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Spatio-Temporal Variability of Rainfall Distribution in the Western Region of Ghana

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Abstract: The Western region of Ghana experiences the highest rainfall. The predominant activity in this region includes agriculture and mining. Due to the good climatic conditions coupled with the concentration of mining companies in the area, people from the various parts of the country migrate to this region. The study was carried out to determine the rainfall distribution pattern over a thirty year period from 1975 to 2005 in the western region of Ghana. Ilwis, ArcGIS and Microsoft excel software were used for the data interpolation and trend of the rainfall pattern. The data used for this included monthly and annual rainfall data for selected districts within the region and topographic map. The results revealed that there is a general rise in recorded rainfall quantities from 1975 through 1985, 1995 to 2005 in all the selected meteorological stations within the study area, except Tarkwa which showed an erratic trend. There are other isolated reductions in rainfall pattern over the period. The rated environmental degradation should to check to improve on the situation within the region.

Key words: Rainfall Distribution Pattern, Western Region of Ghana

INTRODUCTION

The effect of Climatic change is gradual but has pronounced consequences on the environment resulting in rising sea levels, extreme rainfall and excessive drought. The IPCC 1995 report anticipated intensification of the hydrological cycle which would increase global rainfall by 7 to 15% (Ramos, 2001). Therefore an increase in extreme events is assumed which may be destructive to natural and human systems. However, while some areas will have increased rainfall other areas will suffer decreases in rainfall. A 10% increase in annual rainfall along the Guinean coast during the last 30 years has been observed by the Inter governmental Panel on Climate Change (IPCC). In West Africa a decline in annual rainfall has been observed since the end of the 1960s with a decrease of 20 to 40% noted from 1931 to 1960 and from 1968 to 1990. In the tropical rain-forest zone, declines in mean annual precipitation of around 4% in West Africa, 3% in North Congo and 2% in South Congo for the period 1960 to 1998 have been noted (Anonymous, 2010). In other regions, such as Southern Africa, no long-term trend has been noted. Increased inter - annual variability has, however, been observed in the post-1970 period, with higher rainfall anomalies and more intense and widespread droughts reported (Anonymous, 2010). In different parts of southern Africa (Angola, Namibia, Mozambique, Malawi and Zambia), a significant increase in heavy rainfall events has been observed (Anonymous, 2010), including evidence for changes in seasonality and weather extremes (Anonymous, 2010).

The interest in rainfall distribution pattern for the study area stems from the desire to investigate the impacts of climate change on the hydrological cycle as recorded by IPCC 1990 for Ghana and West Africa as a whole. Among various climatic variables, precipitation is mainly required for applications like natural resource management, agricultural management, mining operation scheduling, ecosystem modeling, and hydrological modeling. Understanding its temporal and spatial distribution is also important for undertaking climate change impact studies on various systems (Anonymous, 2010). Changes in climatic conditions are regional in nature and considered as continuous geographic fields measured at selected points in the study area. Spatial interpolation procedure of estimating the value of properties at unsampled sites within the area covered by existing observations are usually applied with the rationale that points close together are more likely to have similar values than points far apart (Tobler's Law of Geography). Both deterministic and statistical methods of interpolation have been applied for precipitation in earlier studies. The geo-statistical interpolation techniques such as kriging (Marco and Andrea, 1997) have been applied to spatial analysis of precipitation. Previous experience

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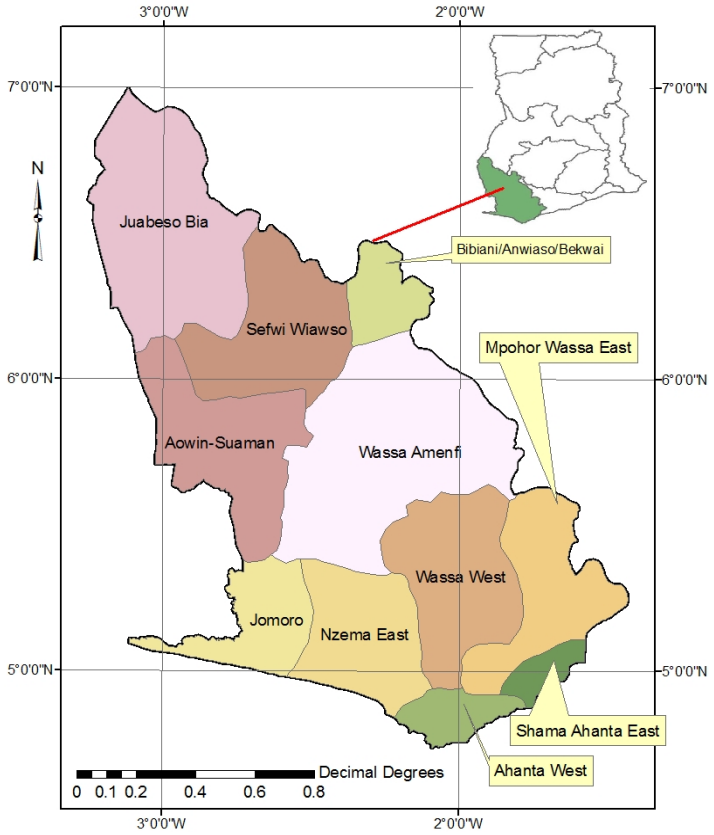

