# TOWARDS THE DEVELOPMENT OF AN OPTIMUM STABILITY INDEX FOR FORECASTING CONVECTIVE WEATHER ACTIVITIES OVER NAIROBI

BY

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# D E C L A R A T I O N

This thesis is my original work and has not been presented for a degree in any other University.

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This thesis has been submitted for examination with our approval as University Supervisors.

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TO THE MEMORY OF

MY SISTER

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# ABSTRACT

Upper air data extracted from the 2300z (2.00 A.M. local time) radiosonde soundings for the Nairobi station during 1988, 1989 and 1990 has been used to develop a number of Stability Indices which could be useful in forecasting convective weather activities (in particular, rain or showers and thunderstorms) in the Nairobi and surrounding area. The development of the Indices was based on a number of factors including the environmental lapse rate of temperature, the effect of diurnal surface heating, the moisture content of the lower levels of the atmosphere and the vertical extent of the moist layer. A relationship was established between the computed Indices' values and the probability of occurrence or non-occurrence of convective weather activities over the area on the successive days that followed the soundings. Optimum threshold values, above or below which convective weather activities should or should not be expected, were determined for each Index. The performances of the various Indices were compared on a monthly, seasonal and annual basis. The comparisons were based on the Reliability and Predictability as well as consistency of the individual Indices during a given period.

Though no particular Index was found to perform better than the others throughout the year, particular Indices were identified and subsequently selected as most suitable for use during specific seasons of the year.

The predictions based purely on the selected Indices were compared to those of the forecasting guides currently being used in the area which are issued by the daily weather forecast bulletins. This was accomplished by subjecting the two to the Chi-square goodness of fit test on a monthly basis for the whole period of study. The results indicated a sigificant improvement in the forecasts when the Indices are used. The use of these Indices should therefore be incorporated in the routine weather forecasting procedures used in the area. However, it was found that the use of Stability Indices as independent forecasting tools can be quite misleading, and at times, an Index may be practically unrepresentative. Therefore, they should be combined, either objectively or subjectively, with other data and synoptic considerations.

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# LIST OF SYMBOLS

| SYMBOLS | |
|---|---|
| g | Acceleration due to gravity |
| $R_d$ | Gas constant for dry air |
| $\rho$ | Density of air |
| T | Temperature |
| $T_d$ | Dew-point Temperature |
| U | Relative humidity |
| P | Pressure |
| CBs | Cumulonimbus Clouds |
| mb | Millibar |

# CHAPTER I

## 1.0 INTRODUCTION

### 1.1 STATEMENT OF THE PROBLEM

Weather forecasting is the main problem of practical meteorology. The solution of the problem is based on an analysed sequence of surface and upper-air maps, vertical sections, radar reports, satellite pictures and plotted upper air soundings available to the weather services. The techniques used and their efficiency vary from place to place and depend on a number of factors such as the availability of data, the climatology, topography and geographical location of the place. The degree of accuracy of the forecasts depends greatly on the ability of the forecaster to balance the effects due to large scale or synoptic scale features and those due to the local features at a given place.

Forecasts based on synoptic features are much more reliable in high latitudes than in the tropics due to a number of factors. The high latitude synoptic features such as fronts and depressions are comparatively well-documented, distinct and easily detectable on weather charts. The weather in high latitudes is mainly characterized by migratory systems such as extratropical waves but in the tropics the weather is controlled, to a large extent, by quasi-stationary systems such as the sub-tropical highs. The meteorological observational network is sufficiently adequate in most areas of the high latitudes but is much less adequate over the tropical region. The diurnal variations of weather elements e.g, temperature and humidity is much less marked in high latitudes than in the tropics where they are accentuated by orography and large water surfaces. The influence of local features on the observed weather patterns is much less in high latitudes in comparison to that in the tropical region.

In general, the most predominant rainfall producing synoptic feature in the tropics is the Inter-tropical Convergence Zone (ITCZ). The ITCZ is a low pressure system lying between the subtropical high pressure belts of the northern and southern Hemispheres where winds of different regimes but usually of same characteristics converge. Though the surface position of the ITCZ is generally well defined over the tropical oceanic regions, it is quite diffuse over land areas due mainly to orographic influences. The ITCZ indicates maximum upward motion i.e, rain, if the converging winds have sufficient moisture. The ITCZ exhibits north-south migrations following the seasonal march of the overhead sun with a time lag of generally about four weeks. These fluctuations are greatest over land and least over oceanic areas. Since the rainfall in most tropical areas is evidently seasonal, with a similar time lag behind the overhead sun and occurs mostly during the periods when the ITCZ is traversing the areas, it is generally accepted that the rains are associated with the ITCZ (for example, Johnson 1962). Apart from the seasonal north-south migrations, the ITCZ exhibits fluctuations with a time scale extending beyond a few days attributed to changes in synoptic scale pressure fields (Sansom 1963, Sawyer 197O). It has been suggested that the occurrence of wet and dry spells within the seasonal rains in some parts of the tropical region could be due to these intermediate oscillations of the ITCZ (Sawyer, 197O). In addition, the ITCZ exhibits diurnal varitions attributed to diurnal surface pressure distribution changes especially in areas of strong meso-scale features (Sansom, 1963).

In addition to the synoptic scale features, another important energy source, particularly in the maintainance and intensification of tropical weather disturbances, is the release of latent heat of condensation (Riehl, 1954). Most latent heat release in the tropics occurs in mesoscale cloud systems which are usually embedded in large-scale circulations. Observations have indicated that most precipitation in the tropical systems is of convective origin and is concentrated in a relatively small number of deep vigorous cumulus convection cells (Holton, 1972). It is therefore clear that in order to forecast cloud formation and precipitation in the tropical regions with reasonable accuracy, a forecast of convective activity is inevitable. In order to forecast convection, it is necessary to investigate the factors that determine or influence its existence and intensification at a given place. The key factors include, among others, the vertical atmospheric stability and the moisture content of the lower and middle levels.

The vertical atmospheric stability is a measure of the capacity of the development of upward or downward movements in a given environment. Modern application of the principles of physical hydrodynamics to weather has given conclusive evidence that the vertical components of air motions are the principal factors in producing the most important meteorological phenomena. Their chief significance comes from the rapid changes in temperature and moisture caused by these upward and downward movements. For, when compared with the rate of increase or decrease of temperature and moisture in horizontally moving air, the rapidity of change of these properties in the vertical currents is tremendous. The weather phenomena of perhaps greatest practical interest are those having to do with condensation e.g. clouds and precipitation. The influence of the vertical atmospheric stability and moisture profiles on convective weather developments, particularly in the lower and middle levels of the atmosphere, emphasizes the importance of upper-air information in the weather forecasting procedures used in the tropics. In fact it is more vital to have upper-air data in the tropics than it is in the high latitudes because in the latter, the surface chart provides the basis for reasonable forecasts but in the tropics and particularly near the equator, the surface chart provides no indication of forthcoming weather whatsoever except perhaps, in the vicinity of typhoons (Thompson, 1957).

The overall stability or instability of an atmospheric sounding may be conveniently expressed in form of a single numerical value called a Stability Index. A good Stability Index should take into account the factors that are likely to lead to the establishment of an unstable atmosphere and thus favour the initiation or intensification of convection. Such factors include the diurnal surface heating and the vertical extent of the moist layer at a given place. Though the Stability Index by itself may not be sufficient to provide an accurate prediction of convective weather activities, it helps to provide a quick check on the possibility of their occurrence and alert the forecaster to those soundings which should be examined more closely as well as indicating to him or her the need to examine the other forecasting guides e.g, surface and upper-air charts, streamline charts, pressure tendency charts e.t.c. in more detail. In fact such an Index is most useful when combined, either objectively or subjectively, with other data and synoptic considerations. However, the Index could be used as an independent forecasting tool in the absence of other forecasting guides or where they may be present but are unreliable. Indices of this type have the advantage that they are easy and quick to compute, give a flexible choice of the layer most pertinent to the particular problem or area, and are expressed in a numerical form convenient for ready use in objective studies and operational forecasting. Even in the developed countries, where extensive meteorological research has been done and adequate data is readily available, such Stability Indices are still of great use. For example, in the United States of America, seven different Stability Indices are currently in use and at least two of them are regularly computed for every radiosonde station and their values included in weather bulletins (WMO and NOAA, 1989).

There is currently one Stability Index being used for forecasing purposes for the Nairobi and surrounding area. The Index, called the Lifted Index, was developed for use in the United States in the mid 1950's and was adopted for use in the area of study only recently (in 1990). No attempt has so far been made to improve its forecasting skill leave alone testing it or investigating its reliability and suitability for use in the area.

From the foregoing, it is justifiable to suggest that there is an urgent need to test and improve, if possible, the forecasting skill of the Index being used in the area of study as well as determining its reliability and suitability for use in the area. There is equally an urgent need to develop and test alternative Indices for comparison. The most suitable Index or Indices should then be selected and adopted for use in the area.

## 1.2 OBJECTIVE OF THE STUDY

The main objective of the studyis to develop a number of Stabiity Indices which could be used for routine forecasting purposes for the Nairobi and surrounding lowlands including the Central Province and parts of Eastern Province. However, orography plays a significant role in inducing rains in this region especially in the highland areas. The Indices are intended to forecast convective weather activities (in particular, rain or showers and thunderstorms) on a daily basis. The number and nature of Indices will depend on the type of data available, in particular, the upper-air data obtained from radiosonde ascents made at the Nairobi station. The Indices will be developed on the basis of all or some of the following factors; the environmental lapse rate of temperature, the effect of diurnal surface heating, the moisture content of the lower and middle levels as well as the vertical extent of the moist layer. The forecasting skill and risk of making errors involved in using each of the Indices to be developed and of the one already in use in the area of study will be evaluated and used in determining their reliability and accuracy.

By comparing the reliability and accuracy of the various Indices, the most suitable will be selected and recommnded for use in the area. An attempt will also be made to establish whether some particular Indices are more suitable than others for use during some specific seasons of the year.

## 1.3 THE CLIMATOLOGY OF THE AREA SURROUNDING THE NAIROBI STATION.

The climatology of the area surrounding the Nairobi radiosonde station can be divided into four well defined seasons. These are the warm dry season, the long rainy season, the cool dry season and the short rainy season.

The warm dry season covers the period from December to the beginning of March. The prevailing winds are the northeast monsoons. This is a period when sunny and warm conditions prevail with generally clear conditions.

The long rainy season covers the period from Mid-March to the end of May. Periods of heavy rains and showers are frequent with increasing cloudiness towards the end of the period. The prevailing winds are north-easterlies becoming south-easterlies in the later part of the period.

The Inter-Tropical Convergence Zone (ITCZ), which is in the southern Hemisphere during the period December to February, gradually moves northwards and crosses the equator in May, so that the south-easterlies persist during the period June to October, the cool and dry season. Low temperatures are generally experienced with drizzle or light rain occurring occasionally. The season is characteristized by generally cloudy or overcast days.

In the period October to November, the short rainy season, the ITCZ crosses the equator from the northern Hemisphere. Light south-easterly winds blow but change to north easterly towards the end of the period. This period usually has frequent showers and rain. It should be mentioned that the beginning and end of the seasons may sometimes be delayed or occur earlier than anticipated.

Apart from the observed seasonal patterns, the rainfall in the Nairobi and surrounding area also undergoes diurnal variations attributed to local features (Asnani and Kinuthia, 1979). There are two clearly evident maxima and one minimum. During the night, particularly in the late night, there is a katabatic flow from west to east over the eastern slopes of the Kenya highlands where Nairobi is situated. This flow interacts with the synoptic scale easterly flow and provides the forced lifting of air in the lower levels, favouring the release of convective instability which is generally present in the tropical atmosphere of the region. This gives rise to the most pronounced maximum which occurs between mid-night and early morning. As the easterly accelerations develop at around 0600 local time, leading to the development of upslope winds later in the day, the rainfall decreases to a minimum at around local noon. The other maximum occurs from late afternoon to early evenining. This is attributed to the convection resulting from the afternoon insolation which contributes to the release of convective instability. However, the predominance of the late night-early morning rainfall suggests that the interaction between the mesoscale and the synoptic scale flows plays a dominant role.

The Nairobi and surrounding area experiences a high frequency of cloudines with an average of about 6 to 8 hours of sunshine per day. The cloudiest period is from July to August when, on the average, only four hours of sunshine per day are exeprienced. The sunniest period is from December to March when the area has over nine hours, on the average, of sunshine per day. The area experiences particularly low temperatures for a tropical region, mainly due to the moderating effect of the altitude. Meteorological observation records show that in general, the mean diurnal range of temperature is large with warm to hot days and cool to cold nights. In contrast, the mean annual range of temperature is small, being on the mean only 4$^{O}$C.

## 1.4 LITERATURE REVIEW

The use of meteorological instruments to investigate the sounding of the atmosphere started more than a century ago. Soundings of the troposhere and lower stratosphere with meteorological instruments were made on an exploratory basis in the latter part of the nineteenth century. One such instrument was the ballonsonde which was first constructed by Teisserenc de Bort in France, in 1890 and in fact, it is by means of a series of soundings made with balloonsondes that he discovered the existence of the stratosphere in 1901 (Godske et al, 1957). However, records from balloonsondes could not be used for daily analysis and forecasting because of the delay involved in obtaining them. Another instrument used by early meteorologists, especially in the United States, was the kite. This too, was not successful in making data available for forecasting as its use was laborious, required special ground stations, equipment, personnel, e.t.c., and seldom furnished information from above 3 km.

In 1934, in the United States, a system of some 24 stations taking daily simultaneous soundings by airplane was started. The aerological network developed rapidily as apart of the regular Weather Bureau forecasting services. This integration of the third dimension of the upper air, with the two-dimensional weather map in day-to-day forecasting, marked an important turning point in Meteorology. In 1938, sounding balloons carrying radiosondes that telemeter, or send, their records back to the ground by radio signals, replaced the airplanes in the network in the United States. During the second world war, and subsequently, ground equipment was developed for radio direction finding from the radiosonde signal, thus making it possible to follow the drift of the balloon and compute the winds at the various levels through which the balloon rises in addition to recording the transmitted temperature, pressure and humidity data.

The use of upper air data has made a significant improvement in routine weather forecasts. This is particularly so in the case of forecasting convective weather activities from atmospheric soundings plotted on thermodynamic diagrams (e.g. Tephigram). Many studies have been made in an attempt to forecast convective weather activities in different parts of the world. Most of these studies are based on the parcel method of determining atmospheric stability which, at one time, was held by many to be a complete and satisfactory convection theory. The parcel method clearly has its shortcomings. One principal defect of the method is the assumption of an undisturbed environment thus, neglecting the mass continuity requirement. Bjerkens (1938) was among the first to recognise this shortcoming. He modified the parcel method by allowing for mass continuity in a manner that considered both upward and downward motion within a limited area. He gave a theoretical treatment of the cumulus convection in an atmosphere which is conditionally unstable. He assumed that the ascending current follows a moist-adiabatic and the descending current a dry-adiabatic path. The result is that the cumulus convection does not convert heat into kinetic energy unless the ratio between the width of the cumulus towers and that of the cloudless intervals is below a certain critical value. His method is referred to as the slice method. Quite generally, the treatment showed that the rate of production of kinetic energy through convection must be far below the estimates based on the parcel method.

Though the vertical stability of the atmosphere is a fairly good indicator of the expected convective activities, it is by no means a guarantee or a must for convective developments. For exmaple, Namias (1938) observed that convection necessary for the genesis of the thunderstorms may be initiated at upper levels. He found that on 24th June 1937, at Detroit, Michigan (U.S.A.), a thunderstorm was observed and yet the sounding showed that stratification in a deep layer from the surface was very stable.

