (vegetation), and land use. The erosion result is usually settled by the current of river at certain points having current speed closing zero. Sediment materials being settled consist of a number of forms, such as river embankment, ridge, sandbar or delta. Erosion and sedimentation process at meander river has specialty, in which it occurs at left or right of riverbank and creation of oxbow lake, namely a remained part of river due to the fact that river flow experiences direct cutting direction at its nearest part.

At land and sea transitional areas, an interaction occurs between powers of sea current and river one. In this process, delta is typically found in river estuary. Various forms of the delta are vital resources for human life. In a condition, in which the number of people tends to be higher and such resources are limited, the natural existence of delta becomes vulnerable for conflict. Conflict due to such delta can be categorized as, although not fully right, claim for land resources between government and people as revealed by [Haggett, 2001]. This spatial conflict is reversal of conflict of border of two countries due to natural process of river meandering.

RESULT AND DISCUSSION

Cimanuk watershed with a total area of 3.550 km² consists of 1.312 km² (37%) of slope less than 8%, 697 km² (19.6%) of slope more than 40% and slope of 8-40% with a total size of 1.541 km² (43.4%). If such data is faced to the data of land size having low sensitivity against erosion of 58.65% of watershed, it can be concluded that most of Cimanuk watershed has high potential erosion. This fact is strengthened by data of annual rainfall of more than 2000 mm at the area with slope steepness over 8%.

The high potential erosion in Cimanuk watershed is attributable to the role of physical weathering of rock surface layer due to the temperature change. Analysis of data of surface temperature from weather station for 30 years shows that an increasing temperature has occurred, either average, maximum, and minimum temperatures. Interval of minimum – maximum temperatures from 1963 till 2002 tends to increase. The increased temperature and the increasingly high of difference between minimum – maximum temperatures will increase extension and reduction powers of rock surface. This condition shows indication a role of climate change against weathering process in the study area.

The high rainfall and the process of weathering result in phenomenon of separated decayed materials due to rainfall is an initial of erosion process. Rain-water brings materials of erosion through run-off, which further enters to the river. Result of measurement of erosion material volume at Station A can be seen in Table 1.

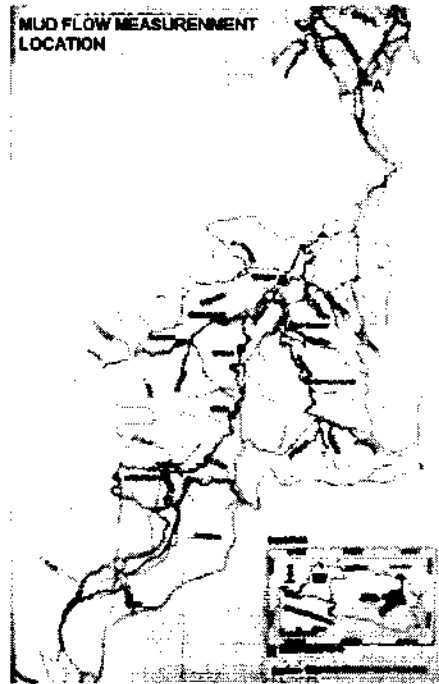


Figure 3. The location of mud flow measurement

Volume of mud from erosion measured in Station A (see Fig. 3) from 1963 – 2002 is higher than 4 million tones/year or around 350 000 tons averagely per month. Starting from 1985, the volume of mud transported decreased by 2,000,000 tons in 2002.

Table 1. Size of Delta and Mud Volume of Cimanuk River for Period of 1963 -2002 [*Hermawan et al.*, 2004].

Year	Delta area extend (ha)	Mud Volume (000 ton)
1963 - 66	1.044	19.86
1967 - 70	1.424	21.08
1971 - 74	1.802	22.70
1975 - 78	2.185	20.03
1979 - 82	2.558	20.95
1983 - 86	2.976	23.06
1987 - 90	2.728	14.61
1991 - 94	2.600	12.40
1995 - 98	2.524	10.80
1999 - 02	2.487	10.45

Size in Cimanuk River for period of 1963-2002.

The erosion output in the form of mud volume is further settled along the river base up to reach river estuary in coastal area. In this area, delta formation occurs. *Hermawan et al.*, [2004] concluded that the size of delta for a period from 1963 – 2002 increased averagely by 350.000 m² per year. This average figure consists of 805.000 m²/year for a period of 1963 – 1986 and 310.630 m²/year for a period of 1986 – 2002.

Based on data of volume of mud from erosion and data on delta size in Cimanuk watershed, it is predicted that the thickness of land layer experiencing erosion reaches averagely over 12.8 cm/year. This projection assumes that 1 kg of mud is equal to 1 dm³ with specific weight of 1, all surfaces of Cimanuk watershed have same erosion, no mud sediment occurs in other places before observation station and excluding flying sediment. However, based on the annual distribution for a period from 1963 – 2002, mud volume measured from 1986 decreased. This condition is predicted due to the climate change, which results in shifting of area of rainfall and reduction of rainfall in the study area. Another factor that is possible to affect if activity of community along the river that leads to sedimentation of erosion mud in downstream area so as the data of measured mud decreases.

In this study, analyzes on land use, land type, meandering process in Cimanuk and other social factors have not been conducted. Hence, these factors do not show their role in weathering, erosion and sedimentation processes. Likewise, empirical data on spatial conflict has not been identified due to dispute of natural formed land (delta, ridge and sandbar) or change in size of land due to meandering process.

The efforts to prevent from land conflict are among others by issuing government regulation on delta formed naturally and conducting socialization continuously to society. The process of enlargement of Cimanuk delta is relatively quick, which is predicted to be 1000 m² per day, so that it is necessary to conduct an intensive monitoring and mapping of the delta enlargement progress.

CONCLUSION

The rapid enlargement of Cimanuk delta, namely averagely one hectare per 10 days indicates the existence of intensive weathering and erosion processes in the Cimanuk River Basin. Such condition is supported by the result of mud measurement in the river, which reaches averagely 350,000 tons per month or around 4,000,000 tons per year.

The enlargement of Cimanuk delta is resulted from attrition of land surface with average thickness of more than 10 cm per year with factors of high rainfall, type of land vulnerable to erosion and sheer slopes dominating in Cimanuk watershed.

Given the limited data of climate element (daily temperature and rainfall), this study has not shown empirical data on the influence of climate change due to global warming against intensity of weathering and erosion of Cimanuk watershed. However, theoretically, the phenomenon of the enlargement of delta which tends to be higher and the existence of increased temperature show a relation between global warming resulting in climate change against weathering and erosion of Cimanuk River Bank.

The emergence of new land (ridge, sandbar and delta) theoretically becomes source of spatial conflict, which can be expressed in dispute of land resources between communities and between community and government.

Based on analysis result above mentioned, there are at least two matters that can be presented in order to cope with such issues, namely (1) management of Cimanuk watershed needs to focus on keeping protected forest and marginal land conservation and (2) continual socialization of laws on delta (new land) to the society in order to prevent from conflict and the importance of environmental management.

ACKNOWLEDGEMENT

The author would like to acknowledge to anonymous reviewers for their constructive reviews of this manuscript.

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