Fig. 1: Map of western region

has shown that kriging is preferable to other rainfall interpolation methods, at least for monthly rainfall or storm totals (Marco and Andrea, 1997). Among three spatial interpolation methods, deterministic and stochastic methods used for assessing seasonal rainfall variability in Guinea Savanna Part of Nigeria, ordinary kriging was found to be suitable for the study because it allows the sharpest interpolation rainfall data and it was the most representative (Ayanlade and Odekunle, 2009). The results of a study on different interpolation models generated in GIS environment to show fine scale precipitation surfaces from precipitation data showed that the multivariate extension model of Ordinary kriging that uses elevation as secondary data was the best model especially for monsoon months (Ashiq *et al*., 2009).

Again, the need to keep track of the changes in rainfall pattern is imperative for agricultural purposes, since agricultural practices in most developing countries like Ghana depend heavily on rainfall. Other impacts on humanity e.g. water management and flooding is also of concern.

In this paper a combination of statistical methods and Kriging (a regionalise spatial interpolation technique) were applied to determine the spatial and temporal variability of monthly and yearly rainfall distribution pattern in the study area over a thirty year period from 1975 to 2005 at ten year intervals in view of the IPCC expectation.

Study area: The Western Region of Ghana lies between latitude 4º00′ to 7º00′ North, and between longitude 3º07′ West and 1°07′ East of the Green Wich Meridian (Fig. 1). The region is located in the south-western part of Ghana and shares boundaries with the Central, Ashanti, and Brong - Ahafo regions. To the West it shares a border with the Republic of Cote D'Ivoire. The region has 192 km of tropical beaches on the Atlantic Ocean and a tropical climate characterised by moderate temperatures all year round. The Region occupies an area of 238,537 km^2, which is about 6.6% of the land area of Ghana (Egan, 1975). It has an estimated population of 19, 403,792 (2010 projection) and an annual population growth rate of 2.6% with 13 administrative districts. It is the second most densely populated region in the country next after Greater Accra with a population density of about 79.3 person's per-square kilometer and 63% of the region is rural (Anonymous, 2005). The region has the highest rainfall in Ghana and has lush green hills and

fertile soils. Some of the large rivers in the region are the Ankobra River, the Bia River, the Pra River in the east and the Tano River partly forming the western national border. There are numerous small and large-scale gold mines (Anonymous, 2005).

The native people of the Western Region are mostly Akans-speaking with various dialects including Ahanta, Nzema, Sefwi, Wassa, Brosa, and Pepesa. Principal religions are Christianity, African Aminism and Islam. The principal economic activities include agriculture (cash crops and food crops), fishing (commercial and subsistence), and mining and manufacturing. The main exportable produce are; cocoa, timber, copra, coffee, rubber/latex, gold, manganese, and bauxite.

MATERIALS AND METHODS

Materials: The area of study is the Western regions of Ghana. To determine the rainfall pattern within the western region, secondary data consisting of monthly and yearly rainfall values were obtained from the Meteorological Service for thirty years duration that is from 1975 to 2005 at ten years intervals from selected meteorological stations in the study area. A digital topographic map of the study area was also acquired from the Survey and Mapping Division of the Lands Commission. Data obtained was processed and analysed using Microsoft Excel, Arc GIS and Ilwis software. This study was conducted in May, 2010.

Methods: The methods employed in the production of monthly distribution patterns and the ten year interval rainfall distribution variability within western region are discussed in the following subsections.