Petterssen (1940) suggested that the problem of forecasting cumulus development could be conveniently divided into two sections: (1) convectively unstable air and (2) surface heating. In the first section he observed that if a layer of air characterized by a decrease of the wet-bulb potential temperature with height becomes saturated, an unstable state will exist. As a result of this instability, cumulus cells develop in the saturated layer. The prediction of this phenomena requires first, a determination of the convective state of the air before it is subjected to some rising motion which, produces the saturation; and second, an estimate of whether the rising motion will occur. The convective state is determined from the distribution of the wet-bulb potential temperature. If a deep layer of the air is convectively unstable then an estimation of the likelihood of the air being lifted to saturation is made. Rising motion may be expected in the vicinity of fronts, along mountain ranges, and in general, in regions of horizontal wind convergence near the earth's surface. In the second section he noted that surface heating may result from the transport of cool air over a warmer surface or from direct radiational heating. A method of predicting cumulus development may be applied to either type of heating. A technique based on the parcel method may be used to estimate the heating necessary to initiate convection. If this heating is expected, then cumulus clouds should develop up to the level where the moist adiabat through the convection condensation level (CCL) meets the sounding curve.

However, he noted that from observations, this method overestimates the level of cumulus development and also offers no satisfactory explanation for the failure of cumulus clouds to develop whenever dry air existed in the middle troposphere.

Normand (1946) noted that the wet-bulb potential temperature of a mass of air is unchanged by ascent or descent, or by evaporation of water into it or the condensation of water vapour out of it. He noted that this temperature is only changed by the effects of radiation and turbulence, both of which are negligible except in the lower levels. He therefore, suggested that the wet-bulb potential temperature, may be useful in identifying a particular airmass. He further observed that in every case where a mass of air shows the wet-bulb potential temperature decreasing with height in any pressure interval, the air within that interval will become unstable if forced to ascend to a sufficiently great height to make it all saturated. He concluded therefore, that a necessary condition for potential (convective) instability is that the wet-bulb potential temperature shall decrease with height.

The improvement to the parcel method by Bjerkens' slice method has already been mentioned. Later, Cressman, (1946) extended Bjerkens' theory by permitting net convergence or divergence to take place inside the area under consideration and thus incorporating synoptic effects.

Another principal defect of the parcel method is the assumption that the vertically moving currents are isolated from their sorroundigns and that only adiabatic temperature changes occur within the cloud and its environment. Observations by Stommel (1947) failed to reveal moist-adiabatic lapse rates of temperature within clouds. Instead, it was observed that the cloud temperature was only slightly different from that of the environment. Also measurements indicate that the liquid-water contents are only a fraction of those expected from the assumption of the moist-adiabatic ascent of air. The empirical data then demonstrated that there must be continued mixing between the rising current and the environment. This mixing of environmental air into the rising current of cloud air is referred to as Entrainment. This led to Stommel (1947) to put forward the idea that the observed cumulus structure could be explained if one assumed that the environmental air was being entrained and mixed with the ascending cloud air. This theoretical method, which estimates the amount of entrainment from a knowledge of the temperature and specific humidity inside and outside the cloud, was applied successfully to some observations of cumulus made near San Juan, Peurto Rico during April, 1946. The results indicated that the amount of entrained outside air is about twice the original volume per 100mb increment. Observations by Byers and Brahm (1948) also failed to reveal moist-adiabatic lapse rates of temperature within clouds. Barret and Riehl (1948) also showed, with observation during the summer and fall of 1947 over the tropical Pacific Ocean, that the lapse rate in cumulus clouds is greater than the moist-adiabatic rate demonstrating that there was mixing between the ascending current and the surroundings. Another shortcoming of the parcel method is that it neglects frictional forces. Williams (1948) and Baum (1951) demonstrated that overturning in the air near the ground need by no means develop when the lapse rate exceeds the dry-adiabatic rate. They noted that owing mainly to viscous forces, a quiescent atmosphere can be observed even when the density increases upward.

It should be mentioned that not all convective clouds will release precipitation. The probability of release of precipitation from convective clouds depends largely upon the depth of the cloud layer and the temperature in the upper portion of the cloud (patterssen et al, 1945). Theoretical evidence (e.g. by Houghton, 1951) as well as observational evidence (e.g., by Byers and Hall, 1955) support this view.

It has already been mentioned that the existence of an unstable atmosphere is by no means a guarantee for convective developments. Austin (1948) studied the occurrence of convective showers in the vicinity of 3 radiosonde stations in the eastern Unted States. He found that the relative humidity of the environment was as important a consideration for the development of showers as the vertical stability of the air. A study by Chalker (1949) investigated a relationship between the vertical stability of the atmosphere and airmass showers produced by the sun's heating on a tropical summer day using data confined to the tropical United States for the period June 17th through September 19th, 1947. The study showed that showers occurred most frequently in regions where the lapse rate was about $6^{o}$C per km, that is, only slightly steeper than the moist-adiabatic lapse rate. He concluded that the principal factor that controls airmass showers, in addition to surface heating, is the relative humidity in the free atmosphere and that it is comparatively unimportant whether the lapse rate is considerably steeper or slightly steeper than the moist-adiabatic lapse rate. However, the earlier suggestion by Petterssen (1940) was supported by radar observations of precipitation areas (Mather, 1949) which showed that the vertical extent of rain cells, and presumably that of convection cells, varies directly with the degree of convective instability. Hence,it should be expected that highly convective unstable air will give rise to tall cumulus cells of thunderstorm dimensions. In the tropics, the surface heating may produce a lapse rate much larger than the dry-adiabatic lapse rate near the ground on warm and sunny days, and for both wet and dry areas, convective instability is the rule rather than the exception. However, the convective instability in tropical regions is of itself an insufficient criterion for availability or release of energy because dry air can be very stable in the tropics in spite of the convective instability within it.

The entrainment theory by Stommel (1947) has already been mentioned. Though he did not have direct evidence, such evidence was furnished by Byers and Hull (1949) who showed that swarms of pilot balloons released around towering cumuli and thunderstorms converged strongly in the lower and middle troposphere. It should be emphasized that the slice, entrainment and other related methods are modifications rather than alternatives to the parcel method. Thus, despite its shortcomings, the parcel method stands out as the most basic single method of estimating atmosheric stability and the convection related to it. Even in its independent form, the parcel method has been widely used at least, in the prediction of the onset of convection over land and the approximate height of cloud bases (Riehl, 1954).

Some research on convective weather in the Nairobi area and the factors that influence its initiation or enhancement has been done in the past. Thompson (1957) carried out an intensive study of weather situations in East Africa particularly in the Nairobi area. He made a number of remarks based on the study. Among them were that, (1) it is certainly true that surface synoptic charts show the location of weather only and offer very little, if any, indication of its probable origin or of its future development; (2) it is more vital to have upper air information for weather forecasting purposes in the tropics than it is in high latitudes; (3) whereas the forecasters in high latidudes are continuously guided by well-documented models of synoptic features, the forecasters in the tropics lack such models of individual synoptic situations with the exception of the easterly wave, equatorial perturbation and typhoon; (4) at Nairobi the only really deliberately successful forecasting is done on the basis that if the lower troposphere (or most of it) is moist there will be rain and if dry there will not be; (5) errors naturally occur because the moisture content sometimes changes very abruptly so that ascents spaced at 24 hour intervals do not necessarily detect a variation and the resulting forecast may go wrong; (6) occasionally (but less frequently), a moist atmosphere does not give significant rain, presumably due to the absence of some other synoptic feature or trigger necessary to release the moisture and (7) thermal convection and airflow convergence are certainly among the triggers. He concldued that by and large the amount of moisture present in the Nairobi atmosphere provides the most reliable indication of Nairobi's weather. Thompson's view, which drew the attention to the importance of humidity in the upper air for forecasting rain areas, was corroborated by Johnson and Morth (1961) who showed that, for the Nairobi area, there was a closer relationship between rainfall and upper air moisture than there was between rain and stability. They used the total mixing ratio deficit over a specified layer (750-500 mbs or 500-300 mbs). The method involved the calculation of the deficit at each 50 mb interval followed by the summation of the individual deficits. However, due to the cumbersome nature and time consumption involved in the computations, this method was unsuitable for purposes of routine forecasting. This led to Sansom's (1963) development of a similar but simpler method which, he hoped, would be preferable for routine use by forecasters. Sansom's approach involved the development of an Index based on the stability of the 800-500 mbs layer and the humidity mixing ratio at 500 mb as evaluated from the radiosonde ascents made at 0600 G.M.T. for both Entebbe and Nairobi stations. He observed that the Index, so developed, produced better results for the Nairobi area than for Entebbe. He also noted that the inclusion of the stability factor in the Index significantly improved the results for the Nairobi area but much less significantly for Entebbe. However, despite its apparent success, Sansom's Index was not adopted for practical routine forecasting probably due to the fact that he used data for only one year (1960) and therefore the results could not be regarded as conclusive. In his conclusion, he conceded that though a forecast based on intelligent use of his Index,in conjunction with a careful study of the synoptic situation, should improve on the results based on use of either the Index or persistence on their own, the overall results of forecasting using only the Index showed no improvement over forecasts based on peristence. It should be noted that a probable setback of Sansom's Index is that it was used to provide 24-hourly weather forecasts using the early morning ascent. This is clearly unrealistic because the early morning stratification can only be used, with justifiable scientific theory, to forecast convective weather activities and changes which result from the radiational surface heating in the area of study. After the occurrence (or the expected time of occurrence) of these activities, the early morning ascent cannot justifiably be used to provide weather forecasts.

Observations have shown that the vertical overturnings that lead to convective clouds and weather rarely occur as isolated phenomena. On the contrary it is found that they occur more or less simultaneously over fairly large areas and are related to the vertical structure of the air masses and the large-scale motion systems. Kuo (1965) investigated the effect on large scale motions of latent heat release by deep cumulus convection in a conditionally unstable atmosphere and devised a method to include this effect directly in the equations for large scale flow. He used a parameterization scheme based on a non-steady deep cumulus model, using the temperature difference between the cumulus cloud and the undisturbed environment, and the large-scale convergence of moisture as indicators. The scheme's basic assumption is that the initial latent heat release in the conditionally unstable regions of a tropical storm is by the deep cumulus convections, and not by the mean vertical motion. However, because the supply of water vapour in tropical storms is controlled by the converging low level mean flow, both the intensity and area coverage of the convective motions increase inward resulting in an inward heating increase of the statistical heating effect and radial temperature gradient at high levels, which tends to drive the large-scale system. Thus, statistically speaking, these deep cumulus convections act collectively as a heat source for the mean motions, besides being agents of diffusion for the mean field.

Ludlam (1966) suggested that atmospheric convection establishes a chracteristic stratification and that the tropical atmoshere can be classified into modes using the equivalent potential temperature. Betts (1973) suggested that the thermodynamic atmospheric structure might be used to determine what type of convection might be present. He made further investigations in 1974 by using observational data from June to early September, 1972 over 300 radiosonde soundings taken at Carrizal Venezuella. He used an analysis based on the vertical profiles of the equivalent potential temperature and the saturation equivalent potential temperature. He found that in some average sense, the tropical atmosphere exhibits both a thermal and vapour stratification which is a function of the level of convective activity. Sanders and Paine (1975), using a total of 58 radiosonde observations made at a network of a 9 stations in Oklahoma (U.S.A.) on 14th May, 1970, found that the potential temperature field is little perturbed by mesoscale vertical motions.

Another important factor to be considered in relation to convection is horizontal convergence. A study by Chen and Orville (1980) showed that by using a two-dimensional time-dependent cloud model, the effects of mesoscale convergence or divergence on cloud convection could be established. The study found that convergence weakens the temperature inversion and leads to strong convection. It was also suggested from the study that some knoweldge of the mesoscale convergence field is needed in order to effectively forecast cloud scale convection 3 to 6 hours in advance, particularly if severe storms are expected. Perkey and Maddox (1985) used frequent upper-air soundings (6 hours apart) taken at eastern United States synoptic soundings sites on 24th and 25th April, 1975 to investigate how widespread and long-lived convective complexes interact with their large-scale environment. They utilized dry and moist numerical simulations of the intense, long-lived mesoscale convective weather that had developed and move eastward during the period of study. Comparisons of the moist and dry simulations with observations indicated that the large-scale dynamic fields were not properly simulated without the inclusions of the moist processes introduced by these mesoscale convective complexes. Furthermore, the analyses and simulations indicated the potential for using numerical models to study the mesoscale structure of convective systems. A study by Wilson and Schreiber (1986) found strong statistical correlations between the position of radar-detectable convergence lines and convective storm formation in eastern Colorado (U.S.A.). Using area data for 1984 and 1985, they showed that at least 80% of the storms forming on the Colorado plains were initiated along pre-existing radar-detectable boundaries. Jascourt et al (1988), using satellite imagery, noted a mesoscale organization of deep convection over the south central United States on 5th June, 1986 yet free convection was expected over the region. The rapid development and organization of the convection simultaneously across a broad area suggested the presence of a mesoscale instability. Analysis of satellite and convectional data suggested that a layer of weak symmetric stability modified the atmospheric response to free convective instability, contributing to the highly banded structure that was observed.

Krishnamurti and Bedi (1988) provided global statistical corrections to a Kuo-type cumulus parameterization scheme in order to optimize the moisturing, heating and rainfall rates over different regions. Forecast comparison with the simpler kuo scheme showed a very marked improvement in the short range precipitation forecasts. Donner (1988) developed a method for initializing parameterizations for cumulus convection in numerical weather prediction models. The initialization adjusts the temperature and humidity fields such that a simplified version of the kuo cumulus parameterization yields diagnosed convective precipitation and vertical heating profiles, if a specified velocity field can support them. In an unfavourable velocity field, the initialization will yield the closest approach to diagnosed convective precipitation possible. The initialization minimises changes in the humidity and temperature fields while satisfying constraints imposed by the cumulus parameterization. Watson et al (1988) investigated the relationship of vertical motion to the occurrence of precipitation from convective and stratiform regions of a mesoscale convective system which developed on 20th to 21st May, 1979, over portions of Oklahoma, Texas and Arkansas (U.S.A.). They concluded that the vertical-motion profiles held the key to the precipitation characteristics over the storm-scale network.

In many sections of the world, there is a year-round or seasonal need for a simple tool which provides a quick check on the possibility of occurrence of convective weather activity. It is such a need that prompted Showalter, in 1946, to develop a Stability Index Computation Chart as an aid in anticipating the infrequent thunderstorms of Southern California. The chart computations were tested extensively especially in the southwestern part of the United States and later, in the Central and Western United States, and by Fawbush and Miller (1952) in Oklahoma. From all the tests it was concluded that the use of the Stability Index Computation Chart was highly significant but not a perfect forecast tool. Because of the time involved in using the chart, a simpler tool was sought. This led to Showalter's (1953) development of what came to be known as the

Showalter Index. This Index is widely used in the United States and is regularly transmitted at the end of teletype raob messages. The procedure for evaluating the Index is as follows; (1) using the 850mb dry-bulb temperature and dew point, the lifting condensation level (LCL) is determined; (2) from the LCL, a moist adiabat is followed and the temperature where it intersects the 500mb level is noted and (3) this temperature is subtracted from the dry-bulb temperature of the sounding at the 500mb level. From experience in the United States, it has been found that the following is the forecast expected on the basis of the Showalter Index, (1) when the Index value is 3°C or less then showers are probable and thunderstorms are possible; (2) when the value is 1°C to - 2°C, thunderstorms are probable; (3) when the value is - 3° or less then severe thunderstorms may occur and (4) when the value is - 6°C or less tornadoes are suspect. By 1953, the lowest value that had been noted was - 8°C at Shreveport on the 1500 GCT, March 21st, 1952 sounding, the date of the severe Arkansas tornado. Showalter concluded by saying that the Stability Index offers an extremely simple, thermodynamically sound and easily understood tool for making a very rapid check on thunderstorm possibilities. There are however, three limitations to the use of the Showalter Index; (1) the Index cannot be applied to areas with an elevation of more than 1000 metres; (2) the Index is unrepresentative, generally, when an inversion or frontal surface is present between the 850 and 500mb levels and (3) the Index does not take into account the effect of diurnal heating.

