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THE INFLUENCE OF WEATHER ON THE INSURANCE INDUSTRY IN NAIROBI

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ABSTRACT:- *This paper investigated the relationship between rainfall and losses in revenue incurred by owners of buildings and property , in fire domestic and industrial insurance classes, during the years 1997 - 2000 and the ensuing claims that insurance companies in Nairobi had to pay. A rainfall derivative was then formulated. The methodologies included correlation, regression analysis, and questionnaire analysis. Results showed that extreme weather events, particularly excessive rainfall, had a direct impact on the extent of damage on buildings and property. It also became clear that insurance companies did not necessarily consult the meteorologists when underwriting policies and furthermore did not particularly consider that the meteorological information and products issued were relevant or accurate. This information will form the basis for a broader, more detailed study within the interdisciplinary field of Actuarial Science and Meteorology in Kenya, and will aim at creating useful and accurate weather derivatives that can be traded.*

KEY WORDS *Weather Derivatives, Heating degree days, cooling degree days, Fire industrial and Fire Domestic Classes, Strike, Tick, exponential and polynomial models, claim-month fractions.*

INTRODUCTION

One of the factors that have affected the annual revenues of many sectors of the economy, and continues to do so, is weather. Muthama *et al* (2002) outline the adverse effects that floods and drought have on Kenya's agricultural, water sectors, and horticultural and tourism industry. Engineering and construction industries, energy, transport and communication sectors are also affected in varying degrees (Oludhe, *et al*, 2002). Insurance companies, which share the risks that these sectors are exposed to, are also vulnerable to extreme weather events.

Heavy losses may be incurred by even small anomalies in temperatures, humidity, precipitation or wind speed, especially if they continue over long periods of time. Though humans have little control over weather, meteorologists can help various sectors of the economy reduce their losses by providing them with specifically tailored weather products. Factoring in weather and climate information in the various economic sectors in Kenya is essential for the region's sustainable socio-economic development. This is true particularly in view of Kenya's population density, size and growth profiles. One such weather product is the Weather Derivative. This is a risk management contract which hedges against the volatility of earnings made by companies in the event that a weather derivative exceeds some specific value (found, by research on the critical meteorological index). Derivatives can be traded between insurance companies and clients, or even between/amongst two or more institutions or companies (Corbally and Henderson, 2002).

In the United States of America and Europe the Weather Derivatives market has grown out of the Energy market. The need for newly deregulated Utilities to hedge against volume risk, caused by temperature fluctuations, has meant that the most actively traded of these products is temperature. Quite often they are based on heating degree-days (HDDs), cooling degree-days (CDDs) and/or cumulative temperatures. Both HDDs and CDDs are the differences between a daily mean temperature and some specified mean temperature e.g. a seasonal mean. Weather derivatives also include derivatives of wind speed, humidity, precipitation, snow and solar radiation.

Dutton and Dischell (2001) illustrates how agricultural industries in the U.S. have developed a focused and sophisticated system for integrating weather, climate and risk information in their planning and managing of crops and to protect against pests. In agriculture, futures contracts are traded extensively in markets that respond to weather events as well as to other forces acting on supply and demand. By limiting both downward risk and upward potential, these contracts provide the grower or processor with acceptable financial boundaries while creating the possibility that third parties who absorb the risk may achieve profit in return.

According to Corbally and Henderson (2002) pricing of a weather risk management product depends on the following factors: Data analysis, weather forecasts, deal valuation based on historical data and different risk management strategies. Improvements in research, weather data analysis and products, as well as establishing well regulated means of trading these products, will not only benefit the meteorologists by them selling these products to companies (and the general community), but the companies/industries will be able to hedge themselves against revenue volatility.

In Kenya, the main problems concerning the current relationships between insurance companies, the insured and meteorologists are the lack of adequate understanding and appreciation of the important roles that these parties play in the economy. This has led to each party assuming that it can operate without fully engaging the services or involvement of the other parties. Meteorologists have yet to fully bridge the gap between themselves and the larger society. Obstacles to its progress include ignorance about the meaning and benefits of meteorology to the general public, the business community and the government. Instances when meteorological forecasts have been perceived as erroneous or irrelevant by the public are numerous.