Monthly rainfall distribution pattern: Rainfall data measured and recorded from selected meteorological station in each district in the region and beyond were acquired from the National Meteorological Service office for the study. Statistical processing was carried out using Microsoft Excel and appropriate graphs generated from the scatter plots of each station. The quantity of rainfall for each stations per given month was plotted for each 10 year period.

Ten year interval rainfall distribution variability: The topographic map of the area was loaded in ArcGIS software environment and the locations and the rainfall quantities (z) imported. Spatial correlation graphs were generated together with experimental variograms which were modelled with a spherical model from the data. The points were finally interpolated using ordinary kriging (the regional interpolation technique which is capable of showing the errors inherent in the estimation).

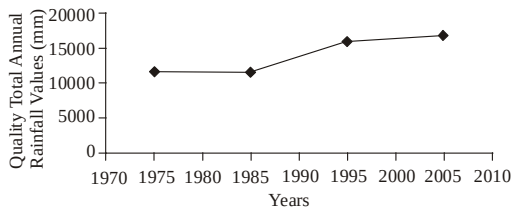

Fig. 2: Graph of total annual rainfall in western region

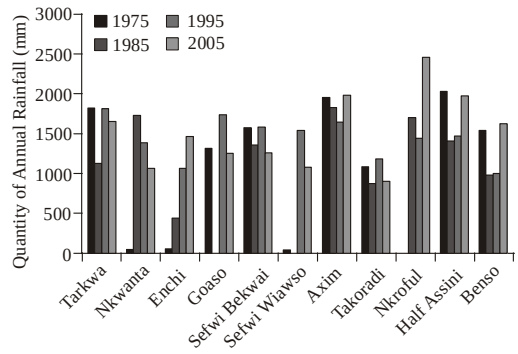

Fig. 3: Graph of total annual rainfall for the selected districts

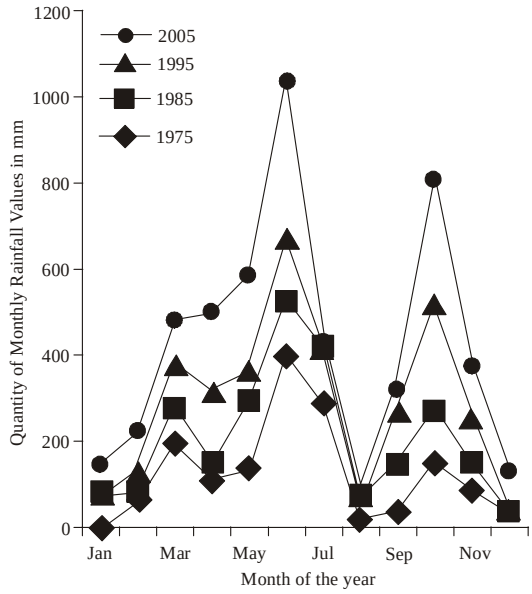

Fig. 4: Graph of monthly rainfall at Benso values

RESULTS AND DISCUSSION

The total annual rainfall quantities over the thirty year period of the study was observed to drop slightly at the end of the first ten years by an average of 0.02% per year but increased steadily by an average of 2.25% per year from 1985 to 2005 (Fig. 2, 3).