In the mid 1950's Galway developed the Lifted Index. This is a modification of the Showalter Index which takes into account the effect of diurnal heating and may be applied to areas over 1000 metres above mean sea level. The procedure for evaluating the Index is as folows; (1) the mean mixing ratio for the lower 100mbs is determined using the equal area method and a maximum temperature is forecasted; (2) the LCL is located using the mean mixing ratio and the forecast maximum temperature; (3) the moist adiabat from the LCL is followed up to the 500mb level and the temperature is noted and (4) this temperature is subtracted from the dry-bulb temperature of the sounding at the 500mb level. Like the Showalter Index, the less the value of the Lifted Index the greater is the potential for development of thunderstorms and showers. Another Index being used in the United States is the Best Lifted Index which was developed by Fujita (WMO and NOAA, 1989). This involves the computation of the Lifted Index for two or more points in the layer between the surface and 1600 metres above. The most unstable value of the Lifted Indices is then the Best Lifted Index. Fujita noted that a Lifted Index computed from a fixed level, such as the surface, might misrepresent the stability of the airmass. This is because the base of an up-draft or unstable layer will vary from point to point in the lower troposphere.

Another Index being used in the United States is the Model Lifted Index. The computation procedure uses parameters available at initial and forecast times. The values of this Index are transmitted in the Forecasts for the United States (FOUS) bulletins. The computation procedure involves use of the boundary layer mean temperature and relative humidity to determine the dew point and temperature of a parcel of air at 25mb above the model terrain at each of the grid points. Parcels at the mid-point of boundary layer are lifted first dry adiabatically to saturation and then moist adiabatically to the 500mb level. The resultant temperatures at the 500mb level are compared to the initialized (or forecast) 500mb level temperatures at each grid point to give the initial and forecast Model Lifted Index. The initial or forecast temperature at 500mb minus the parcel temperature is the Model Lifted Index. This Index can be interpreted as one similar to a surface based Lifted Index.

There are two other Stability Indices being used in the United States. These are the "K" Index and the "Total Totals" Index. The "K" Index, which was first proposed by Bailey in 1955, is a measure of thunderstorm potential based on the vertical temperature lapse rate, moisture content of the lower atmosphere and the vertical extent of the moist layer (George, 1960). The temperature difference between the 850mb and 500mb is used to parameterize the vertical temperature lapse rate. The 850mb dew-point temperature provides information on the moisture content of the lower atmosphere. The vertical extent of the moist layer is represented by the 700mb temperature-dew point depression. This Index is derived arithmetically and does not require a plotted sounding. The procedure for evaluating the "K" Index is as follows; K = (850mb temperature-500mb temperature) + 850mb dew-point temperature - 700mb temperature-dew point depression. With this Index, the higher the positive number, the greater is the likelibood of thunderstorm development. It has been observed that the "K" Index is also important in forecasting heavy rains. However, the Index cannot be reliably computed for mountain stations.

The "Total Totals" Index was introduced by Miller in 1972 for use in identifying potential areas of thunderstorm development. "Total Totals" is actually the sum of two other convective Indices, "Vertical Totals" and "Cross Totals". "Vertical Totals" = 850mb temperature - 500mb temperature. This value expresses the temperature lapse rate between two constant pressure surfaces.

"Cross Totals" = 850mb dew-point temperature - 500mb temperature. "Total Totals" = "Vertical Total" + "Cross Totals" = (850mb temperature + 850mb dew-point temperature) - 2 (500mb temperature). The higher the positive number, the greater the likelihood of thunderstorm or showers development. Like the "K" Index, this Index does not require a plotted sounding. Observations in the United States have shown that the "Vertical Totals" correlate best with thunderstorm activity in areas where thunderstorms are orographic or airmass in nature.

It has already been mentioned that there is currently one Stability Index in use in the Nairobi and surrounding area. The Index is computed using a procedure very similar to that of the Lifted Index used in the United States. The reliability of this Index in the area of study is not known as no attempt has so far been made to test its forecasting skill. Also being used in the area of study is the convection (or critical) temperature which is evaluated from the 2300z sounding. It is used as a forecasting guide in such a way that if the forecast maximum temperature exceeds it, then convective developments are expected. Like the Stability Index, the reliability of the convection temperature criterion is yet to be evaluated.

# CHAPTER II

## 2. DATA AND METHODOLOGY

### 2.1 SOURCE AND TYPE OF DATA

All the data used in the study was obtained from the Kenya Meteorological Department. It includes upper air data of the dry-bulb temperature, dew-point temperature and relative humidity at various pressure levels obtained from the night (2300z) radiosonde soundings for the Nairobi station. In addition, it includes the daily weather observations made at three observatories in the area of study. These are, the Kenya Meteorological Department Headquarters (Dagoretti Corner), Jomo Kenyatta International Airport and Wilson Airport Observatories. The period of study is from 1st January, 1988 to 31st December, 1990. However, there was some missing data which, unfortunately, could not be obtained whatsoever. On 21st September, 1988, two sondes were released but both failed due to interferences. No ascents were done on 4th and 5th October, 1988, due to lack of balloons. There was no ascent on 7th October, 1988, because of the power failure from 9.00 p.m. to 6.30 a.m (local time) the following day. Also on 11th October, 1988, the ascent failed. In 1989, there were no ascents done from 1st March to 13th June because of the delay in receiving some necessary equipment that had been ordered from abroad. This means that the soundings used in the study were for a total of 976 days.

## 2.2.0 METHODOLOGY

Basically five different Stability Indices have been used but together with their modifications a total of 23 Stability Indices have been developed and tested. The procedure for evaluating the various Indices is illustrated in this section.

### 2.2.1 THE AREA INDEX (AI)

Since the tropical atmosphere is usually generally conditionally unstable and since radiational surface heating is a key factor in initiating convection in the area of study, it is important to develop a Stability Index based on the amount of heat energy that should be supplied by radiational surface heating in order to establish a dry-adiabatic lapse rate in the atmospheric layer below the Convection Condensation Level (CCL). This is a necessary condition for convection to occur in such an atmosphere. The lowest surface temperature that is required in order to initiate the formation of convective clouds as a result of radiational surface heating is called the convection temperature.

Using the parcel method, the vertical

stability of the atmosphere may be estimated by assuming that an air parcel is displaced vertically from its initial position without mixing with the environment which is assumed to be in hydrostatic equilibrium. This implies that a balance of forces in the air surrounding the parcel exists between the vertical component of the pressure gradient force and of gravity. Considering these forces per unit mass and the hydrostatic equation gives

$$0 = -g - \frac{1}{\rho} \frac{\partial p}{\partial z} \quad \ldots\ldots\ldots \quad (1)$$

For the air parcel which is not in hydrostatic equilibrium, the resultant of the two forces will give the parcel a vertical acceleration according to Newton's second law, i.e,

$$\frac{dw}{dt} = - g - \frac{1}{\rho'} \frac{\partial p'}{\partial z} \quad \ldots\ldots\ldots \quad (2)$$

where g is the acceleration due to gravity, w is the vertical velocity of the displaced air parcel and, $\rho'$ and $p'$ are its density and pressure respectively.

By assuming that the pressure acting on the accelerating parcel is always adjusted to that of the environment at the same level (i.e, that $p' = p$), the pressure gradient force may be eliminated between equations (1) and (2) to give

$$\frac{dw}{dt} = g\,\frac{(\rho - \rho')}{\rho'} \qquad \ldots\ldots\ldots \qquad (3)$$

Upon subsitution from the equation of state for moist air ($p = \rho R_d T_v$) gives

$$\frac{dw}{dt} = g\left(\frac{T_v' - T_v}{T_v}\right) \qquad \ldots\ldots\ldots \qquad (4)$$

where $T_v'$ and $T_v$ are the virtual temperatures of the air parcel and environment respectively.

Multiplying both sides of equation (4) by dz gives

$$\frac{dw}{dt}\,dz = g\left(\frac{T_v' - T_v}{T_v}\right)dz \qquad \ldots\ldots\ldots \qquad (5)$$

By changing operators on the left hand side of equation (5) and replacing dz by $-\frac{1}{g}\frac{dp}{\rho}$ from the hydrostatic equation on the right hand side gives

$$\frac{dz}{dt}\,dw = -g\left(\frac{T_v' - T_v}{T_v}\right)\frac{dp}{g\rho} \qquad \ldots\ldots\ldots \qquad (6)$$

Since $\frac{dz}{dt} = w$ and $\rho = \frac{p}{R_d T_v}$ (from the equation of state for moist air), equation (6) may be re-written as

$$w\,dw = -R_d(T_v' - T_v)\frac{dp}{p} \qquad \ldots\ldots\ldots \qquad (7)$$

Now from differential calculus, $\frac{dp}{p} = d(\ln p)$ and $d(w^2) = d(w.w) = wdw + wdw = 2wdw$ implying that

$$wdw = \frac{d(w^2)}{2}$$

and therefore equation (7) may be written as

$$\frac{d(w^2)}{2} = -R_d(T_v' - T_v)\,d(\ln p) \qquad \ldots\ldots\ldots \qquad (8)$$

Integrating equation (8) for a finite displacement between two pressure levels (say $p_1$ to $p_2$) gives

$$\frac{w_2^2 - w_1^2}{2} = -R_d \int_1^2 (T'_v - T_v)\, d(\ln p) \qquad \ldots\ldots\ldots \quad (9)$$

or

$$\frac{w_2^2 - w_1^2}{2} = R_d(\bar{T}'_v - \bar{T}_v)\ln\left(\frac{p_1}{p_2}\right) \qquad \ldots\ldots\ldots \quad (10)$$

where $w_2$ and $w_1$ are the vertical velocities of a parcel of air of unit mass at pressure levels $p_2$ and $p_1$ respectively, and $\bar{T}'_v$ and $\bar{T}_v$ are the mean virtual temperatures of the air parcel and environment respectively between levels $p_1$ and $p_2$.

The term on the left hand side of equation (10) represents the kinetic energy change or work done on the air parcel per unit mass in moving from level $p_1$ to $p_2$ and the right hand side represents the corresponding area enclosed on a thermodynamic diagram (e.g., Tephigram) between the p-$T_v$ curves of the parcel and environment. Thus, the energy required (or work done) to lift an air parcel from level $p_1$ to $p_2$ is proportional to the corresponding area on a thermodymamic diagram. This implies that an approximation of this area (or its representative) should give an appropriate Stability Index for the layer between levels $p_1$ and $p_2$. Since an Index is supposed to be used for operational purposes, it should be quick to compute. For this reason, instead of using the virtual temperatures, the observed temperatures may be used directly. After all, the difference between the two is insignificant in this case, considering that, approximately, $T_v = T(1+0.61r)$ where r is the mixing ratio which is almost always below 20g/kg (0.02 kg/kg) for a tropical continental airmass. During the period of study the highest value was 19.3 g/kg (0.0193 kg/kg) on 22nd April, 1990 and the maximum temperature for day was 24°C. Thus, the corresponding virtual temperature was 24.28°C.

The evaluation of the Area Index from the 2300z sounding is illustrated in figure (1).

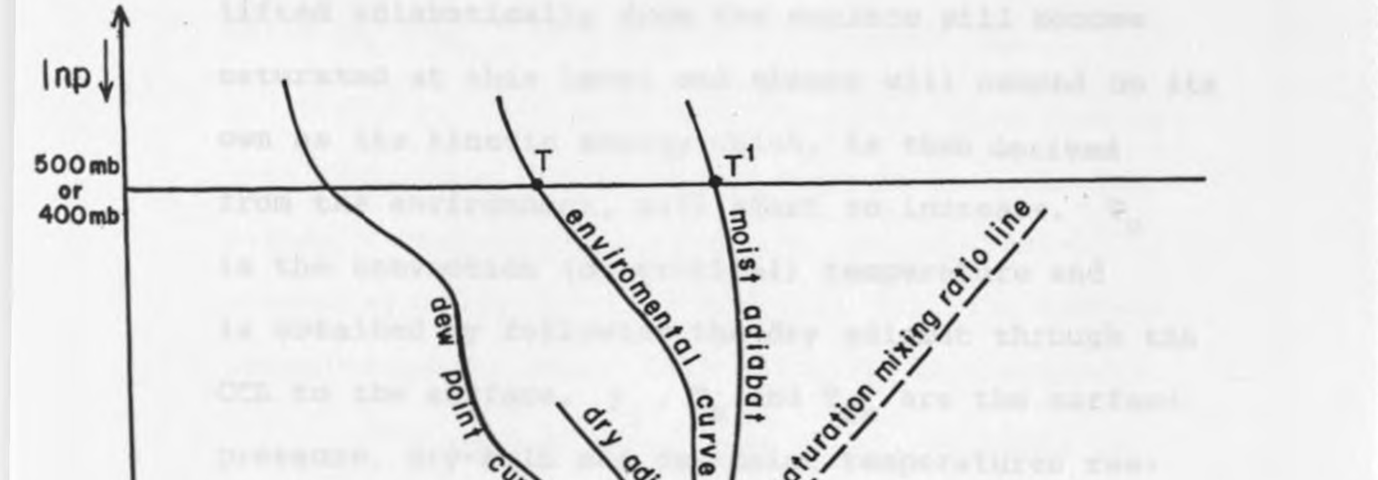


Figure 1: Evaluation of the Area and Lifted Indices from a thermodynamic diagram.

The shaded area is the one to be estimated. The convection condensation level (CCL) is found by locating the point of intersection between the mean saturation mixing ratio line for the first 100mb layer from the surface and the environmental curve. To approximate the mean mixing ratio, the area marked A should be equal to that marked B in figure (1). The lowest 100mbs are used because they give an approximation of the modifications due to the heating and mixing resulting from the diurnal insolation. At the CCL, the Lifting Condensation Level (LCL) coincides with the Level of Free Convection (LFC). A parcel of air lifted adiabatically from the surface will become saturated at this level and thence will ascend on its own as its kinetic energy which, is then derived from the environment, will start to increase. $T_c$ is the convection (or critical) temperature and is obtained by following the dry adiabat through the CCL to the surface. $p_1$, $T_s$ and $T_{ds}$ are the surface pressure, dry-bulb and dew-point temperatures respectively. $T_1$ and $T_1'$ are taken half way of the lowest 100mbs from the surface while $T_2$ and $T_2'$ are taken at the level 100mbs from the surface. The quantities with a prime (') refer to the air parcel and correspond to those of the environmental air, which are without a prime.

Let $\overline{T}$ and $\overline{T}'$ respectively, be the environmental and ascending air parcel mean temperatures between the surface and the CCL.

Then,

$$\overline{T} = \frac{T_s+T_1+T_2+T_{CCL}}{4} \quad \text{and} \quad \overline{T}' = \frac{T_c+T_1'+T_2'+T_{CCL}'}{4}$$

It should be noted that $T_{CCL} = T_{CCL}'$.

In the event of the CCL being situated below the 100mb level from the surface, the mean temperatures are given by

$$\overline{T} = \frac{T_s + T_1 + T_{CCL}}{3} \quad \text{and} \quad \overline{T}' = \frac{T_c + T_1' + T_{CCL}'}{3}$$

The Area Index (AI) is then defined as follows:

$$AI = (\overline{T}'-\overline{T})\ln(\frac{p_1}{p_2}) \quad \ldots\ldots\ldots \quad (11)$$

where $p_2 = p_{CCL}$ as indicated in figure (1)

It should be mentioned that the Area Index does not give the actual value of the area in question but rather a respresentative of it. It is clear by comparing equations (10) and (11) that the two are proportional to each other since $R_d$ is a constant.

The smaller the value of AI, the less is the energy required to lift a parcel of air of unit mass from the surface to the CCL and hence the greater should be the probability of the occurence of convective weather activities. Also the lower the CCL, the smaller will be the convection temperature ($T_c$) and consequently the area in question and value of AI. However, the environmental lapse rate has a greater influence on the size of the area (and thus the value of the Index) than the convection temperature. It should also be noted that the higher the moisture content of the lowest 100mb layer, the closer will be the dry-bulb and dew-point temperature curves and hence the lower the CCL and consequently, the less the computed value of the Index.

The Area-Humidity Index (AHI)

This is a modified Area Index which incorporates the mean relative humidity ($\overline{U}$) of the environmental layer between the 700mb and 500mb levels and is evaluated as follows:

Let the relative humidity at the 700mb, 600mb and 500mb levels be $U_{700}$, $U_{600}$ and $U_{500}$ respectively and let $\overline{U}$ be defined as

$$\overline{U} = \frac{U_{700} + U_{600} + U_{500}}{3} \quad \ldots\ldots\ldots \quad (12)$$

$$\text{Then } AHI = 100\ AI - \overline{U} \quad \ldots\ldots\ldots \quad (13)$$

The less the value of AHI, the more probable should be the occurrence of convective activities. It is clearly seen that the smaller the value of AI and the larger that of $\overline{U}$, the less is the value of AHI and hence the greater the likelihood of convective weather developments. It's noteworthy that the relative humidity below the 700mb level is not included in the evaluation of $\bar{U}$. This is due to the fact that it has already been implicitly incorporated in the evaluation of AI.