There is a lack of adequate use of meteorological products or predictions that could improve insurance policies. Kenyan insurance companies have policies based mostly on voluntary risks (Kenya Alliance Insurance, 2002). They also have policies that guarantee payment of claims for damage or loss of life due to fires and floods. However, these policies are based on involuntary risks or “acts of God” as some put it. They do not take into consideration that many of these weather related hazards can be predicted or that the predictions can be used to improve their policies for the benefit of both the insurance company and the client. Understanding how each industry (not just the insurance industry) is affected by weather and how weather derivatives can help curb losses of revenue, would be the first step towards improving general business and hedging against disastrous events.

The main objective of this work was therefore to investigate the impact of weather on the insurance industry in Kenya. The specific objectives were:

- To evaluate the weather related loss of revenue by owners of property (in fire industrial and domestic classes) and thus insurance companies upon settling of claims.
- To investigate the relationship between weather and revenue losses incurred by insurance companies and other companies (based on records kept by insurance companies).
- To produce a rainfall derivative, which can be used by end-users to insure or hedge against losses caused by harsh or fluctuating weather, thus contributing to weather risk management.

DATA AND METHODS

Insurance data was collected in two ways - from a questionnaire that was distributed to six insurance companies (Alico Kenya, Kenya Alliance Assurance, Apollo Insurance, Occidental Insurance, Canon Assurance, and Kenindia Assurance) and in the form of monthly claims figures from the data - bases of three of the insurance companies. The questionnaires were provided to employees of the claims’ section and the claims consisted of figures of fire domestic and fire industrial losses and the particular months or days and years that this took place (1997 – 2002). From the Commissioner of Insurance, data of two forms were obtained. These were net insurance claims of insurers under general insurance business, class-wise for each end of year and for each month. The classes were : aviation, engineering, fire domestic, fire industrial, liability, marine and transit, motor private, motor commercial, personal accident, theft, workmen’s compensation, and miscellaneous. In addition, a summary of gross direct premium incomes under general insurance business for the years 1987 to 2000 were also obtained.

Monthly rainfall figures in millimetres were obtained from the Kenya Meteorological Department. It comprised of data from three meteorological stations in Nairobi, i.e. Dagoretti, Wilson and Jomo Kenyatta International Airport (JKIA) from 1958 to 2001.

Rainfall values were subjected to the cumulative mass curve, to check for homogeneity. Many studies have used it for data quality control, including Leander, R et al (2004). The cumulative mass curve involved cumulatively adding the rainfall values and plotting them in the form of a graph to see if it forms a relatively straight line – in which case it is indicative of homogeneity. Missing values were obtained using the arithmetic mean method. This method involves getting the mean of all the available values and using this mean in place of the missing values.

$$X = (x_1 + x_2 + ...+ x_n) / n \qquad \text{I}$$

Where X is the unknown value of rainfall, n is the number of known values and x is the actual value per month.

Rainfall values were first plotted to determine the trend of rainfall over the years (Fig. 1)

The claims data was subjected to regression analysis and a weather derivative was generated. According to Lixin (2002), an insurance premium can be computed using a simple equation:

$$P = k\ (W - S) \qquad \text{II}$$

W = total precipitation, P = amount to be paid by either the seller or the buyer, S (strike) = the pre-negotiated threshold, k (tick) = pre-agreed –upon constant factor that determines the amount of the payment per unit weather index.

This weather derivative that companies would need to purchase in order to safeguard their businesses, are simply contracts which guarantee payment to the first party (e.g. a business), and sometimes a second party (e.g. an insurance company) by a third party (e.g. a bank or some other company) in the event that a weather derivative exceeds some specific value. These derivatives can also be traded solely between the insurance company and the client, or even between a meteorological institution and any other company. This specific value (found, by research on the critical meteorological index) is one above or below which it has been established that the company incurs unacceptable losses.