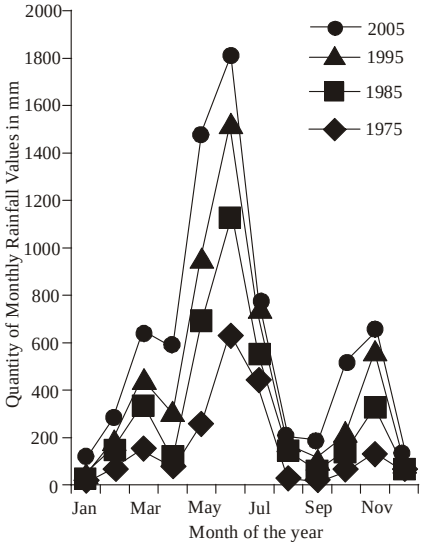

Fig. 5: Graph of monthly rainfall at Axim

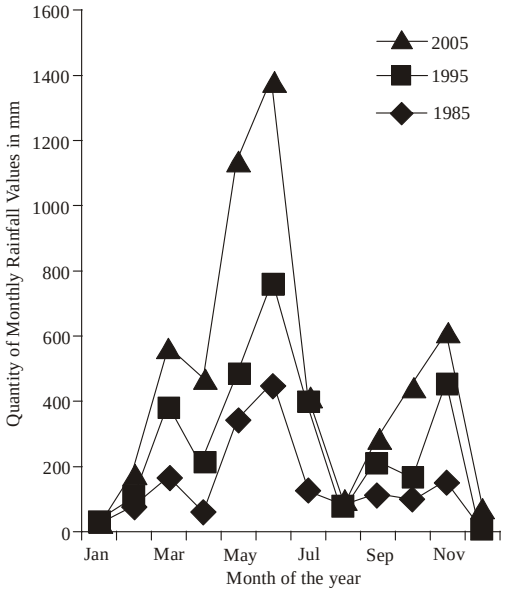

Fig. 6: Graph of monthly rainfall at Nkroful

Figure 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 and 14 are the scatter plots of the Monthly rainfall distribution for the selected stations.

The following (Fig. 15, 16, 17 and 18) are the maps generated from the interpolation by Kriging of the annual total rainfall values for the selected stations at ten-year intervals.

Observations from the scatter plots and Interpolated maps: There is a general rise in recorded rainfall quantities from 1975 through 1985, 1995 to 2005 in all the selected meteorological stations within the study area,

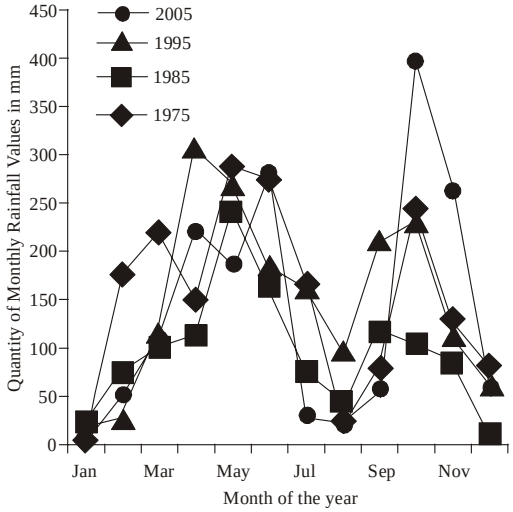

Fig. 7: Graph of monthly rainfall at Tarkwa

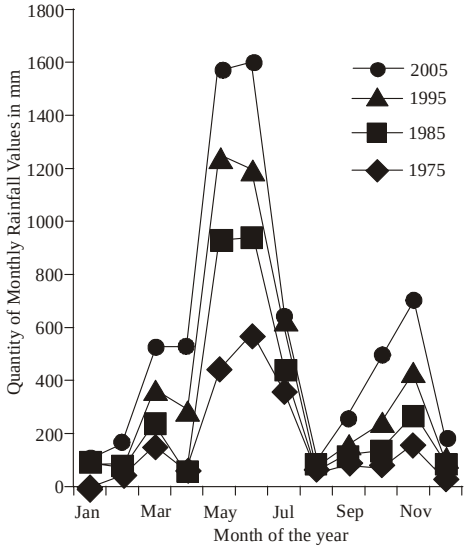

Fig. 8: Graph of monthly rainfall at half Assini

except Tarkwa which showed an erratic trend. The central part of the region around Sefwi Wiawso showed the least recorded maximum rainfall values followed by Tarkwa, Enchi, Goaso and Sefwi Bekwai. Whiles highest rainfall values are recorded in Axim, followed by Half Assini, Benso, Nkroful, Nkwanta and Takoradi.

The rainfall distribution pattern for the 1975 map shows low values in the central part of the western region; around Sefwi Wiawso and stretches to wassa Amenfi southwards to the middle portion of the region to Aowin-Suaman. Gradual increase is shown radially in all directions. The forest belt in the south - eastern direction of the southern part of the region shown maximum rainfall values, this pattern reduces as it approaches the