THE AREA-DEW POINT DEPRESSION INDEX (ADI)

This is a modification of AI that takes into account the vertical extent of the moist layer and is evaluated as follows: Let $T_{650}$ and $T_{600}$ be the environmental dry-bulb temperatures at the 650mb and 600mb levels respectively and $T_{d650}$ and $T_{d600}$ be the corresponding dew-point temperatures. Let $D_{650}$ and $D_{600}$ denote the temperature-dew point depressions at the 650mb and 600mb levels respectively i.e,

$$D_{650} = T_{650} - T_{d650} \text{ and } D_{600} = T_{600} - T_{d600}$$

Then the mean value of the depressions ($\bar{D}$) is given by

$$\bar{D} = \frac{D_{650} + D_{600}}{2} \qquad \ldots\ldots\ldots \qquad (14)$$

This has been used as a measure of the vertical extent of the moist layer. An average value has been used because it was noted in the course of study that the two depressions ($D_{650}$ and $D_{600}$) are usually quite different and in fact a mean value produced better results than either used individually.

The Index is then defined as

$$ADI = AI + \frac{\bar{D}}{10} \qquad \ldots\ldots\ldots \qquad (15)$$

The smaller the value of both AI and $\overline{D}$, the less will be the value of ADI and therefore the greater the likelihood of occurrence of convective weather activities. It should be noted that the more humid the middle levels of the atmoshere, the closer is the dry-bulb and dew-point temperature curves and hence the less the value of $\overline{D}$ and consequently, that of ADI.

2.2.2 THE LIFTED INDEX (LI)

This is the Index currently being used for forecasting purposes in the Nairobi and surrounding area. Its evaluation is illustrated in figure (1). The CCL is obtained by using the equal area method as already demonstrated in the evaluation of the Area Index. As already mentioned, the equal area method improves the results (particularly in locating the CCL) as it approximates the modifications in the mixing ratio of the first 100mb layer from the surface, caused by the heating and mixing resulting from diurnal insolation. The temperature at the point of intersection of the moist adiabat through the CCL and the 500mb or 450mb isobar is noted. The Lifted Index is obtained by subtracting this temperature from the environmental temperature at the 500mb or 450mb level.

Thus $LI_1 = T_{500} - T'_{500}$ ........ (16)

The suffix 1 has been used in this case to specify that the level at which the temperatures of the ascending (or lifted) air parcel and the environment are being compared is 500mb. Similarly, suffix 2 has been used in reference to the 450mb level.

Thus $LI_2 = T_{450} - T'_{450}$ ....... (17)

The purpose of evaluating the Index for both the 500mb and 450mb levels has been to determine the one more appropriate for use in the Nairobi area. It is clear from equations (16) and (17) that the warmer the ascending air parcel compared to the environment at the 500mb or 450mb level, the smaller will be the value of the Lifted Index and the more likely will be the occurrence of convective weather activities. On the other hand, the warmer the environment in comparison to the air parcel, the less likely will be the occurrence of the activities.

THE LIFTED-HUMIDITY INDEX (LHI)

This is a modified Lifted Index which incorporates the mean relative humidity of the environmental layer between the 700mb and 500mb levels and is evaluated as follows:

$$LHI_1 = LI_1 - \frac{\overline{U}}{20} \quad \text{........} \quad (18)$$

and similarly for the 450mb level

$$LHI_2 = LI_2 - \frac{\overline{U}}{20} \quad \text{.......} \quad (19)$$

It is clear from equations (18) and (19) that the smaller the value of $LI_1$ or $LI_2$ and the greater that of $\overline{U}$, the smaller will be that of $LHI_1$ or $LHI_2$ and consequently, the greater the likelihood of convective weather developments.

THE LIFTED-DEW POINT DEPRESSION INDEX (LDI)

This is a modification of the Lifted Index that takes into account the vertical extent of the moist layer. It is defined as follows:

$$LDI_1 = LI_1 + \frac{\overline{D}}{2} \quad ....... \quad (20)$$

for the 500mb level and

$$LDI_2 = LI_2 + \frac{\overline{D}}{2} \quad ...... \quad (21)$$

for the 450mb level.

The smaller the value of the Lifted Index and $\overline{D}$, the smaller is that of $LDI_1$ or $LDI_2$ and the greater is the likelihood of the occurrence of convective weather activities.

2.2.3 THE SHOWALTER INDEX (SI)

This is the Showalter Index being used in the United States except for the slight modification in its evaluation. Instead of using 850mb as the reference level, the 750mb level has been used. The modification has been done in order to suit the altitude of the Nairobi area.

The method considers a parcel of air being lifted dry-adiabatically from 750mbs to the Lifting Condensation Level (LCL) i.e, to saturation and then moist-adiabaticlaly to the 500mb or 450mb level. The temperature of the parcel is then compared to that of the environment. The procedure is illustrated in Figure (2).

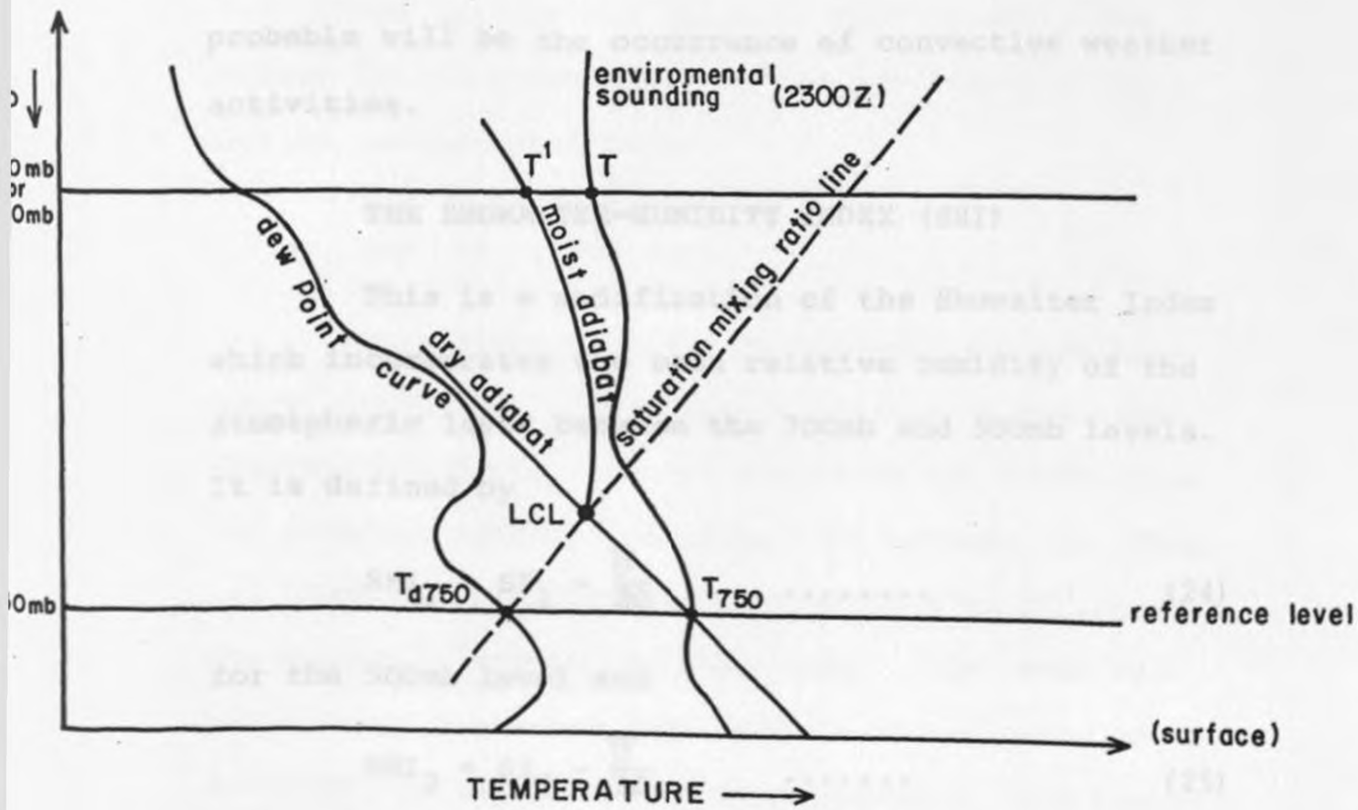


Figure 2: Evalution of the Showalter Index from the the 2300z sounding on a thermodynaic diagram.

From figure (2), the Showalter Index is given by

$$SI_1 = T_{500} - T'_{500} \quad \ldots\ldots\ldots \quad (22)$$

where $T_{500}$ and $T'_{500}$ are the temperatures of the environment and air parcel respectively at the 500mb level.

Similarly for the 450mb level,

$$SI_2 = T_{450} - T'_{450} \quad \ldots\ldots\ldots \quad (23)$$

Like the Lifted Index, the smaller the computed value of the Showalter Index, the more probable will be the occurrence of convective weather activities.

THE SHOWALTER-HUMIDITY INDEX (SHI)

This is a modification of the Showalter Index which incorporates the mean relative humidity of the atmospheric layer between the 700mb and 500mb levels. It is defined by

$$SHI_1 = SI_1 - \frac{\overline{U}}{20} \quad \ldots\ldots\ldots \quad (24)$$

for the 500mb level and

$$SHI_2 = SI_2 - \frac{\overline{U}}{20} \quad \ldots\ldots\ldots \quad (25)$$

for the 450mb level.

The smaller the value of $SHI_1$ or $SHI_2$, the greater is the likelihood of the development of convective weather activities.

THE SHOWALTER-DEW POINT DEPRESSION INDEX (SDI)

This is a modification of the Showalter Index which incorporates the vertical extent of the moist layer. It is defined by

$$SDI_1 = SI_1 + \frac{\overline{D}}{2} \quad \ldots\ldots \quad (26)$$

for the 500mb level and

$$SDI_2 = SI_2 + \frac{\overline{D}}{2} \quad \ldots\ldots\ldots \quad (27)$$

for the 450mb level.

The smaller the value of $SDI_1$ or $SDI_2$, the greater is the probability of the occurrence of convective weather activities.

2.2.4 THE "K" INDEX (KI)

This Index is based on the vertical environmental lapse rate, the moisture content of the lower atmosphere and the vertical extent of the moist layer. The sounding temperature difference between the 750mb and 500mb or 450mb levels has been used to parameterize the vertical temperature lapse rate. The 750mb dew-point temperature has been used as an indicator of the moisture content of the lower atmosphere. The higher the dew-point temperature, the more the moisture content and vice-versa. The vertical extent of the moist layer has been represented by the mean temperature-dew point depression between the 650mb and 600mb levels

($\overline{D}$) as given by equation (14). The "K" Index is derived arithmetically and does not require a plotted sounding. With this Index, the greater the computed value, the more is the likelihood of the occurrence of convective weather activities. The procedure for evaluating the "K" Index is summarized as follows:

$$KI_1 = T_{750} - T_{500} + T_{d750} - \overline{D} \quad ....... \quad (28)$$

where $T_{750}$ and $T_{d750}$ are the dry-bulb and dew-point temperatures respectively of the sounding at the 750mb level.

Similarly, for the 450mb level,

$$KI_2 = T_{750} - T_{450} + T_{d750} - \overline{D} \quad ....... \quad (29)$$

It is clear from equations (28) and (29) that the warmer the lower levels and the cooler the upper levels, the greater will be the computed value of the Index. Also the more moist the lower levels, the higher is the dew-point temperature and consequently, the larger the computed value of the Index. Likewise the more moist the middle levels, the smaller will be the value of $\overline{D}$ and by equations (28) and (29), the larger will be the value of the Index.

2.2.5 THE TOTAL TOTALS INDEX (TTI)

This Index is actually a sum of two other convective Indices, the Vertical Totals (VT) and the

Cross Totals (CT). The Vertical Totals expresses the vertical temperature lapse rate between two constant pressure levels (in this case between the 750mb and 500mb or 450mb levels) while the Cross Totals combines a measure of low-level moisture with temperatrues aloft. It is clear that the higher the dew-point temperature (and hence moisture content) in the lower layer and the lower the temperatures aloft, the more favourable will be the development of convective weather acitivities. The Cross Totals is based on this principle. The Total Totals Index is evaluated as follows:

$$VT_1 = T_{750} - T_{500} \quad \text{and}$$

$$CT_1 = T_{d\ 750} - T_{500}$$

$$TTI_1 = VT_1 + CT_1$$

i.e, $$TTI_1 = T_{750} + T_{d750} - 2T_{500} \quad \ldots\ldots\ldots \quad (30)$$

and similarly, for the 450mb level,

$$TTI_2 = T_{750} + T_{d750} - 2T_{450} \quad \ldots\ldots\ldots \quad (31)$$

The Total Totals Index is derived arithmetically and does not require a plotted sounding. The greater the computed value of the Index, the greater is the likelihood of occurrence of convective weather activities.

THE TOTAL TOTALS-HUMIDITY INDEX (TTHI)

This is a modification of TTI which incorporates the effect of the mean relative humidity between the 700mb and 500mb levels. The Index is evaluated as follows:

$$TTHI_1 = TTI_1 + \frac{\overline{U}}{2} \quad ....... \quad (32)$$

in case of the 500mb level and

$$TTHI_2 = TTI_2 + \frac{\overline{U}}{2} \quad ....... \quad (33)$$

for the 450mb level.

The greater the values of $TTI_1$ or $TTI_2$ and $\overline{U}$, the greater the computed value of the Index and thus the likelihood of convective developments.

THE TOTAL TOTALS-DEW POINT DEPRESSION INDEX (TTDI).

This is a modification of the Total Totals Index which incorporates the vertical extent of the moist layer. It is evaluated as follows:

$$TTDI_1 = TTI_1 - \overline{D} \quad ....... \quad (34)$$

for the 500mb level and

$$TTDI_2 = TTI_2 - \overline{D} \quad ....... \quad (35)$$

for the 450mb level

The larger the computed value of the Index, the greater should be the probability of the occurrence of convective weather activities.

## 2.3.0 ANALYSIS METHODS

The values of all the Indices were computed on a daily basis for the whole period of study using the procedures illustrated in the previous section. The values were adjusted in order to find the optimum thresholds that correlated best with the observed late afternoon or early evening convective weather activities on the day that followed each sounding. The weather activities were, in particular, rain or showers and thunderstorms.