Because premiums are a partial reflection of how many claims the insurance company encountered in the past or how large the risk is, it follows that finding a correlation between claims and the rainfall variable would be appropriate. The claims were subjected to running averages to de-trend them, before performing the regression analysis. Most phenomena are random in nature and a probabilistic model was thus more suitable than a simple linear model. This model took the form of

$$Y = ß_o + \Sigma\, ß_i X_i + \varepsilon \qquad \text{III}$$

Where Y is dependent variable, X is the independent variable, β is the coefficient of each variable and ε is the error term.

When the linear models proved inaccurate in modelling the claims data, polynomial of the form:

$$Y = ax^2 + bx + c \qquad \text{IV}$$

and exponential graphs of the form:

$$Y = e^{kx} \qquad \text{V}$$

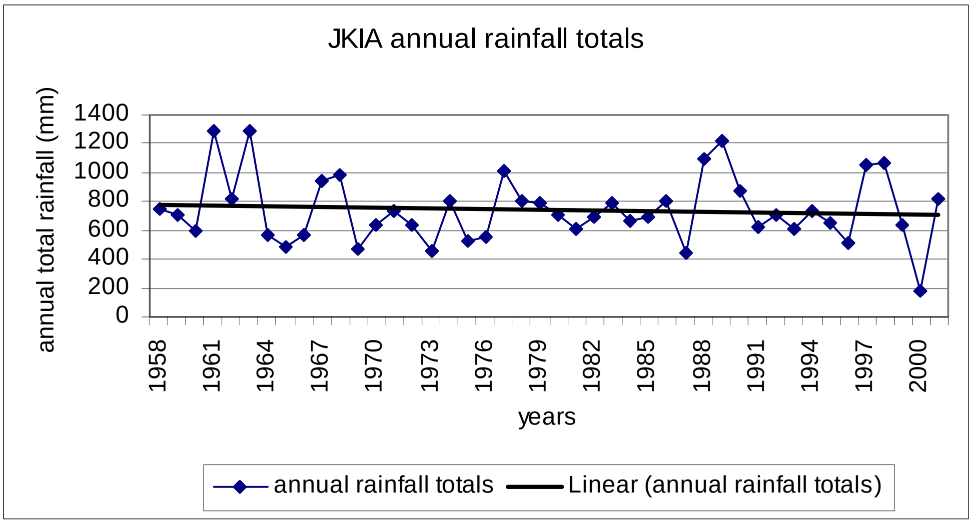

Figure 1: Rainfall trend for JKIA (Jomo Kenyatta International Airport)

were used. Where Y is the dependent variable, a, b, k are the coefficients of x - the independent variables and c is the y-intercept.

The answers from the questionnaires were analyzed and summarized.

RESULTS

From the insurance companies, net claims for Fire Industrial (FI) and Fire Domestic (FD) classes for various years as well as total losses were obtained. The premium totals for FI and FD classes from the respective insurance companies were not obtainable because it was considered confidential information. This meant that for those particular classes it would be difficult to create a weather derivative that was applicable. For premiums obtained from the commissioner of insurance, it would be possible. However, how suitable this derivative would be for weather related risks is not known. In addition ten questionnaires were filled by six insurance companies. From the Kenya Meteorological Department, Dagoretti rainfall data did not have missing values But Wilson and JKIA rainfall data had missing values for November and December 2001. These values were estimated by computing the average of the values of these months of all preceding years. In addition, the homogeneity of the rainfall was tested.

From the cumulative rainfall results it was evident that the rainfall data was homogeneous (Fig 2). Results indicated that severity of weather events had a direct impact on the extent of damage to buildings and property, with incurred losses in the hundreds of thousands - even millions of Kenyan shillings. From the three insurance companies (Alico Kenya, Kenindia Assurance and Occidental Insurance), it was found that the percentage of weather related claims, for fire classes alone, out of total claims for any particular year, varied between 0.04 % and 27.4% or higher. In the case of Occidental, the percentage of weather related cases out of general claims was 520% (Table 1).