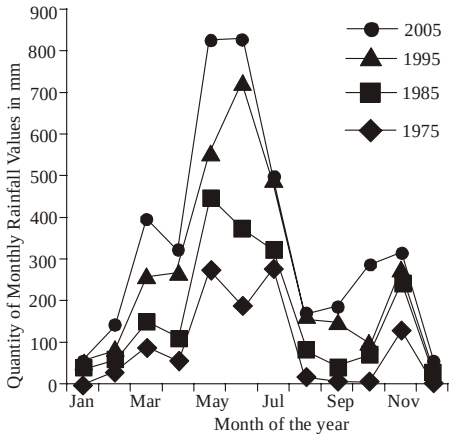

Fig. 9: Graph of monthly rainfall at Takoradi

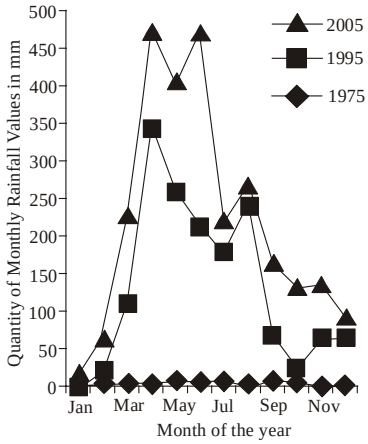

Fig. 12: Graph of monthly rainfall at Sefwi Wiawso

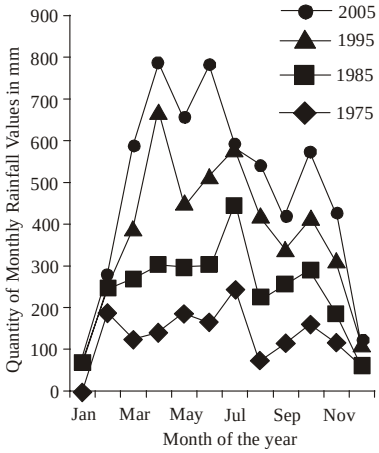

Fig. 10: Graph of monthly rainfall at Sefwi Bekwai

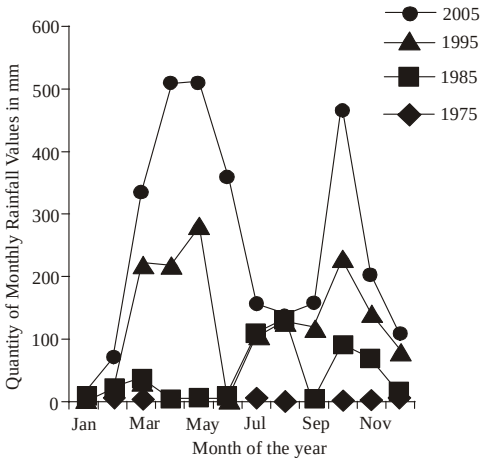

Fig. 13: Graph of monthly rainfall at Enchi

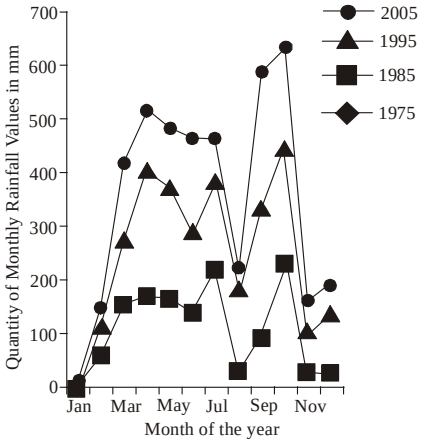

Fig. 11: Graph of monthly rainfall at Goaso

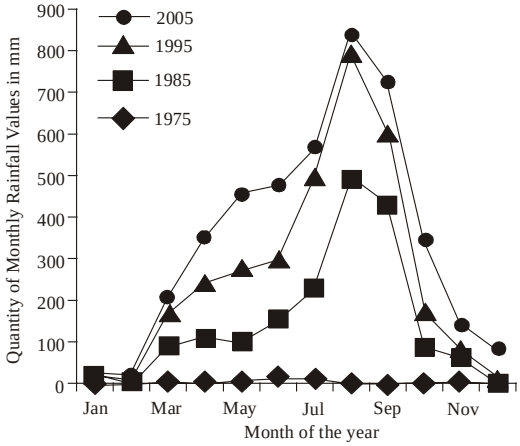

Fig. 14: Graph of monthly rainfall at Nkwanta

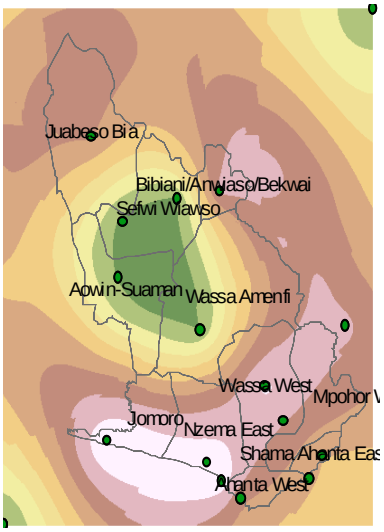

Fig. 15: Map of rainfall distribution in the western region for 1975

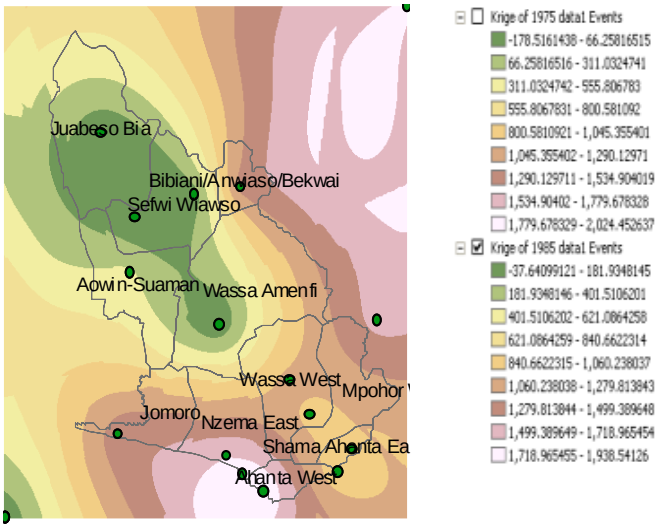

Fig. 16: Map of rainfall distribution in the western region for 1985

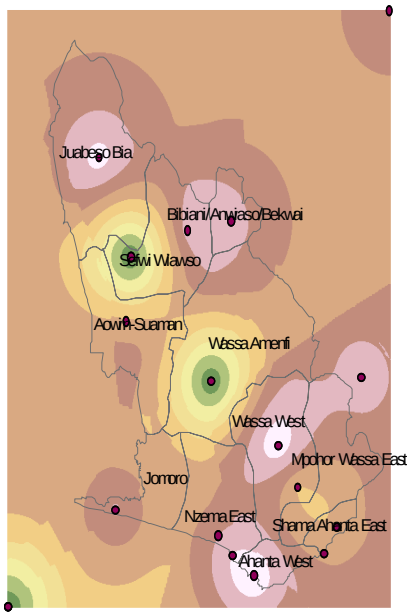