In order to estimate the onset of convective weather activities, a method that compares the time lag(TL), in hours, between the attainment of the convection temperature ($T_c$) and the initial formation of afternoon cumulonimbus clouds (CBs) was used. Frequency distribution tables 1, 2 and 3 show the comparisons for the years 1988, 1989 and 1990 respectively and table 4, for the whole period of study. From these tables, it was observed that at least 50% of all the CBs occurred after a time lag of 2 to 4 hours and that at least 85% occurred after a time lag of at least one hour. Those which occurred before or less than an hour after the attainment

TABLE 1: FREQUENCY DISTRIBUTION OF THE TIME LAG(TL) BETWEEN THE ATTAINMENT OF THE CONVECTION TEMPERATURE ($T_C$) AND THE INITIAL FORMATION OF CBS DURING 1988.

| MONTH | TL<0 (days) | TL=0 (days) | TL=1 (days) | TL=2 (days) | TL=3 (days) | TL=4 (days) | TL=5 (days) | TL>5 (days) | $T_C > T_{max}$ (days) | CBs (Total) | Total (days) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan. | 1 | 3 | 3 | 3 | 6 | 4 | 1 | 1 | 5 | 27 | 31 |
| Feb. | 2 | 0 | 1 | 5 | 4 | 4 | 1 | 1 | 3 | 21 | 29 |
| Mar. | 3 | 2 | 2 | 8 | 6 | 3 | 2 | 2 | 2 | 30 | 31 |
| Apr. | 2 | 6 | 3 | 7 | 5 | 4 | 1 | 0 | 2 | 30 | 30 |
| May | 2 | 0 | 4 | 8 | 3 | 2 | 3 | 2 | 3 | 27 | 31 |
| Jun. | 1 | 0 | 0 | 1 | 1 | 1 | 2 | 0 | 8 | 14 | 20 |
| Jul. | 0 | 0 | 1 | 3 | 2 | 0 | 0 | 0 | 3 | 9 | 31 |
| Aug. | 3 | 0 | 1 | 3 | 1 | 4 | 1 | 0 | 4 | 17 | 31 |
| Sept. | 0 | 2 | 1 | 3 | 2 | 2 | 2 | 1 | 8 | 21 | 29 |
| Oct. | 0 | 2 | 4 | 5 | 6 | 2 | 6 | 0 | 0 | 25 | 27 |
| Nov. | 2 | 2 | 2 | 4 | 8 | 5 | 4 | 3 | 0 | 30 | 30 |
| Dec. | 4 | 4 | 1 | 5 | 3 | 2 | 3 | 6 | 2 | 30 | 31 |
| Annual Total | 20 | 21 | 23 | 55 | 47 | 33 | 26 | 16 | 40 | 281 | 351 |
| % of total CBS | 7% | 7% | 8% | 20% | 17% | 12% | 9% | 6% | 14% | | |

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TABLE 2: FREQUENCY DISTRIBUTION OF THE TIME LAG(TL) BETWEEN THE ATTAINMENT OF THE CONVECTION TEMPERATURE($T_c$) AND THE INITIAL FORMATION OF CBS DURING 1989

| MONTH | TL<0 (days) | TL=0 (days) | TL=1 (days) | TL=2 (days) | TL=3 (days) | TL=4 (days) | TL=5 (days) | TL>5 (days) | $T_c > T_{max}$ (days) | CBS (Total) | Total (days) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan | 4 | 3 | 3 | 4 | 6 | 2 | 2 | 4 | 2 | 30 | 31 |
| Feb. | 1 | 2 | 1 | 5 | 5 | 4 | 2 | 2 | 1 | 23 | 28 |
| Mar. | - | - | - | - | - | - | - | - | - | - | - |
| Apr. | - | - | - | - | - | - | - | - | - | - | - |
| May | - | - | - | - | - | - | - | - | - | - | - |
| Jun. | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 6 | 17 |
| Jul. | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 2 | 1 | 7 | 31 |
| Aug. | 1 | 0 | 2 | 1 | 0 | 1 | 1 | 1 | 3 | 10 | 31 |
| Sept. | 3 | 1 | 0 | 2 | 4 | 2 | 3 | 3 | 2 | 20 | 30 |
| Oct. | 1 | 2 | 4 | 4 | 5 | 5 | 0 | 4 | 4 | 29 | 31 |
| Nov. | 5 | 2 | 3 | 3 | 4 | 6 | 2 | 0 | 4 | 29 | 30 |
| Dec. | 1 | 2 | 9 | 3 | 6 | 7 | 1 | 1 | 1 | 31 | 31 |
| Annual total | 16 | 13 | 23 | 24 | 32 | 27 | 13 | 18 | 19 | 185 | 260 |
| % of total CBS | 9% | 7% | 12% | 13% | 17% | 15% | 7% | 10% | 10% | | |

TABLE 3: FREQUENCY DISTRIBUTION OF THE TIME LAG(TL) BETWEEN THE ATTAINMENT OF THE CONVECTION TEMPERATURE($T_c$) AND THE INITIAL FORMATION OF CBS DURING 1990.

| MONTH | TL<O (days) | TL=O (days) | TL=1 (days) | TL=2 (days) | TL=3 (days) | TL=4 (days) | TL=5 (days) | TL>5 (days) | $T_c > T_{max}$ (days) | CBS (Total) | Total (days) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan | 4 | 5 | 2 | 4 | 1 | 7 | 1 | 3 | 1 | 28 | 31 |
| Feb. | 2 | 3 | 2 | 6 | 4 | 6 | O | 1 | 4 | 28 | 28 |
| Mar. | 2 | 3 | 6 | 8 | 8 | 2 | 2 | O | O | 31 | 31 |
| Apr. | 5 | 4 | 3 | 4 | 8 | 1 | O | O | 4 | 29 | 30 |
| May | 1 | 2 | 2 | 6 | 9 | 6 | 3 | O | O | 29 | 31 |
| Jun. | O | 2 | O | O | 4 | 1 | 2 | 4 | 1 | 14 | 30 |
| Jul. | O | O | 4 | 4 | 1 | 1 | 1 | O | 2 | 13 | 31 |
| Aug. | 1 | O | 1 | 3 | O | 2 | 1 | O | O | 8 | 31 |
| Sept. | O | 1 | 3 | 4 | 2 | 2 | O | 3 | O | 15 | 30 |
| Oct. | 2 | 2 | 1 | 4 | 5 | 7 | 1 | 6 | O | 28 | 31 |
| Nov. | O | 3 | 5 | 4 | 2 | 7 | 3 | O | 6 | 30 | 30 |
| Dec. | O | 2 | 3 | 9 | 12 | 3 | O | O | 2 | 31 | 31 |
| Annual total | 17 | 27 | 32 | 56 | 56 | 45 | 14 | 17 | 20 | 284 | 365 |
| % of total CBS | 6% | 9% | 11% | 20% | 20% | 16% | 5% | 6% | 7% | | |

TABLE 4: FREQUENCY DISTRIBUTION OF THE TIME LAG(TL) BETWEEN THE ATTAINMENT OF THE CONVECTION TEMPERATURE($T_c$) AND THE INITIAL FORMATION OF CBS DURING 1988, 1989 AND 1990.

| MONTH | TL<O (days) | TL=O (days) | TL=1 (days) | TL=2 (days) | TL=3 (days) | TL=4 (days) | TL=5 (days) | TL>5 (days) | $T_c > T_{max}$ (days) | CBS (Total) | Total (days) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan | 9 | 11 | 8 | 11 | 13 | 13 | 4 | 8 | 8 | 85 | 93 |
| Feb. | 5 | 5 | 4 | 16 | 13 | 14 | 3 | 4 | 8 | 72 | 85 |
| Mar. | 5 | 5 | 8 | 16 | 14 | 5 | 4 | 2 | 2 | 61 | 62 |
| Apr. | 7 | 10 | 6 | 11 | 13 | 5 | 1 | O | 6 | 59 | 60 |
| May | 3 | 2 | 6 | 14 | 12 | 8 | 6 | 2 | 3 | 56 | 62 |
| Jun. | 1 | 3 | O | 2 | 6 | 2 | 5 | 5 | 10 | 34 | 67 |
| Jul. | O | O | 6 | 8 | 4 | 1 | 2 | 2 | 6 | 29 | 93 |
| Aug. | 5 | O | 4 | 7 | 1 | 7 | 3 | 1 | 7 | 35 | 93 |
| Sept. | 3 | 4 | 4 | 9 | 8 | 6 | 5 | 7 | 10 | 56 | 89 |
| Oct. | 3 | 6 | 9 | 13 | 16 | 14 | 7 | 10 | 4 | 82 | 89 |
| Nov. | 7 | 7 | 10 | 11 | 14 | 18 | 9 | 3 | 10 | 89 | 90 |
| Dec. | 5 | 8 | 13 | 17 | 21 | 12 | 4 | 7 | 5 | 92 | 93 |
| Grand total | 53 | 61 | 78 | 135 | 135 | 105 | 53 | 51 | 79 | 750 | 976 |
| % of total CBS | 7% | 8% | 10% | 18% | 18% | 14% | 7% | 7% | 11% | | |

of $T_c$ may be attributed to any other rain producing features such as the horizontal wind convergence. Bearing in mind that there is usually a time lag between the initial formation of CBs and release of precipitation, it was decided that any precipitation which occurred during the period from two hours after the attainment of $T_c$ to 1600z (7.00 p.m. local time) may be attributed to convection. The latent heat of condensation, released by the convective processes, contributes to their sustainance and they may persist for several hours. After 1600z, cloud formation may be due to other factors e.g., horizontal wind convergence and radiative cooling in the atmosphere. Precipitation release may also result from the destablization brought about by cloud top radiative cooling. It was also observed that in about 10% of all the cases, CBs occurred yet the recorded environmental temperature had not reached $T_c$. This probably derives from the circumstance that the convection is released from overheated areas where the temperature is higher than that recovered by a screened and ventilated thermometer. Therefore $T_c$ may be reached while the recorded temperature indicates otherwise. Moreover, in most cases, where the recorded maximum daily temperature ($T_{max}$) was less than $T_c$ and yet convective weather activities occurred, the difference between the two temperatures was $1^{o}C$ and not more than $2.5^{o}C$ in all cases.

Threshold values were determined for each Stability Index as already stated. These are the limiting values below or above which convective weather activities are expected (or not expected) to occur. Two categories, A and B, of thresholds were set. The first (category A), gives the values below or above which no convective weather activities should be expected. These were set primarily on the basis that they should assist the forecaster by indicating to him or her the days when no much time and effort should be devoted to further analysis and other considerations. The threshold values in category B were set on the basis that they should reflect the actual probability (or likelihood) of the occurrence or non-occurrence of convective weather activities as accurately as possible. This way, the Indices could be used as independent forecasting tools when other forecasting guides are absent or unreliable and may also serve as comparisons or compliments to the guides. In any case, they should be useful to the forecaster by alerting him or her to those soundings which should be examined more closely as well as highlighting the need to look at the other forecasting guides such as the surface and upper air charts, streamline charts, pressure tendency charts e.t.c. more carefully.

The forecasting skills of the individual Indices as well as the probability (or risk) of making either a type I or type II error expected when using them,were computed and used as guides in determining the reliability and predictability, and subsequently, the suitability of the Indices for use in the Nairobi and surrounding area. The Indices selected as most suitable were then tested by using the Chi-square goodness of fit test in order to establish how well their computed values correlated with the frequency of weather activities that occurred during the late afternoon or early evening on the corresponding days during 1988, 1989 and 1990. In addition, their goodness of fit was compared to that of the forecasting guides used in the Nairobi and surrounding area.

2.3.1 COMPUTATION OF FORECASTING SKILLS AND ERRORS

Let YY(Yes, Yes) represent the number of days when convective weather activities were expected, according to the computed value of a particular Index,and actually occurred.

Let NN(No,No) represent the number of days when convective weather activities were not expected, according to the computed Index value, and actually did not occur.

Let YN(Yes, No) represent the number days when convective weather activities were expected, according to the computed value of the Index, but did not occur.

Let NY(No, Yes) represent the number of days when convective weather activities were not expected, according to the computed value of the Index, but occurred.

Then the forecasting skill (FS) of an Index, expressed as a percentage, is given by

$$FS = \frac{\text{Number of correct predictions}}{\text{Total number of predictions made}} \times 100\%$$

$$\text{i.e,} \quad FS = \frac{YY + NN}{YY + NN + YN + NY} \times 100\% \quad \ldots\ldots\ldots \quad (36)$$

Making a type I error means that convective weather activities were not expected according to the computed value of the Index but occurred. The probability (or risk) of making atype I error (PTI) involved in using a particular Index, expressed as a percentage, is given by

$$PTI = \frac{\text{Number of days when convective weather activities were not expected but occurred}}{\text{Total number of days when convective weather activiteis were not expected}} \times 100\%$$

$$\text{i.e,} \quad PTI = \frac{NY}{NN + NY} \times 100\% \quad \ldots\ldots\ldots \quad (37)$$

Making a type II error means that convective weather activities were expected but did not occur. The probability of making a type II error (PTII) is thus given by

$$PTII = \frac{YN}{YY + YN} \times 100\% \quad \ldots\ldots \quad (38)$$

The three parameters FS, PTI and PTII were computed on a monthly basis and used in determining the suitability of each Index for use in the area of study.

For category A, the most important parameter is PTI since the primary objective in this category is to rule out the occurrence of convective weather activities i.e, to have NY(and thus PTI) equal to zero. So, the most suitable Indices in this category are those which minimise the risk of making a type I error. Inevitably, the minimization leads to an increase in the risk of making a type II error. However, the PTII is almost insignificant in this case given that the primary objective is to predict, as accurately as possible, the number of days (however few) when convective weather developments should not be expected. The forecasting skill (FS) is also important in this category though to a lesser degree than PTI. Of course if two or more Indices have the same PTI, then the one with a larger FS is more suitable. Perhaps the only importance of PTII in this category is in deciding the most suitable Index in the event of two or more Indices having equal values of both PTI and FS. In such a case, the one with a smaller PTII is preferred. In order to avoid subjectivity in determining the suitability of the Indices, a quantity called the Index Reliability

(IR) was defined and evaluated for each Index. The larger its value, the more suitable should be the Index. The quantity gives more weight to PTI while at the same time giving consideration to the importance of FS. The quantity is defined as follows:

$$IR = 100\ (FS - 3PTI) \quad \ldots\ldots \quad (39)$$

The numerical factor of 100 in equation (39) is necessary since FS and PTI are percentages (or fractions). The number 3 is a weighting factor which was arrived at after comparing with several others and found more representative. It is clear from equation (39) that the larger and smaller the values of FS and PTI respectively, the greater is the Index Reliability.

In selecting the most suitable Index during a given period e.g. month or season, the FS and PTI and subsequently, the IR were computed for the whole period in question and the Indices were assigned ranks indicative of their suitability. The ranks were assigned in ascending order starting with the one having the highest IR. Therefore, the smaller the rank, the more suitable should be the Index for use during the period in question.

In category B, all the 3 parameters FS, PTI and PTII are important. However, FS is the most important since the primary objective is to predict the actual probability or likelihood (rather than just the possibility) of the occurrence of convective weather activities. It is comparately easier to determine the suitability of the Indices in this category since it is clear that the larger the FS and smaller the PTI or PTII, the better should be the performance of a given Index. A quantity called the Index Predictability (IP) was defined as follows for the purpose of comparing the suitability of the various Indices;

$$IP = 100\ [FS - (\frac{TPI + TPII}{2})] \quad ....... \quad (40)$$

or $$IP = 100\ FS - 50(TPI + TPII) \quad ....... \quad (41)$$

It is clear from equation (41) that the larger the IP value, the more suitable should be the Index. In case two or more Indices have the same IP, the one with the largest FS should be more suitable.

## 2.3.2 THE CHI-SQUARE GOODNESS OF FIT TEST

The Indices selected as most suitable in category B were tested to find out how well the predictions based on their computed values correlated with the observed weather activities that occurred during the late afternoon or early evening on the corresponding days in 1988, 1989 and 1990 except where data was missing. This was accomplished by using the chi-square goodness of fit test and was done on a monthly basis. The procedure involved finding the number of days when precipitation or thunderstorms were predicted (expected), according to the computed Index values, and the days when they actually occurred (were observed) during each month. Also the number of days, when they actually never occurred, were determined. Using the same notation as in section 2.3.1, the procedure is as follows:

Number of days when precipitation or thunderstorms were predicted (expected) = YY + YN

Number of days when precipitation or thunderstorms occurred (were observed) = YY

Number of days when no precipitation or thunderstorms were predicted (expected) = NN + NY

Number of days when no precipitation or thunderstorms occurred (were observed) = NN.

Let E represent the expected frequency and O the observed. Then the computed chi-square value ($\chi_c^2$) is given by

$$\chi_c^2 = \frac{\sum (O - E)^2}{E} \qquad \ldots\ldots\ldots \quad (42)$$

$$\text{i.e,} \quad \chi_c^2 = \frac{[YY - (YY + YN)]^2}{YY + YN} + \frac{[NN - (NN + NY)]^2}{NN + NY}$$

$$\text{or} \quad \chi_c^2 = \frac{(YN)^2}{YY + YN} + \frac{(NY)^2}{NN + NY} \qquad \ldots\ldots\ldots \quad (43)$$

The computed value was then compared with the chi-square critical value using a level of significance of 0.05 (i.e, $\chi^2_{0.95}$ value). Since there are only two possible outcomes (the occurrence or non-occurrence), the critical value for one (i.e, 2-1) degree of freedom was used. Any Index was considered to have passed the goodness of fit test if

$$\chi^2_c < \chi^2_{0.95}$$

From standard tables, $\chi^2_{0.95}$ = 3.841 for one degree of freedom. Therefore an Index passed the test whenever

$$\chi^2_c < 3.841$$

2.3.3 COMPARISON BETWEEN THE PREDICTIONS BASED ON THE STABILITY INDICES AND THOSE BASED ON THE OTHER FORECASTING GUIDES

The comparisons were made by considering the computed chi-square values and predictability of the two, on a monthly basis, during the whole period of study. The chi-square values and predictability of the forecasting guides used in the Nairobi and surrounding area were computed using the routine daily weather forecast bulletins (WFB) for the whole period of study except where data was missing. The evaluation procedure was the same as that used for the Indices. The one with a lower Chi-square value or higher predictability was presumed more suitable.