Table 1: Weather related claims as a percentage of total claims for the year

Insurance company	1998	1999	2000
Alico Kenya	15%	0.043%	3.8%
Kenindia Assurance	27.4%	--	0%
Occidental Insurance	520.8%	--	27.9%

The exponential models (Figure 3 and 4) and the polynomial model (Figure 5) seemed to capture the number of claims fairly accurately. The polynomial model seemed to fit closely with actual claims of 100 and below. However, above 100, the model missed certain claim numbers. The extent and severity of claims (within FI and FD classes) depends on several factors such as water drainage, location, architectural design, temperature and humidity. Hence the equation may be written simply as:

Occidental Insurance:

$$Y = \beta_o + 0.794\ \ \beta_1 + X_2\beta_2 + X_3\beta_3 + X_4\beta_4 + X_5\beta_5 + X_6\beta_6 + \varepsilon \qquad \text{VI}$$

Alico Kenya:

$$Y = \beta_o + 0.724\beta_1 + X_2\beta_2 + X_3\beta_3 + X_4\beta_4 + X_5\beta_5 + X_6\beta_6 + \varepsilon \qquad \text{VII}$$

Kenindia Assurance:

$$Y = \beta_o + 0.715\beta_1 + X_2\beta_2 + X_3\beta_3 + X_4\beta_4 + X_5\beta_5 + X_6\beta_6 + \varepsilon \qquad \text{VIII}$$

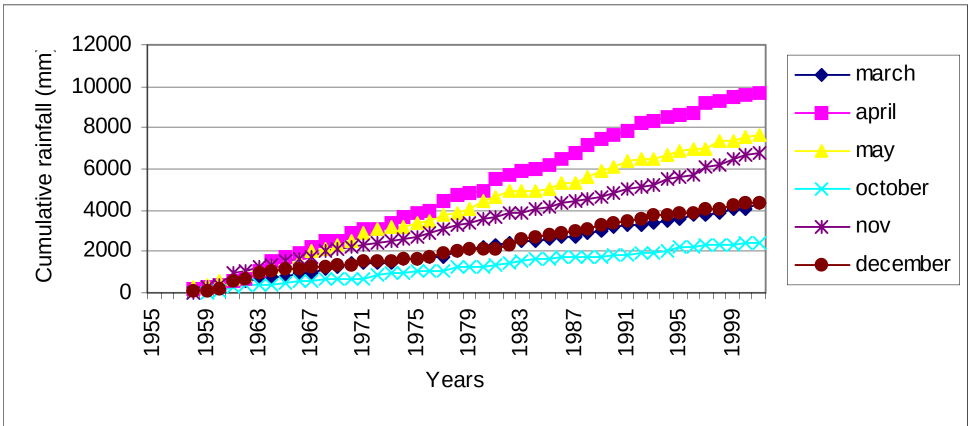

Figure 2: Cumulative mass curves for March, April, May, October, November and December for Dagoretti station