Fig. 17: Map of rainfall distribution in the western region for 1995

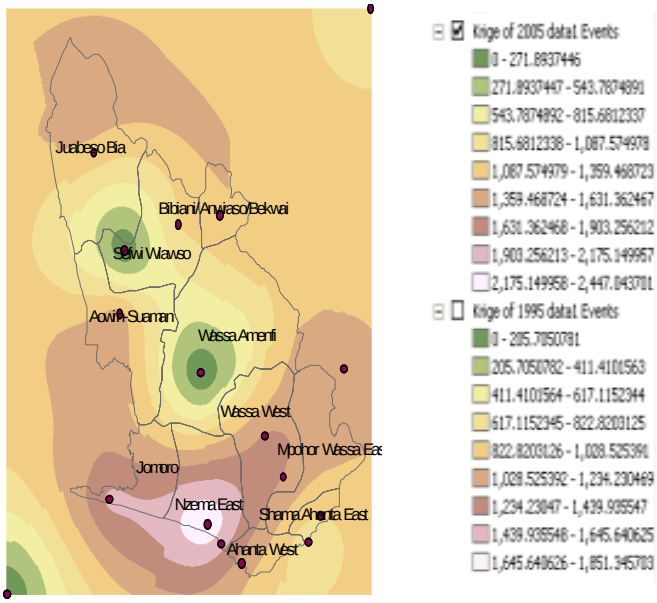

Fig. 18: Map of rainfall distribution in the western region for 2005

parallel coast east of Ahanta West but increases towards the west probably due the nature of the coast line.

CONCLUSION

- The study shows a gradual increase in the rainfall values from 1985 to the year 2005 for the study area.
- Low rainfall distribution pattern was observed over the thirty year along the stretch of west south west coast perpendicular to the direction of the monsoon winds from the Atlantic oceans.
- The erratic trend of rainfall in Tarkwa area can be attributed to high concentration of mining companies and the land use/land cover change over the period.

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