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RAINFALL EROSIVITY MAP FOR GHANA

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ABSTRACT

Monthly rainfall data, spanning over a period of more than thirty years, were used to compute rainfall erosivity indices for various stations in Ghana, using the Fournier index, c, defined as p^2/P, where p is the rainfall amount in the wettest month and P is the annual rainfall amount. Values of the rainfall erosivity indices ranged from 24.5mm at Sunyani in the mid-portion of Ghana to 180.9mm at Axim in the south western coastal portion. The indices were used to construct a rainfall erosivity map for the country.

The map revealed that Ghana may be broadly divided into five major erosion risk zones. The middle sector of Ghana is generally in the low erosion risk zone; the northern sector is in the moderate to severe erosion risk zone, while the coastal sector is in the severe to extremely severe erosion risk zone.

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INTRODUCTION

Soil erosion has been of much concern especially to countries like Ghana whose economies depend on agriculture. Generarized maps by Norman (1981), of the geographical distribution of rainfall and wind erosion, puts Ghana in the area designated as particularly susceptible to rainfall erosion. Population growth, with its attendant increase in demand for land and agricultural products, is likely to worsen the problem.

Baver (1965) has indicated that soil erosion by water is due to the dispersive action and transporting power of water. It is affected by rainfall erosivity and the soil erodibility. Rainfall erosivity is mainly a function of rainfall characteristics, while soil erodibility is mainly a function of the physical properties and management of the soil.

In order to prevent or minimize soil erosion, there is need to select appropriate strategies for soil conservation. Soil erosion prediction is one powerful tool used by soil conservationists.

Erosion prediction based on fundamental hydrologic and erosion processes is accomplished using mathematical equations that describe these processes and their relationships (Foster, 1990).

The most suitable expression of the erosivity of rainfall is an index based on the kinetic energy and momentum of runoff. Thus, erosivity index of a rainstorm is a function of its intensity and duration, and of the mass, diameter, and velocity of the raindrops.

A number of indices which relate the erosivity of a rainstorm and its associated runoff to soil loss prediction have been established. The most commonly used indices include the Fournier Index (Fournier, 1960), Hudson's KE > 25 Index (Hudson, 1965), Lal's AI_m Index (Lal, 1976) and the erosivity index (EI_{30}) of the Universal Soil Loss Equation (Wischmeier and Smith, 1978).

In this study, the Fournier Index is used to estimate the rainfall erosivity indices for various stations in Ghana. The indices are then used in constructing a rainfall erosivity map for the country.

The Fournier index, described as a climatic index c, is defined as:

$$c = p^2/P$$

where p is the rainfall amount in the wettest month and P is the annual rainfall amount.

The choice of this index is based on the premise that, like Lal's AI_m index, it was developed in West Africa and hence under similar climatic conditions as Ghana. Besides, it incorporates relief characteristics, since it is a function of mean annual precipitation which is itself dependent on relief (Bollinne et al., 1980). Thus, it is better related to erosion. Its input data are also more easily obtainable.

The map will enable soil conservationists and agriculturists to know the degree of erosion at various locations, and thereby apply the necessary precautions to minimize soil erosion in those areas. Civil and construction engineers may also find the map useful in the design and construction of buildings, roads, dams, and pipelines.

ANALYSIS OF DATA

Monthly rainfall data were collected for thirty-eight stations scattered across Ghana. These rainfall data, which at most stations spanned a period of over thirty years, were obtained from the Ghana Meteorological Services Department, Accra, Ghana. The average monthly and annual rainfall values were computed for each station. The erosivity indices for the stations were then computed using the Fournier

index, p^2/P. These indices are given in Table 1. The rainfall erosivity indices were used in constructing a rainfall erosivity map for Ghana.

RESULTS AND DISCUSSION

Fig. 1 shows the rainfall erosivity map of Ghana constructed from the rainfall erosivity indices for the various stations using the Fournier index. The pattern of the iso-erosivity lines agrees with that of the rainfall erosivity map for Africa north of the equator, constructed by Arnoldus (1980) using the modified Fournier index, p^2/P.

The highest rainfall erosivity value of 180.9mm is at Axim, in the south western coastal portion of Ghana, while the lowest value of 24.5mm is at Sunyani in the mid portion of Ghana.

From the map, Ghana may be broadly classified into five major erosion risk zones. The middle sector is generally in the low risk zone; the northern sector is in the moderate to severe erosion risk zone, while the southern or coastal sector is in the severe to extremely severe erosion risk zone.