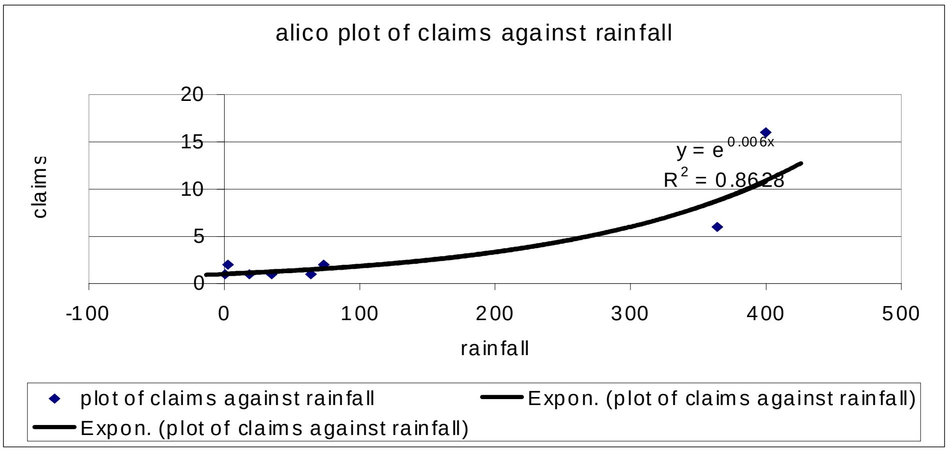

Figure 3: Exponential plot of Alico claims against rainfall values

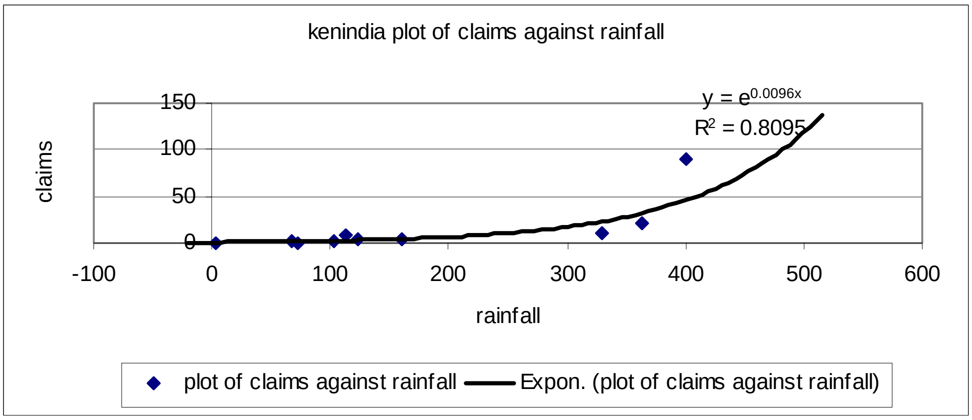

Figure 4: Exponential plot of Kenindia claims against rainfall values

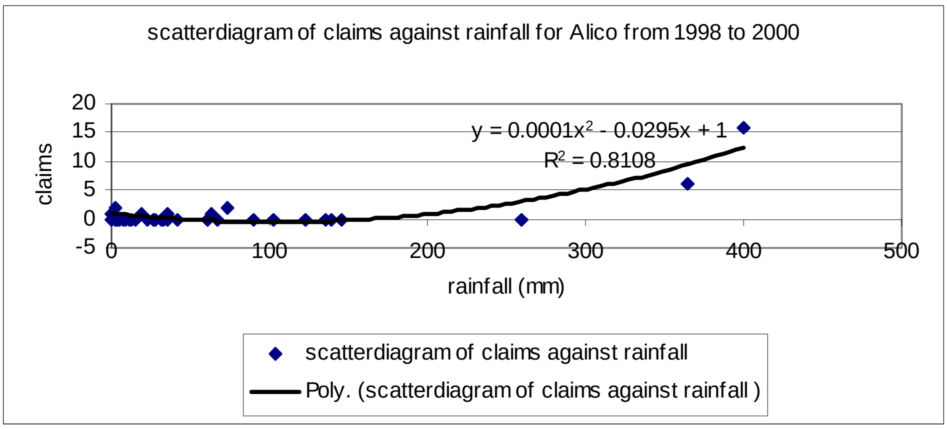

Figure 5: Polynomial plot of Alico claims against rainfall values

Where **Y** = number of claims of damaged property,
β_o =some constant factor
β_1 = rainfall amount
β_2 = water drainage factor
β_3 = maintenance of property
β_4 = location of property
β_5 = temperature and/or humidity
β_6 = design or property/architecture
$X_2 \ldots X_6$ are undetermined constants
and ε is an error term.

The weather derivative was given as:
The call contract:

$$P = k\,(W\text{-}S) \qquad \text{IX}$$

The put contract:

$$P = k\,(S\text{-}W) \qquad \text{X}$$

Where W is the total amount of rainfall.
S is the pre-negotiated rainfall threshold.
P is premium.
The predetermined k may be given as:

$$k = Y_1/Y_2 \times 0.25\,(N)/S \qquad \text{XI}$$

Where Y_1 may be forecasted claims and Y_2 may be actual claims,
0.25 is the figure of the insured value at which the premiums are computed.
N is the value of insured property.
S is the pre-negotiated rainfall threshold.

The rainfall derivative is therefore:

$$P = [Y_1/Y_2 \times 0.25\,(N)/S] \times [W - S] \qquad \text{XII}$$

And Y_1 may be substituted by the polynomial or exponential equation of the best model.