2.3.4 THUNDERSTORM FORECASTING

An attempt was made to establish whether there are some Indices particularly more suitable than others in forecasting thunderstorms in the Nairobi and surrounding area. Similarly, the two categories already stated were used. Category A was used to find the Indices most suitable for ruling out the possibility of occurrence of thunderstorms and B, those most suitable in predicting the actual probability of occurrence or non-occurrence of thunderstorms. In category A, the Index Reliability was computed for each Index and used in determining their suitability as already discussed in section 2.3.1. In category B, a quantity similar to the Index Predictability (IP), called the Thunderstorm Forecasting Potential (TFP), was defined as follows:-

$$TFP = 100\left[FS - \frac{(PTI + PTII)}{2}\right] \quad \ldots\ldots\ldots \quad (44)$$

or

$$TFP = 100\,FS - 50(PTI + PTII) \quad \ldots\ldots\ldots \quad (45)$$

The larger the computed value of TFP, the more suitable should be Index. The most suitable Indices were selected and tested using the Chi-square goodness of fit test and their performances compared to those of the forecasting guides used in the Nairobi and surrounding area using the same methods discussed in section 2.3.3.

The results obtained are shown and discussed in the following chapter.

## 3.0 RESULTS AND DISCUSSION

### 3.1 PRECIPITATION FORECASTING USING STABILITY INDICES

The results have been arranged in two categories, A and B. In category A, the Stability Indices most suitable for predicting the non-occurrence of late afternoon or early evening precipitation in the Nairobi and surrounding area, were determined. In category B, the Indices which give the highest number of correct predictions of the occurrence or non-occurrence of the precipitation (i.e, with the highest forecasting skills) with the least possible errors were determined.

#### 3.1.1 CATEGORY A - PREDICTION OF NON-OCCURRENCE PRECIPITATION

Threshold values for the various Indices i.e, the values below or above which precipitation should not be expected are shown in Table 5.

##### 3.1.1.1 THE WARM DRY SEASON

In general, most Indices performed quite well during this season. As observed in Table 6, a total of 15 Indices out of the 23 had an Index Reliability (IR) of at least 30, of which, 8 are greater than 40. This is an indication that much of the late afternoon or early evening rainfall during the season is of convective origin. The Index with best seasonal

TABLE 5: THRESHOLD VALUES FOR THE NON-OCCURRENCE AND LIKELIHOOD OF CONVECTIVE WEATHER ACTIVITIES OVER THE NAIROBI AND SURROUNDING AREA.

| INDEX | CATEGORY A (Non-occurrence) | CATEGORY B (Likelihood) |
|---|---|---|
| AI | ≥ 0.5 | 0.25 ≤ |
| AHI | ≥ - 20 | - 40 ≤ |
| ADI | ≥ 1.5 | 0.8 ≤ |
| $LI_1$ | ≥ 1 | -1 ≤ |
| $LHI_1$ | ≥ -2 | -4 ≤ |
| $LDI_1$ | ≥ 4 | 2 ≤ |
| LI2 | ≥ 1 | -1 ≤ |
| $LHI_2$ | ≥ -2 | -4 ≤ |
| $LDI_2$ | ≥ 4 | 2 ≤ |
| $SI_1$ | ≥ 3 | 1 ≤ |
| $SHI_1$ | ≥ 0 | -2 ≤ |
| $SDI_1$ | ≥ 5 | 3 ≤ |
| $SI_2$ | ≥ 3 | 1 ≤ |
| $SHI_2$ | ≥ 0 | -2 ≤ |
| $SDI_2$ | ≥ 5 | 3 ≤ |
| $KI_1$ | 20 ≤ | ≥ 23 |
| $KI_2$ | 25 ≤ | ≥ 28 |
| $TTI_1$ | 30 ≤ | ≥ 34 |
| $TTHI_1$ | 60 ≤ | ≥ 68 |
| $TTDI_1$ | 25 ≤ | ≥ 29 |
| $TTI_2$ | 40 ≤ | > 44 |
| $TTHI_2$ | 70 ≤ | ≥ 78 |
| $TTDI_2$ | 33 ≤ | ≥ 38 |

TABLE 6: COMPARISON OF THE PERFORMANCES OF THE STABILITY INDICES DURING THE WARM DRY SEASONS OF 1988, 1989 AND 1990.

| INDEX | YY | NN | YN | NY | TOTAL | CORRECT | FS % | PTI % | PTII % | IR | RANK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AI | 52 | 111 | 96 | 12 | 271 | 163 | 60 | 10 | 65 | 30 | 15 |
| AHI | 56 | 118 | 89 | 8 | 271 | 174 | 64 | 6 | 61 | 46 | 6 |
| ADI | 61 | 91 | 116 | 3 | 271 | 152 | 56 | 3 | 66 | 47 | 5 |
| $LI_1$ | 59 | 37 | 170 | 5 | 271 | 96 | 35 | 12 | 74 | - 1 | 23 |
| $LHI_1$ | 58 | 49 | 158 | 6 | 271 | 107 | 39 | 11 | 73 | 6 | 21 |
| $LDI_1$ | 57 | 78 | 129 | 7 | 271 | 135 | 50 | 8 | 69 | 26 | 17 |
| $LI_2$ | 58 | 47 | 160 | 6 | 271 | 105 | 39 | 11 | 73 | 6 | 21 |
| $LHI_2$ | 58 | 67 | 140 | 6 | 271 | 125 | 46 | 8 | 71 | 22 | 18 |
| $LDI_2$ | 56 | 92 | 115 | 8 | 271 | 148 | 55 | 8 | 67 | 31 | 14 |
| $SI_1$ | 60 | 51 | 156 | 4 | 271 | 111 | 41 | 7 | 72 | 20 | 19 |
| $SHI_1$ | 61 | 69 | 138 | 3 | 271 | 130 | 48 | 4 | 69 | 36 | 13 |
| $SDI_1$ | 57 | 105 | 102 | 7 | 271 | 162 | 60 | 6 | 64 | 42 | 7 |
| $SI_2$ | 60 | 67 | 140 | 4 | 271 | 127 | 47 | 6 | 70 | 29 | 16 |
| $SHI_2$ | 62 | 85 | 122 | 2 | 271 | 147 | 54 | 2 | 66 | 48 | 2 |
| $SDI_2$ | 53 | 118 | 89 | 11 | 271 | 171 | 63 | 9 | 63 | 36 | 12 |
| $KI_1$ | 54 | 114 | 93 | 10 | 271 | 168 | 62 | 8 | 63 | 38 | 11 |
| $KI_2$ | 54 | 118 | 89 | 10 | 271 | 172 | 63 | 8 | 62 | 39 | 9 |
| $TTI_1$ | 59 | 52 | 155 | 5 | 271 | 111 | 41 | 9 | 72 | 14 | 20 |
| $TTHI_1$ | 60 | 99 | 108 | 4 | 271 | 159 | 59 | 4 | 64 | 47 | 3 |
| $TTDI_1$ | 57 | 106 | 101 | 7 | 271 | 163 | 60 | 6 | 64 | 42 | 7 |
| $TTI_2$ | 61 | 77 | 130 | 3 | 271 | 138 | 51 | 4 | 68 | 39 | 10 |
| $TTHI_2$ | 60 | 105 | 102 | 4 | 271 | 165 | 61 | 4 | 63 | 49 | 1 |
| $TTDI_2$ | 60 | 99 | 108 | 4 | 271 | 159 | 59 | 4 | 64 | 47 | 3 |

TABLE 7: COMPARISON OF THE PERFORMANCES OF THE STABILITY INDICES DURING DECEMBER, 1988, 1989 AND 1990.

| INDEX | YY | NN | YN | NY | TOTAL | CORRECT | FS % | PTI % | PTII % | IR | RANK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AI | 24 | 23 | 41 | 5 | 93 | 47 | 51 | 18 | 63 | - 3 | 12 |
| AHI | 27 | 23 | 41 | 2 | 93 | 50 | 54 | 8 | 60 | 30 | 3 |
| ADI | 28 | 17 | 47 | 1 | 93 | 45 | 48 | 6 | 63 | 30 | 4 |
| $LI_1$ | 25 | 11 | 53 | 4 | 93 | 36 | 39 | 27 | 68 | -42 | 21 |
| $LHI_1$ | 25 | 11 | 53 | 4 | 93 | 36 | 39 | 27 | 68 | -42 | 21 |
| $LDI_1$ | 25 | 20 | 44 | 4 | 93 | 45 | 48 | 17 | 64 | - 3 | 13 |
| $LI_2$ | 23 | 15 | 49 | 6 | 93 | 38 | 41 | 29 | 68 | -46 | 23 |
| $LHI_2$ | 24 | 20 | 44 | 5 | 93 | 44 | 47 | 20 | 65 | -13 | 17 |
| $LDI_2$ | 24 | 22 | 42 | 5 | 93 | 46 | 49 | 19 | 64 | - 8 | 16 |
| $SI_1$ | 25 | 13 | 51 | 4 | 93 | 38 | 41 | 24 | 67 | -31 | 20 |
| $SHI_1$ | 27 | 17 | 47 | 2 | 93 | 44 | 47 | 11 | 64 | 14 | 7 |
| $SDI_1$ | 25 | 23 | 41 | 4 | 93 | 48 | 52 | 15 | 62 | 7 | 10 |
| $SI_2$ | 25 | 19 | 45 | 4 | 93 | 44 | 47 | 17 | 64 | - 4 | 14 |
| $SHI_2$ | 27 | 20 | 44 | 2 | 93 | 47 | 51 | 9 | 62 | 24 | 5 |
| $SDI_2$ | 20 | 31 | 33 | 9 | 93 | 51 | 55 | 23 | 62 | -14 | 18 |
| $KI_1$ | 22 | 28 | 36 | 7 | 93 | 50 | 54 | 20 | 62 | - 6 | 15 |
| $KI_2$ | 22 | 29 | 35 | 7 | 93 | 51 | 55 | 19 | 61 | - 2 | 11 |
| $TTI_1$ | 25 | 14 | 50 | 4 | 93 | 39 | 42 | 22 | 67 | -24 | 19 |
| $TTHI_1$ | 28 | 24 | 40 | 1 | 93 | 52 | 56 | 4 | 59 | 44 | 1 |
| $TTDI_1$ | 25 | 25 | 39 | 4 | 93 | 50 | 54 | 14 | 61 | 12 | 8 |
| $TTI_2$ | 26 | 20 | 44 | 3 | 93 | 46 | 49 | 13 | 63 | 10 | 9 |
| $TTHI_2$ | 28 | 22 | 42 | 1 | 93 | 50 | 54 | 4 | 60 | 42 | 2 |
| $TTDI_2$ | 27 | 20 | 44 | 2 | 93 | 47 | 51 | 9 | 62 | 24 | 5 |

TABLE 8: COMPARISON OF THE PERFORMANCES OF THE STABILITY INDICES DURING JANAURY, 1988, 1989 AND 1990.

| INDEX | YY | NN | YN | NY | TOTAL | CORRECT | FS % | PTI % | PTII % | IR | RANK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AI | 14 | 43 | 29 | 7 | 93 | 57 | 61 | 14 | 67 | 19 | 23 |
| AHI | 16 | 45 | 27 | 5 | 93 | 61 | 66 | 10 | 63 | 36 | 16 |
| ADI | 20 | 35 | 37 | 1 | 93 | 55 | 59 | 3 | 65 | 50 | 6 |
| $LI_1$ | 20 | 16 | 56 | 1 | 93 | 36 | 39 | 6 | 74 | 21 | 21 |
| $LHI_1$ | 19 | 22 | 50 | 2 | 93 | 41 | 44 | 8 | 72 | 20 | 22 |
| $LDI_1$ | 19 | 27 | 45 | 2 | 93 | 46 | 49 | 7 | 70 | 28 | 20 |
| $LI_2$ | 21 | 19 | 53 | 0 | 93 | 40 | 43 | 0 | 72 | 43 | 13 |
| $LHI_2$ | 20 | 25 | 47 | 1 | 93 | 45 | 48 | 4 | 70 | 36 | 18 |
| $LDI_2$ | 19 | 31 | 41 | 2 | 93 | 50 | 54 | 6 | 68 | 36 | 17 |
| $SI_1$ | 21 | 19 | 53 | 0 | 93 | 40 | 43 | 0 | 72 | 43 | 13 |
| $SHI_1$ | 20 | 27 | 45 | 1 | 93 | 47 | 51 | 4 | 69 | 39 | 15 |
| $SDI_1$ | 19 | 39 | 33 | 2 | 93 | 58 | 62 | 5 | 63 | 47 | 9 |
| $SI_2$ | 21 | 24 | 48 | 0 | 93 | 45 | 48 | 0 | 70 | 48 | 8 |
| $SHI_2$ | 21 | 34 | 38 | 0 | 93 | 55 | 59 | 0 | 64 | 59 | 2 |
| $SDI_2$ | 20 | 42 | 30 | 1 | 93 | 62 | 67 | 2 | 60 | 61 | 1 |
| $KI_1$ | 19 | 39 | 33 | 2 | 93 | 58 | 62 | 5 | 63 | 47 | 9 |
| $KI_2$ | 19 | 44 | 28 | 2 | 93 | 63 | 68 | 4 | 60 | 56 | 3 |
| $TTI_1$ | 20 | 21 | 51 | 1 | 93 | 41 | 44 | 5 | 72 | 29 | 19 |
| $TTHI_1$ | 19 | 37 | 35 | 2 | 93 | 56 | 60 | 5 | 65 | 45 | 12 |
| $TTDI_1$ | 19 | 38 | 34 | 2 | 93 | 57 | 61 | 5 | 64 | 46 | 11 |
| $TTI_2$ | 21 | 28 | 44 | 0 | 93 | 49 | 53 | 0 | 68 | 53 | 5 |
| $TTHI_2$ | 19 | 41 | 31 | 2 | 93 | 60 | 65 | 5 | 62 | 50 | 6 |
| $TTDI_2$ | 20 | 38 | 34 | 1 | 93 | 58 | 62 | 3 | 63 | 53 | 4 |

TABLE 9: COMPARISON OF THE PERFORMANCES OF THE STABILITY INDICES DURING FEBRUARY, 1988, 1989 AND 1990.