The north-eastern portion of the northern sector also lies in the severe erosion risk zone. Vegetation in that area is Sudan savanna, dominated by short grass (Dickson and Benneh, 1970). The land is

generally bare for most part of the year, especially during the dry season. The onset of the torrential rains, characteristic of the area, therefore has a great devastating effect in causing erosion.

The vegetation of the remaining portion of the northern sector is Guinea savanna, dominated by tall grass with a few widely scattered trees (Dickson and Benneh, 1970). The soils in the area are generally of the sandy loam type. This type of soil is highly susceptible to erosion. Like the north-eastern portion, a major part of the area is bare during the dry season. The area also experiences torrential rains, the onset of which has great erosive effect. Practices capable of enhancing erosion in these areas, such as bush burning and leaving constructional areas bare, should therefore be greatly minimized.

The middle zone is generally covered by forest. This, in addition to the fact that erosion risk in the zone is generally low, greatly minimizes erosion in the zone. Practices capable of enhancing erosion in the sector should however be discouraged.

The strip of land stretching from Ho and Kpando in the east through Mampong to Sunyani in the west has the least erosion risk. Akim Oda and its environs also fall in the least erosion risk zone.

One area of interest in the middle zone is Juaso and its environs. This area lies right at the centre of the middle zone, yet it is one of the severe erosion risk areas in the country.

The southern zone is generally covered by forest in the western part and coastal shrub and grassland in the eastern part. The soils range from loamy in the western region to coastal sandy soils with patches of clay through the Accra plains to the eastern part of the zone. These soil types are very erodible. Fortunately, the adequate vegetation cover in the western portion of this zone helps in minimizing erosion in that part of the zone. However, since the area is in the very severe to extremely severe erosion risk zone, measures against deforestation coupled with good farming systems must be strictly adhered to in order to minimize erosion in the area.

The eastern part of the southern zone, including the Accra plains, has virtually no natural features to guard against erosion. The little vegetative cover is threatened by high population density. The neglect of soil conservation methods in this part could therefore be very disastrous.

The Keta and Ada areas are of particular concern. They fall under the severe erosion risk zone. Besides, they are seriously threatened by sea erosion and have already lost large portions of arable land to the sea.

While attempts are being made at fighting sea erosion in those areas, rigorous attempts should also be made at protecting the remaining portions of the land from rainfall erosion.

CONCLUSION

Except in the middle sector of Ghana where the erosion risk is generally low, the erosion risk in other parts of the country range from moderate to extremely severe. It is especially high in the southern (coastal) sector and the northeastern part of the country. The highest erosion risk is at Axim in the southwest.

Every effort should be made to minimize the risk of erosion in all parts of the country through judicious land management practices. There is need to adopt the "guidelines for clearing, development and protection of tropical lands for farming" proposed by the International Committee on Land Clearing and Development (ICLCD) in 1982 (Lal et al., 1986, p. 427), and the appropriate technologies proposed by the International Board for Soil Research and Management (IBSRAM) (Lal, 1987).

It is hoped that the map will be useful for soil and water conservation planning in Ghana.

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Table 1: Rainfall Erosivity Indices (c), for various stations in Ghana

Station	No. of Years of Data	c /mm
Aburi	55	38.9
Accra	55	53.7
Ada	39	75.3
Akim Oda	47	28.4
Asamankese	31	34.5
Atebubu	53	36.2
Axim	45	180.9
Bawku	43	63.6
Bibiani	30	38.0
Bole	51	40.2
Cape Coast	30	96.7
Damango	38	44.3
Dormaa Ahenkro	34	30.9
Dunkwa-on-Offin	40	38.3
Gambaga	37	61.0
Ho	45	26.1
Hohoe	51	37.2
Juaso	45	73.1
Koforidua	25	34.5
Keta	44	60.2
Kete Krachi	41	38.2
Kintampo	47	43.0
Kpong Tamale	50	41.7
Kpando	32	29.1
Kumasi	53	30.9
Mampong (Ashanti)	54	29.0
Mpraeso	29	40.7
Navrongo	44	68.5
Salaga	51	41.8
Sefwi-Bekwai	26	39.5
Sunyani	17	24.5
Tafo	51	35.8
Takoradi	53	81.0
Tamale	51	49.7
Tarkwa	53	51.9
Wa	31	45.0
Wenchi	42	33.2
Yendi	21	56.5