It became clear from the questionnaire that insurance companies did not significantly consult with the meteorologists and did not always consider that meteorological information was relevant or accurate (Table 2).

From the analysis, the factors that contribute to claims and premiums may be summarized in Figure 6 below.

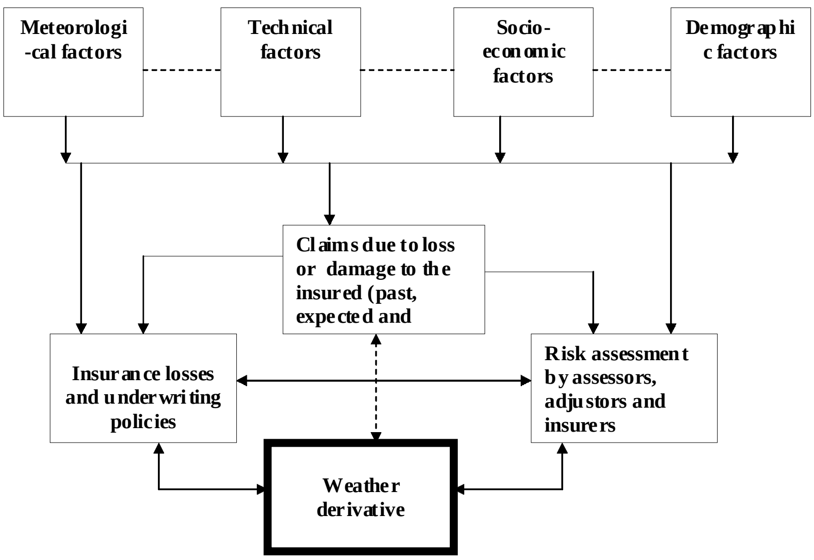

Figure 6: Flow chart showing contribution of factors to claims and premiums

Table 2: Summary of Questionnaire

	Question	Company	Answer
	Underwriting information		
4	Knowledge/use of weather derivatives?	Cannon	No
		Occidental	No
		Apollo	Did not answer
		Kenindia	No
		Kenyan Alliance	Yes
		Alico	Did not answer
2	Policies covering weather related risk?	Only Kenindia covered Livestock (L).	FD, FI, AR, CR, PL, GT, MP, MA, EE, E, PA, L*
3	Factors considered in weather related insurance?	All insurance companies	Location and type of enterprise or property, poor maintenance, experience of losses/ risk surveys, weather in area
5	Factors that determine premiums in weather risks?	All insurance companies	Geographical location, exposure of property, standard premium rates of between 0.25 and 0.5 % of insured value, excess charged in extreme cases.
11	Disaster prone areas?	Cannon	River banks, Western Kenya , coastal floods, N.E. Kenya, Industrial Area,
		Occidental	Hurlingham, Brookside Area, Ectovile,
		Apollo	Nyanza, Tana River, N.E Kenya
		Kenindia	Nairobi, Kericho, Kisii
		Kenyan Alliance	
		Alico	
12	Ways of determining catastrophe prone areas?	All insurance companies	Surveys, past experience, press reports, weather records
13/14.	Different policies for different clients?	All insurance companies	Yes, depending on their location
15	Underwriting problems related to weather related policies?	Cannon	Did not answer ,
		Occidental	Insufficient meteorological info
		Apollo	Did not answer
		Kenindia	Does not use weather info.
		Kenyan Alliance	Setting fair premiums for both company and client, Obtaining information reliable weather data on catastrophe prone areas,
		Alico	Did not answer
18/19.	Complaints from clients?	All insurance companies	Clients want insurance in adverse weather prone areas, fewer exclusions in policies and lower premiums.
20	Requests for other weather related covers?	Cannon	No,
		Occidental	Did not answer
		Apollo	Did not answer
		Kenindia	Yes, against changes in temperature and humidity.
		Kenyan Alliance	No
		Alico	Did not answer
21	Can the insurance companies incorporate weather factors into their policies?	Cannon	Yes. No, too risky Did not answer
		Occidental	Yes,
		Apollo	Yes, they have
		Kenindia	
		Kenyan Alliance	Did not answer
		Alico	
22	Usefulness of meteorological information?	Cannon	Yes, a lot
		Occidental	Not at all
		Apollo	Did not answer
		Kenindia	A little
		Kenyan Alliance	Yes
		Alico	Not at all
23	More meteorological information needed?	Cannon	Did not answer
		Occidental	Proper weather survey reports
		Apollo	Did not answer
		Kenindia	Actual statistics on weather such as seasons,
		Kenyan Alliance	Yes any info welcome
		Alico	Detailed info