| INDEX | YY | NN | YN | NY | TOTAL | CORRECT | FS % | PTI % | PTII % | IR | RANK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AI | 14 | 45 | 26 | 0 | 85 | 59 | 69 | 0 | 65 | 69 | 1 |
| AHI | 13 | 50 | 21 | 1 | 85 | 63 | 74 | 2 | 62 | 68 | 2 |
| ADI | 13 | 39 | 32 | 1 | 85 | 52 | 61 | 3 | 71 | 52 | 11 |
| $LI_1$ | 14 | 10 | 61 | 0 | 85 | 24 | 28 | 0 | 81 | 28 | 23 |
| $LHI_1$ | 14 | 16 | 55 | 0 | 85 | 30 | 35 | 0 | 80 | 35 | 21 |
| $LDI_1$ | 13 | 31 | 40 | 1 | 85 | 44 | 52 | 3 | 75 | 43 | 17 |
| $LI_2$ | 14 | 13 | 58 | 0 | 85 | 27 | 32 | 0 | 81 | 32 | 22 |
| $LHI_2$ | 14 | 22 | 49 | 0 | 85 | 36 | 42 | 0 | 78 | 42 | 18 |
| $LDI_2$ | 13 | 39 | 32 | 1 | 85 | 52 | 61 | 3 | 71 | 52 | 11 |
| $SI_1$ | 14 | 19 | 52 | 0 | 85 | 33 | 39 | 0 | 79 | 39 | 19 |
| $SHI_1$ | 14 | 25 | 46 | 0 | 85 | 39 | 46 | 0 | 77 | 46 | 15 |
| $SDI_1$ | 13 | 43 | 28 | 1 | 85 | 56 | 66 | 2 | 68 | 60 | 6 |
| $SI_2$ | 14 | 24 | 47 | 0 | 85 | 38 | 45 | 0 | 77 | 45 | 16 |
| $SHI_2$ | 14 | 31 | 40 | 0 | 85 | 45 | 53 | 0 | 74 | 53 | 10 |
| $SDI_2$ | 13 | 45 | 26 | 1 | 85 | 58 | 68 | 2 | 67 | 62 | 4 |
| $KI_1$ | 13 | 47 | 24 | 1 | 85 | 60 | 71 | 2 | 65 | 65 | 3 |
| $KI_2$ | 13 | 45 | 26 | 1 | 85 | 58 | 68 | 2 | 67 | 62 | 4 |
| $TTI_1$ | 14 | 17 | 54 | 0 | 85 | 31 | 36 | 0 | 79 | 36 | 20 |
| $TTHI_1$ | 13 | 38 | 33 | 1 | 85 | 51 | 60 | 3 | 72 | 51 | 13 |
| $TTDI_1$ | 13 | 43 | 28 | 1 | 85 | 56 | 66 | 2 | 68 | 60 | 6 |
| $TTI_2$ | 14 | 29 | 42 | 0 | 85 | 43 | 51 | 0 | 75 | 51 | 14 |
| $TTHI_2$ | 13 | 42 | 29 | 1 | 85 | 55 | 65 | 2 | 69 | 59 | 8 |
| $TTDI_2$ | 13 | 41 | 30 | 1 | 85 | 54 | 64 | 2 | 70 | 58 | 9 |

performance was the $TTHI_2$ with an IR of 49 followed by the $SHI_2$ with 48. Out of the 271 days in the season, the $TTHI_2$ predicted no rainfall for a total of 109 days and was wrong only in 4 cases while the $SHI_2$ predicted 87 with only 2 wrong cases. In addition, these two Indices were the most consistent during the season. For instance, the $TTHI_2$ was ranked $2^{nd}$, $6^{th}$ and 8th in December, January and February respectively as shown in Tables 7, 8 and 9 This should be compared to say, the $SDI_2$ which, despite having been ranked $1^{st}$ and $4^{th}$ in January and February respectively, it was ranked $18^{th}$ in December and consequently, $12^{th}$ in the overall sea-seasonl performance. It should be noted that the ADI and $TTDI_2$ also performed consistently during this season. It's also noteworthy that the $LI_1$, which is the only Index being used in the area of study, performed the poorest of all during the season.

3.1.1.2 THE LONG RAINY SEASON

This is the season during which the ITCZ traverses the East African region on its way to the northern Hemisphere and is responsible for much of the rainfall received by the region. The influences on the local weather by convection and the ITCZ are highly interactive with the latter playing the dominant role. The flow during the season is described by the "equatorial duct" with an entrance over the region observed when two high pressure centres (the Mascarene and Arabian highs) lie on either side of the equator resulting into deep convergence, and therefore,the intensity of weather activities over the region is largely determined by the by the intensity and orientation of these highs(Johnson and Morth, 1960). Consequently, the performances of the Indices were poorest during this season especially in April and May when only 3 and 7 Indices respectively, had an IR greater than zero. Comparatively, the performances were much better in March, the transitional month between the warm dry and long rainy seasons, when all the Indices but one had an IR greater than 5, of which,8 were at least 50.

Evidently, the $LHI_2$ and $TTI_2$ were the most successful during this season with IR of 28 and 24 respectively, as shown in Table 10. In addition, the two performed most consistently during the season with the $LHI_2$ being ranked $3^{rd}$, $4^{th}$ and $3^{rd}$ in March, April and May respectively, and the $TTI_2$ $1^{st}$, $6^{th}$ and $1^{st}$ respectively, in the corresponding months as observed in Tables 11, 12 and 13. Out of the 184 days in the season, the $LHI_2$ and $TTI_2$ predicted 35 and 40 without precipitation and were wrong in only 4 and 5 cases respectively. It should be noted that it is very difficult to predict correctly the non-occurrence of precipitation during this season due mainly to the large diurnal changes in the airmass over the region. The prevailing atmospheric conditions often change rapidly

TABLE 10: COMPARISON OF THE PERFORMANCES OF THE STABILITY INDICES DURING THE LONG RAINY SEASONS OF 1988 AND 1990.

| INDEX | YY | NN | YN | NY | TOTAL | CORRECT | FS % | PTI % | PTII % | IR | RANK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AI | 71 | 16 | 82 | 15 | 184 | 87 | 47 | 48 | 54 | -97 | 23 |
| AHI | 70 | 25 | 73 | 16 | 184 | 95 | 52 | 39 | 51 | -65 | 21 |
| ADI | 82 | 19 | 79 | 4 | 184 | 101 | 55 | 17 | 49 | 4 | 8 |
| $LI_1$ | 83 | 17 | 71 | 3 | 184 | 100 | 54 | 15 | 49 | 9 | 4 |
| $LHI_1$ | 79 | 33 | 65 | 7 | 184 | 112 | 61 | 18 | 45 | 7 | 5 |
| $LDI_1$ | 76 | 41 | 57 | 10 | 184 | 117 | 64 | 20 | 43 | 4 | 7 |
| $LI_2$ | 79 | 24 | 74 | 7 | 184 | 103 | 56 | 23 | 48 | -13 | 13 |
| $LHI_2$ | 82 | 31 | 67 | 4 | 184 | 113 | 61 | 11 | 45 | 28 | 1 |
| $LDI_2$ | 73 | 44 | 54 | 13 | 184 | 117 | 64 | 23 | 43 | - 5 | 10 |
| $SI_1$ | 81 | 8 | 90 | 5 | 184 | 89 | 48 | 38 | 53 | -66 | 22 |
| $SHI_1$ | 80 | 17 | 81 | 6 | 184 | 97 | 53 | 26 | 50 | -25 | 19 |
| $SDI_1$ | 71 | 44 | 54 | 15 | 184 | 115 | 63 | 25 | 43 | -12 | 12 |
| $SI_2$ | 83 | 16 | 82 | 3 | 184 | 99 | 54 | 16 | 50 | 6 | 6 |
| $SHI_2$ | 80 | 26 | 72 | 6 | 184 | 106 | 58 | 19 | 47 | 1 | 9 |
| $SDI_2$ | 70 | 47 | 51 | 16 | 184 | 117 | 64 | 25 | 42 | -11 | 11 |
| $KI_1$ | 69 | 46 | 52 | 17 | 184 | 115 | 63 | 27 | 43 | -18 | 16 |
| $KI_2$ | 69 | 48 | 50 | 17 | 184 | 117 | 64 | 26 | 42 | -14 | 14 |
| $TTI_1$ | 80 | 19 | 79 | 6 | 184 | 99 | 54 | 24 | 50 | -18 | 17 |
| $TTHI_1$ | 72 | 41 | 57 | 14 | 184 | 113 | 61 | 25 | 44 | -14 | 15 |
| $TTDI_1$ | 70 | 42 | 56 | 16 | 184 | 112 | 61 | 28 | 44 | -23 | 18 |
| $TTI_2$ | 81 | 35 | 63 | 5 | 184 | 116 | 63 | 13 | 44 | 24 | 2 |
| $TTHI_2$ | 70 | 39 | 59 | 16 | 184 | 109 | 59 | 29 | 46 | -28 | 20 |
| $TTDI_2$ | 77 | 40 | 58 | 9 | 184 | 117 | 64 | 18 | 43 | 10 | 3 |

TABLE 11: COMPARISON OF THE PERFORMANCES OF THE STABILITY INDICES DURING MARCH, 1988 AND 1990.

| INDEX | YY | NN | YN | NY | TOTAL | CORRECT | FS % | PTI % | PTII % | | RANK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AI | 27 | 8 | 25 | 2 | 62 | 35 | 56 | 10 | 48 | 26 | 11 |
| AHI | 25 | 13 | 20 | 4 | 62 | 38 | 61 | 24 | 44 | -11 | 23 |
| ADI | 28 | 11 | 22 | 1 | 62 | 39 | 63 | 8 | 44 | 39 | 9 |
| $LI_1$ | 29 | 3 | 30 | 0 | 62 | 32 | 52 | 0 | 51 | 52 | 6 |
| $LHI_1$ | 29 | 9 | 24 | 0 | 62 | 38 | 61 | 0 | 45 | 61 | 2 |
| $LDI_1$ | 26 | 16 | 17 | 3 | 62 | 42 | 68 | 16 | 40 | 20 | 14 |
| $LI_2$ | 29 | 4 | 29 | 0 | 62 | 33 | 53 | 0 | 50 | 53 | 5 |
| $LHI_2$ | 29 | 8 | 25 | 0 | 62 | 37 | 60 | 0 | 46 | 60 | 3 |
| $LDI_2$ | 26 | 14 | 19 | 3 | 62 | 40 | 65 | 18 | 42 | 11 | 21 |
| $SI_1$ | 29 | 2 | 31 | 0 | 62 | 31 | 50 | 0 | 52 | 50 | 7 |
| $SHI_1$ | 28 | 6 | 27 | 1 | 62 | 34 | 55 | 14 | 49 | 13 | 19 |
| $SDI_1$ | 25 | 16 | 17 | 4 | 62 | 41 | 66 | 20 | 40 | 6 | 22 |
| $SI_2$ | 29 | 2 | 31 | 0 | 62 | 31 | 50 | 0 | 52 | 50 | 7 |
| $SHI_2$ | 28 | 7 | 26 | 1 | 62 | 35 | 56 | 13 | 48 | 17 | 15 |
| $SDI_2$ | 25 | 17 | 16 | 4 | 62 | 42 | 68 | 19 | 39 | 11 | 20 |
| $KI_1$ | 25 | 18 | 15 | 4 | 62 | 43 | 69 | 18 | 38 | 15 | 16 |
| $KI_2$ | 25 | 18 | 15 | 4 | 62 | 43 | 69 | 18 | 38 | 15 | 16 |
| $TTI_1$ | 29 | 6 | 27 | 0 | 62 | 35 | 56 | 0 | 48 | 56 | 4 |
| $TTHI_1$ | 26 | 17 | 16 | 3 | 62 | 43 | 69 | 15 | 38 | 24 | 12 |
| $TTDI_1$ | 26 | 18 | 15 | 3 | 62 | 44 | 71 | 14 | 37 | 29 | 10 |
| $TTI_2$ | 29 | 11 | 22 | 0 | 62 | 40 | 65 | 0 | 43 | 65 | 1 |
| $TTHI_2$ | 26 | 15 | 18 | 3 | 62 | 41 | 66 | 17 | 41 | 15 | 18 |
| $TTDI_2$ | 26 | 17 | 16 | 3 | 62 | 43 | 69 | 15 | 38 | 24 | 12 |

TABLE 12: COMPARISON OF THE PERFORMANCES OF THE STABILITY INDICES DURING APRIL, 1988 AND 1990.

| INDEX | YY | NN | YN | NY | TOTAL | CORRECT | FS % | PTI % | PTII % | IR | RANK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AI | 24 | 3 | 24 | 9 | 60 | 27 | 45 | 75 | 50 | -180 | 22 |
| AHI | 26 | 7 | 20 | 7 | 60 | 33 | 55 | 50 | 43 | - 95 | 17 |
| ADI | 31 | 3 | 24 | 2 | 60 | 34 | 57 | 40 | 44 | - 63 | 14 |
| $LI_1$ | 33 | 2 | 25 | 0 | 60 | 35 | 58 | 0 | 43 | 58 | 1 |
| $LHI_1$ | 31 | 3 | 24 | 2 | 60 | 34 | 57 | 40 | 44 | -63 | 14 |
| $LDI_1$ | 31 | 8 | 19 | 2 | 60 | 39 | 65 | 20 | 38 | 5 | 3 |
| $LI_2$ | 29 | 3 | 24 | 4 | 60 | 32 | 53 | 57 | 45 | -118 | 21 |
| $LHI_2$ | 32 | 3 | 24 | 1 | 60 | 35 | 58 | 25 | 43 | - 17 | 4 |
| $LDI_2$ | 28 | 10 | 17 | 5 | 60 | 38 | 63 | 33 | 38 | - 36 | 5 |
| $SI_1$ | 32 | 0 | 27 | 1 | 60 | 32 | 53 | 100 | 46 | -247 | 23 |
| $SHI_1$ | 32 | 2 | 25 | 1 | 60 | 34 | 57 | 33 | 44 | - 42 | 7 |
| $SDI_1$ | 28 | 9 | 18 | 5 | 60 | 37 | 62 | 36 | 39 | - 46 | 9 |
| $SI_2$ | 32 | 2 | 25 | 1 | 60 | 34 | 57 | 33 | 44 | - 42 | 7 |
| $SHI_2$ | 32 | 5 | 22 | 1 | 60 | 37 | 62 | 17 | 41 | 11 | 2 |
| $SDI_2$ | 27 | 9 | 18 | 6 | 60 | 36 | 60 | 40 | 40 | - 60 | 12 |
| $KI_1$ | 27 | 10 | 17 | 6 | 60 | 37 | 62 | 38 | 39 | - 52 | 10 |
| $KI_2$ | 27 | 10 | 17 | 6 | 60 | 37 | 62 | 38 | 39 | - 52 | 10 |
| $TTI_1$ | 29 | 4 | 23 | 4 | 60 | 33 | 55 | 50 | 44 | - 95 | 18 |
| $TTHI_1$ | 28 | 5 | 22 | 5 | 60 | 33 | 55 | 50 | 44 | - 95 | 18 |
| $TTDI_1$ | 26 | 9 | 18 | 7 | 60 | 35 | 58 | 44 | 41 | - 74 | 16 |
| $TTI_2$ | 30 | 6 | 21 | 3 | 60 | 36 | 60 | 33 | 41 | - 39 | 6 |
| $TTHI_2$ | 28 | 5 | 22 | 5 | 60 | 33 | 55 | 50 | 44 | - 95 | 18 |
| $TTDI_2$ | 29 | 6 | 21 | 4 | 60 | 35 | 58 | 40 | 42 | - 62 | 13 |

TABLE 13: COMPARISON OF PERFORMANCES OF THE STABILITY INDICES DURING MAY, 1988 AND 1990.