Table 2: Classes of rainfall erosion risk based on the rainfall erosivity index (c)

Erosivity Index, c	Erosion Risk Class
< 40.0	Low
40.0 - 60.0	Moderate
60.0 - 80.0	Severe
80.0 - 100.0	Very Severe
>100.0	Extremely Severe

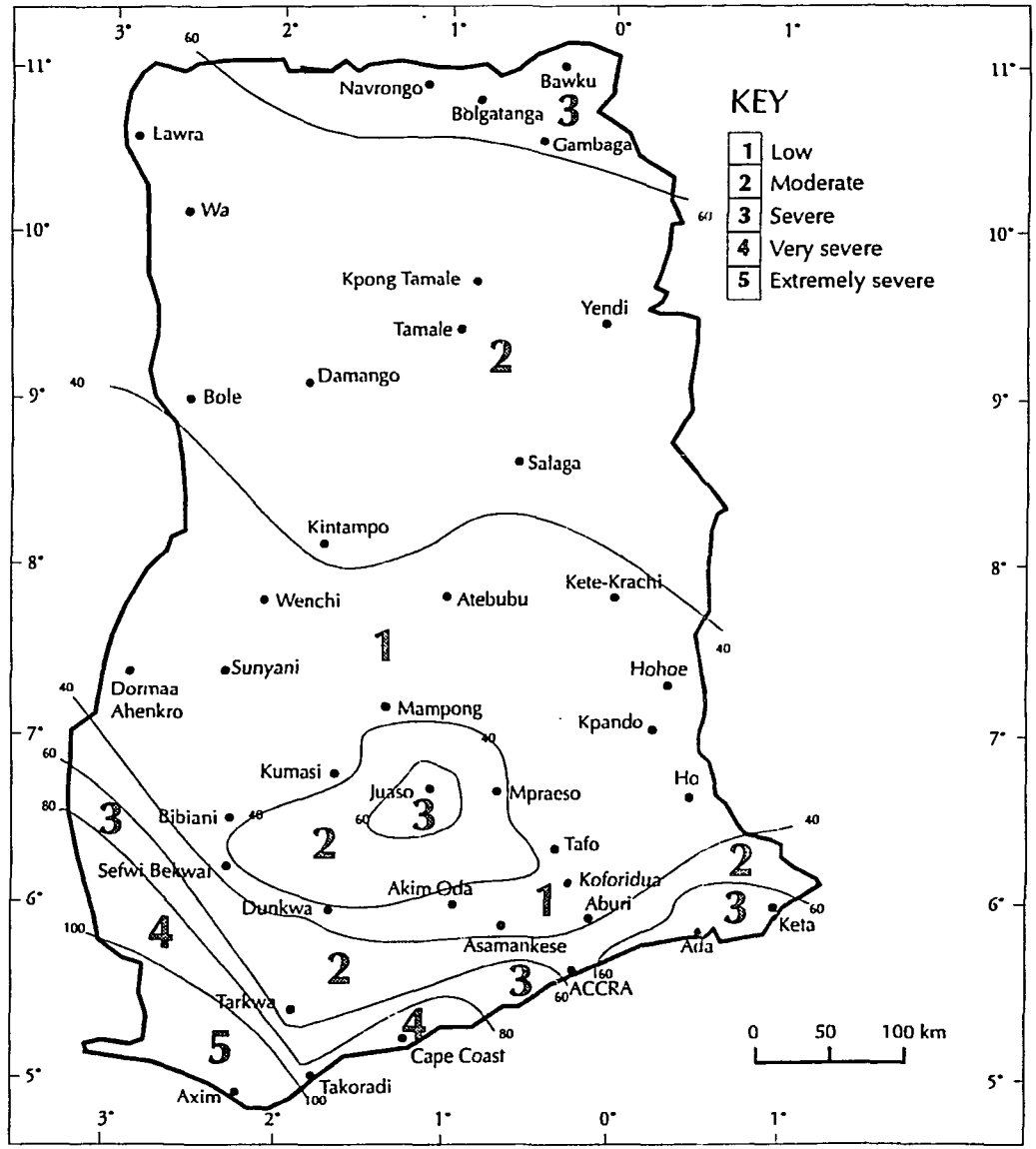

Fig. 1. Rainfall erosivity map of Ghana showing iso-erosivity lines and various erosion-risk zones.