* FD = Fire domestic, FI = fire Industrial, AR = All Risks, CR = Contractors' Risk, PL = Public liability, GT = Goods in transit, MP = Motor policy, MA = Marine policy, EE = Electronic equipment, E= Engineering, PA = Personal accident, L = Livestock.

The above flow chart may be explained as follows:

1. The dependent and independent variables are the meteorological, technical, demographic and economic factors, all of which affected the extent of loss or damage to property and hence to claims.

2. The past claims in turn affected the losses experienced by the insurance company, which in turn assessed the risks involved in each case. Therefore, the variables directly affected the kind of risk assessment that was made on the insured and indirectly affected the insurance's financial losses as well as underwriting policies.

3. In addition, past claims will affect the way the weather derivative appears as a result of the risk assessment and underwriting policies. The weather derivative will in turn offer the insurance company ways of hedging against risks, which means that expected claims will be more predictable and the actual claims more manageable.

On looking at the claims data between 1997 and 2000 for Kenindia, and between 1998 and 2000 for Occidental and Alico Insurance Companies, and comparing them with the monthly rainfall from 1998 to 2000, It was decided to categorise the rainfall into three main groups (namely below normal rainfall, normal rainfall and above normal rainfall) and compare the claims with these categories in mind. In fact the scatter plot of claims against rainfall naturally created these three rough categories, that is, rainfall below 100 mm was termed 'below normal rainfall', rainfall between 100 and 200 mm 'normal rainfall' and rainfall above 200 mm as ' above normal rainfall. The months in which claims were incurred were thereafter termed as 'claim-months'. These were summed up for each category of rainfall and displayed as fractions of the total number of months for which data was available (Fig 7).

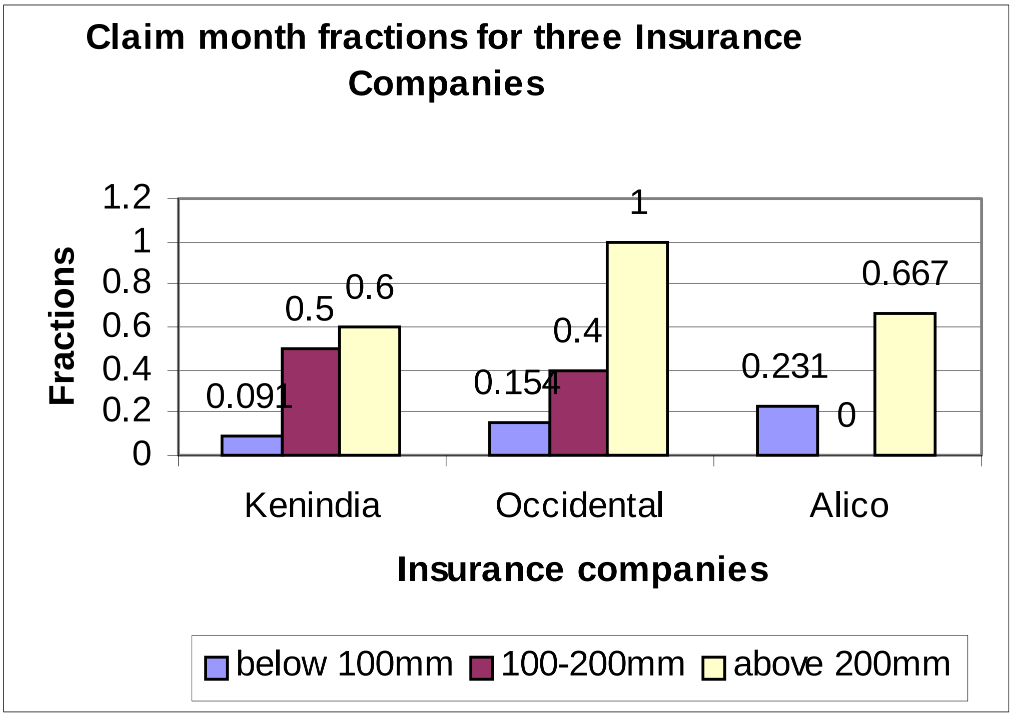

Figure 7: Claim month fractions of three Insurance companies

DISCUSSIONS AND CONCLUSIONS

The FI and FD classes, in which general property, homes, small businesses and factories were categorized, have been studied. It was noted that FI and FD premiums had increased over the years while rainfall totals fluctuated. Reasons for this increase could have been a weakening of the shilling (though this was not verified with the insurance company), changes in underwriting policies due to large claims in previous years and/or increase in general business. Other insurance classes (vehicles, factories, farms, the construction industry, and the transport and communication sectors) were not analysed.

From the three insurance companies, it was found that the percentage of weather related claims, for fire classes alone, out of total claims for any particular year, varied between 0.04 % and 27.4% or higher (Table 1). Occidental Insurance showed 520.8 %. These results indicated that total weather related claims incurred by Occidental far-exceeded total general claims that were reported to Commissioner of Insurance. It was not clear how much the total claims incurred under general business at Occidental were. As the study did not look at the other classes, it was not possible to say to what extent weather extremes had contributed to damage and losses in those classes.

The polynomial and exponential models of rainfall against claims were fairly accurate. However, insufficiency of data hampered testing of the weather derivatives.
It may thus be projected that future insurance claims will depend on the frequency and severity of weather events. None of the insurance companies interviewed had any knowledge of weather derivatives except Kenyan Alliance, which claimed that they did. Lack of integration of weather in their underwriting affects the extent to which they can cover their clients.

Premiums and claims depended on factors such as location and accompanying risks, maintenance and value of property and type of business

It may therefore be suggested that a broader and more detailed study of the interdisciplinary field of Actuarial processes and Meteorology in Kenya would support a better understanding of the fluctuations of premiums and claims in relation to weather variations/extremes, and hence more useful changes could be made to current and future weather products and services.

REFERENCES

Corbally, M. and R. J. Henderson, 2002: How do you play with the weather and win? If you're an insurance company, very, very carefully. *Element Re Capital Products Inc*., 23-26.

Dutton J. and B. Dischel, 2001: Weather And Climate Predictions: Minutes to months. *Weather Risk, a special report from Risk Magazine and eEnergy and Power Risk Management.* - **http://www.wxpx.com/publications/weather%20Risk%20Publications.htm**

Kelly J., 2002 : Opportunities for 21st Century Meteorology: New Markets for Weather, water And Climate Information. *National Weather Service*, NOAA, 1-5.

Kenyan Alliance Insurance, 2002: *Fire domestic insurance policy, 2002.*

Lixin, Z., 2002: Weather derivatives and weather insurance: Concept, application and analysis. Risk analysis and technologies, E.W. Blanch Company Minneapolis, Minnesota. *American Meteorological Society online publications*.

Muthama N.J., A.O. Opere and C.B. Lukorito, 2002: Utilization of Meteorological products in Agriculture and Water sectors in Central and Eastern Kenya. Journal of African Meteorological Society, Vol. 6.

Oludhe, C., D. Theuri, P. Muturi and K. Mutambo, 2002: Energy, Industry, Transport and Communication Sectors. *Factoring of weather and climate information and products into disaster management policy.* IGAD, DMCN, May 2002, 87, 152 – 205.

Leander, R. and Buishand T.A, 2004: Rainfall Generator for Meuse Basin - Inventory and Homogeneity analysis of long daily precipitation records. KNMI publication, 196 - II .p 7. http://www.knmi.nl/onderzk/klimscen/papers/knmipublikatie_196_2.pdf#search='rainfall%20homogeneity%20test'