| INDEX | YY | NN | YN | NY | TOTAL | CORRECT | FS % | PTI % | PTII % | | RANK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AI | 20 | 5 | 33 | 4 | 62 | 25 | 40 | 44 | 62 | - 92 | 22 |
| AHI | 19 | 5 | 33 | 5 | 62 | 24 | 39 | 50 | 63 | -111 | 23 |
| ADI | 23 | 5 | 33 | 1 | 62 | 28 | 45 | 17 | 59 | - 6 | 10 |
| $LI_1$ | 21 | 12 | 26 | 3 | 62 | 33 | 53 | 20 | 55 | - 7 | 11 |
| $LHI_1$ | 19 | 21 | 17 | 5 | 62 | 40 | 65 | 19 | 47 | 8 | 6 |
| $LDI_1$ | 19 | 17 | 21 | 5 | 62 | 36 | 58 | 23 | 53 | - 11 | 12 |
| $LI_2$ | 21 | 17 | 21 | 3 | 62 | 38 | 61 | 15 | 50 | 16 | 4 |
| $LHI_2$ | 21 | 20 | 18 | 3 | 62 | 41 | 66 | 13 | 46 | 27 | 3 |
| $LDI_2$ | 19 | 20 | 18 | 5 | 62 | 39 | 63 | 20 | 49 | 3 | 7 |
| $SI_1$ | 20 | 6 | 32 | 4 | 62 | 26 | 42 | 40 | 62 | - 78 | 21 |
| $SHI_1$ | 20 | 9 | 29 | 4 | 62 | 29 | 47 | 31 | 59 | - 46 | 20 |
| $SDI_1$ | 18 | 19 | 19 | 6 | 62 | 37 | 60 | 24 | 51 | - 12 | 14 |
| $SI_2$ | 22 | 12 | 26 | 2 | 62 | 34 | 55 | 14 | 54 | 13 | 5 |
| $SHI_2$ | 20 | 14 | 24 | 4 | 62 | 34 | 55 | 22 | 55 | - 11 | 13 |
| $SDI_2$ | 18 | 21 | 17 | 6 | 62 | 39 | 63 | 22 | 49 | - 3 | 8 |
| $KI_1$ | 17 | 18 | 20 | 7 | 62 | 35 | 56 | 28 | 54 | - 28 | 17 |
| $KI_2$ | 17 | 20 | 18 | 7 | 62 | 37 | 60 | 26 | 51 | - 18 | 16 |
| $TTI_1$ | 22 | 9 | 29 | 2 | 62 | 31 | 50 | 18 | 57 | - 4 | 9 |
| $TTHI_1$ | 18 | 19 | 19 | 6 | 62 | 37 | 60 | 24 | 51 | - 12 | 14 |
| $TTDI_1$ | 18 | 15 | 23 | 6 | 62 | 33 | 53 | 29 | 56 | - 34 | 19 |
| $TTI_2$ | 22 | 18 | 20 | 2 | 62 | 40 | 65 | 10 | 48 | 35 | 1 |
| $TTHI_2$ | 16 | 19 | 19 | 8 | 62 | 35 | 56 | 30 | 54 | - 34 | 18 |
| $TTDI_2$ | 22 | 17 | 21 | 2 | 62 | 39 | 63 | 11 | 49 | 30 | 2 |

because of the variation of moisture transport into the region by the more moist prevailing southeasterlies. It should also be noted that the Indices whose evaluation is based purely on atmospheric stability (i.e, does not incorporate the atmospheric moisture content in the middle or upper levels) performed reasonably well when compared to their performance during the warm dry season. For Example, apart from the $TTI_2$ which was ranked 2nd, the $LI_1$ and $SI_2$ were ranked 4th and 6th respectively. This derives from the fact that the moisture incorporating Indices can be quite misleading during very wet periods. During such periods, the magnitudes of the computed values of these Indices is determined, to a larger extent, by the atmospheric humidity rather than stability, and yet the former has frequent diurnal fluctuations. These fluctuations may result into the humidity profile at the time of the radiosonde ascent being quite different from that several hours later. A good example is when the 2300Z ascent is made while it is raining (and this is common during the rainy seasons), the sounding will depict a highly humid atmosphere and consequently, the computed values of the moisture incorporating Indices will indicate favourable conditions for convective weather developments. But the intensity of the diurnal surface heating on the day following the ascent may not be enough to initiate convection or evaporate back to the atmosphere a sufficient amount of moisture to cause precipitation. Assuming no moisture advection into the area occurs, there is likely to be no precipitation in such circumstances. On the other hand, consider an ascent made several hours after a heavy afternoon or early evening shower. The sounding may depict low humidity values in the middle and upper levels and consequently the Indices' values may indicate un-favourable conditions for convective weather developments. But if the diurnal surface heating on the day following the ascent is intense enough to transport sufficient moisture back to the atmosphere, there may be precipitation. From the foregoing, it is clear that for the purpose of ruling out convective weather activities during wet periods, particularly observed during the rainy seasons, the moisture incorporating Indices may not be representative and could be quite misleading at times. For this reason, the $TTI_2$ is highly recommended for use during the long rainy season. It should be remembered that there was no radiosonde data for March, April and May, 1989 and therefore, the period was not considered.

3.1.1.3 THE COOL AND DRY SEASON

During this season, the atmosphere is relatively dry and stable, with low temperatures as the usually cloudy conditions over the area effectively reduce the insolation reaching the surface. The presence of medium level diffluence/divergence, together with the well-known 700-600mb temperature inversion suppresses the growth and vertical extent of the clouds and most of the rainfall received is orographically induced. However, on a number of occasions, there is sufficient insolation giving rise to some afternoon rainfall. As illustrated in Table 14 a total of 18 Indices had an IR greater than 30, of which, 11 have one of at least 40. Because of this, it was relatively difficult to select the most suitable Index during the season. However, the $LDI_2$ and $TTI_2$, each with an IR of 46, had an edge over the others. Out of the 342 days in the season, the $LDI_2$ predicted a total of 225 with no precipitation and was wrong in 20 cases while the $TTI_2$ predicted 232 and was wrong in 25. In addition, the $LDI_2$ and $TTI_2$ were ranked $13^{th}$, $1^{st}$, $5^{th}$, $9^{th}$ and $7^{th}$, $7^{th}$, $11^{th}$, $1^{st}$ in June, July, August and September respectively, as shown in Tables 15, 16, 17 and 18.

3.1.1.4 THE SHORT RAINY SEASON

This is when the ITCZ traverses the E.African region for the second time in the year. This time it crosses the equator from the northern into the southern Hemisphere. As was the case during the long rainy season, the influences of convection and the ITCZ on the local weather are highly interactive with the latter playing the dominant role. Consequently, the performances of the Indices was found to be generally poor though not to the extent observed during the long rainy season.

INDICES DURING THE COOL AND DRY

| FS % | PTI % | PTII % | IR | RANK |
|---|---|---|---|---|
| 47 | 22 | 83 | -22 | 23 |
| 56 | 18 | 79 | 2 | 22 |
| 51 | 14 | 77 | 9 | 21 |
| 59 | 11 | 72 | 26 | 20 |
| 64 | 8 | 68 | 40 | 11 |
| 68 | 9 | 67 | 42 | 8 |
| 65 | 10 | 69 | 35 | 15 |
| 69 | 10 | 66 | 39 | 12 |
| 73 | 9 | 62 | 46 | 1 |
| 65 | 11 | 69 | 32 | 17 |
| 69 | 10 | 66 | 39 | 12 |
| 77 | 11 | 58 | 44 | 4 |
| 75 | 11 | 61 | 42 | 7 |
| 76 | 11 | 59 | 43 | 5 |
| 80 | 13 | 52 | 41 | 9 |
| 74 | 12 | 62 | 38 | 14 |
| 75 | 11 | 60 | 42 | 6 |
| 58 | 10 | 72 | 28 | 19 |
| 61 | 9 | 71 | 34 | 16 |
| 67 | 9 | 67 | 40 | 10 |
| 70 | 8 | 64 | 46 | 2 |
| 64 | 11 | 70 | 31 | 18 |
| 66 | 7 | 67 | 45 | 3 |

TABLE 15: <u>COMPARISON OF THE PERFORMANCES OF THE STABILITY INDICES DURING JUNE,1988, 1989 AND 1990</u>.

| INDEX | YY | NN | YN | NY | TOTAL | CORRECT | FS % | PTI % | PTII % | IR | RANK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AI | 3 | 28 | 34 | 2 | 67 | 31 | 46 | 7 | 92 | 25 | 23 |
| AHI | 4 | 33 | 29 | 1 | 67 | 37 | 55 | 3 | 88 | 46 | 20 |
| ADI | 4 | 27 | 35 | 1 | 67 | 31 | 46 | 4 | 90 | 34 | 22 |
| $LI_1$ | 3 | 37 | 25 | 2 | 67 | 40 | 60 | 5 | 89 | 45 | 21 |
| $LHI_1$ | 4 | 40 | 22 | 1 | 67 | 44 | 66 | 2 | 85 | 60 | 18 |
| $LDI_1$ | 3 | 51 | 11 | 2 | 67 | 54 | 81 | 4 | 79 | 69 | 12 |
| $LI_2$ | 3 | 40 | 22 | 2 | 67 | 43 | 64 | 5 | 88 | 49 | 19 |
| $LHI_2$ | 4 | 41 | 21 | 1 | 67 | 45 | 67 | 2 | 84 | 61 | 17 |
| $LDI_2$ | 2 | 53 | 9 | 3 | 67 | 55 | 82 | 5 | 82 | 67 | 13 |
| $SI_1$ | 5 | 45 | 17 | 0 | 67 | 50 | 75 | 0 | 77 | 75 | 6 |
| $SHI_1$ | 5 | 48 | 14 | 0 | 67 | 53 | 79 | 0 | 74 | 79 | 3 |
| $SDI_1$ | 2 | 56 | 6 | 3 | 67 | 58 | 87 | 5 | 75 | 72 | 8 |
| $SI_2$ | 5 | 47 | 15 | 0 | 67 | 52 | 78 | 0 | 75 | 78 | 4 |
| $SHI_2$ | 5 | 51 | 11 | 0 | 67 | 56 | 84 | 0 | 69 | 84 | 2 |
| $SDI_2$ | 3 | 59 | 3 | 2 | 67 | 62 | 93 | 3 | 50 | 84 | 1 |
| $KI_1$ | 2 | 55 | 7 | 3 | 67 | 57 | 85 | 5 | 78 | 70 | 10 |
| $KI_2$ | 3 | 53 | 9 | 2 | 67 | 56 | 84 | 4 | 75 | 72 | 9 |
| $TTI_1$ | 5 | 40 | 22 | 0 | 67 | 45 | 67 | 0 | 81 | 67 | 15 |
| $TTHI_1$ | 3 | 49 | 13 | 2 | 67 | 52 | 78 | 4 | 81 | 66 | 16 |
| $TTDI_1$ | 4 | 50 | 12 | 1 | 67 | 54 | 81 | 2 | 75 | 75 | 5 |
| $TTI_2$ | 5 | 44 | 18 | 0 | 67 | 49 | 73 | 0 | 78 | 73 | 7 |
| $TTHI_2$ | 3 | 50 | 12 | 2 | 67 | 53 | 79 | 4 | 80 | 67 | 14 |
| $TTDI_2$ | 4 | 47 | 15 | 1 | 67 | 51 | 76 | 2 | 79 | 70 | 11 |

TABLE 16: COMPARISON OF THE PERFORMANCES OF THE STABILITY INDICES DURING JULY, 1988, 1989 AND 1990.

| INDEX | YY | NN | YN | NY | TOTAL | CORRECT | FS % | PTI % | PTII % | IR | RANK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AI | 8 | 40 | 37 | 8 | 93 | 48 | 52 | 17 | 82 | 1 | 22 |
| AHI | 7 | 48 | 29 | 9 | 93 | 55 | 59 | 16 | 81 | 11 | 17 |
| ADI | 11 | 37 | 40 | 5 | 93 | 48 | 52 | 12 | 78 | 16 | 15 |
| $LI_1$ | 9 | 38 | 39 | 7 | 93 | 47 | 51 | 16 | 81 | 3 | 21 |
| $LHI_1$ | 10 | 43 | 34 | 6 | 93 | 53 | 57 | 12 | 77 | 21 | 13 |
| $LDI_1$ | 10 | 49 | 28 | 6 | 93 | 59 | 63 | 11 | 74 | 30 | 9 |
| $LI_2$ | 11 | 45 | 32 | 5 | 93 | 56 | 60 | 10 | 74 | 30 | 10 |
| $LHI_2$ | 11 | 53 | 24 | 5 | 93 | 64 | 69 | 9 | 69 | 42 | 3 |
| $LDI_2$ | 12 | 53 | 24 | 4 | 93 | 65 | 70 | 7 | 67 | 49 | 1 |
| $SI_1$ | 6 | 47 | 30 | 10 | 93 | 53 | 57 | 18 | 83 | 3 | 20 |
| $SHI_1$ | 7 | 50 | 27 | 9 | 93 | 57 | 61 | 15 | 79 | 16 | 14 |
| $SDI_1$ | 7 | 63 | 14 | 9 | 93 | 70 | 75 | 13 | 67 | 36 | 6 |
| $SI_2$ | 6 | 57 | 20 | 10 | 93 | 63 | 68 | 15 | 77 | 23 | 12 |
| $SHI_2$ | 6 | 59 | 18 | 10 | 93 | 65 | 70 | 14 | 75 | 28 | 11 |
| $SDI_2$ | 6 | 66 | 11 | 10 | 93 | 72 | 78 | 13 | 65 | 39 | 4 |
| $KI_1$ | 6 | 62 | 15 | 10 | 93 | 68 | 73 | 14 | 71 | 31 | 8 |
| $KI_2$ | 8 | 61 | 16 | 8 | 93 | 69 | 74 | 12 | 67 | 38 | 5 |
| $TTI_1$ | 7 | 41 | 36 | 9 | 93 | 48 | 52 | 18 | 84 | - 2 | 23 |
| $TTHI_1$ | 8 | 45 | 32 | 8 | 93 | 53 | 57 | 15 | 80 | 12 | 16 |
| $TTDI_1$ | 7 | 47 | 30 | 9 | 93 | 54 | 58 | 16 | 81 | 10 | 19 |
| $TTI_2$ | 10 | 51 | 26 | 6 | 93 | 61 | 66 | 11 | 72 | 33 | 7 |
| $TTHI_2$ | 7 | 48 | 29 | 9 | 93 | 55 | 59 | 16 | 81 | 11 | 17 |
| $TTDI_2$ | 13 | 44 | 33 | 3 | 93 | 57 | 61 | 6 | 72 | 43 | 2 |

TABLE 17: COMPARISON OF THE PERFORMANCES OF THE STABILITY INDCES DURING AUGUST, 1988, 1989 AND 1990.

| INDEX | YY | NN | YN | NY | TOTAL | CORRECT | FS % | PTI % | PTII % | | RANK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AI | 9 | 32 | 41 | 11 | 93 | 41 | 44 | 26 | 82 | -34 | 23 |
| AHI | 9 | 40 | 35 | 9 | 93 | 49 | 53 | 18 | 80 | - 1 | 22 |
| ADI | 15 | 33 | 42 | 3 | 93 | 48 | 52 | 8 | 74 | 28 | 21 |
| $LI_1$ | 13 | 48 | 27 | 5 | 93 | 61 | 66 | 9 | 68 | 39 | 16 |
| $LHI_1$ | 14 | 51 | 24 | 4 | 93 | 65 | 70 | 7 | 63 | 49 | 6 |
| $LDI_1$ | 13 | 49 | 26 | 5 | 93 | 62 | 67 | 9 | 67 | 40 | 14 |
| $LI_2$ | 11 | 53 | 22 | 7 | 93 | 64 | 69 | 12 | 67 | 33 | 19 |
| $LHI_2$ | 11 | 56 | 19 | 7 | 93 | 67 | 72 | 11 | 63 | 39 | 15 |
| $LDI_2$ | 13 | 55 | 20 | 5 | 93 | 68 | 73 | 8 | 61 | 49 | 5 |
| $SI_1$ | 11 | 50 | 25 | 7 | 93 | 61 | 66 | 12 | 69 | 30 | 20 |
| $SHI_1$ | 12 | 50 | 25 | 6 | 93 | 62 | 67 | 11 | 68 | 34 | 18 |
| $SDI_1$ | 12 | 59 | 16 | 6 | 93 | 71 | 76 | 9 | 57 | 49 | 4 |
| $SI_2$ | 12 | 63 | 12 | 6 | 93 | 75 | 81 | 9 | 50 | 54 | 2 |
| $SHI_2$ | 11 | 59 | 16 | 7 | 93 | 70 | 75 | 11 | 59 | 42 | 11 |
| $SDI_2$ | 9 | 65 | 10 | 9 | 93 | 74 | 80 | 12 | 53 | 44 | 9 |
| $KI_1$ | 12 | 58 | 17 | 6 | 93 | 70 | 75 | 9 | 59 | 48 | 7 |
| $KI_2$ | 12 | 58 | 17 | 6 | 93 | 70 | 75 | 9 | 59 | 48 | 7 |
| $TTI_1$ | 16 | 39 | 36 | 2 | 93 | 55 | 59 | 5 | 69 | 44 | 10 |
| $TTHI_1$ | 16 | 36 | 39 | 2 | 93 | 52 | 56 | 5 | 71 | 41 | 13 |
| $TTDI_1$ | 16 | 45 | 30 | 2 | 93 | 61 | 66 | 4 | 65 | 54 | 3 |
| $TTI_2$ | 12 | 54 | 21 | 6 | 93 | 66 | 71 | 10 | 64 | 41 | 12 |
| $TTHI_2$ | 15 | 41 | 34 | 3 | 93 | 56 | 60 | 7 | 69 | 39 | 17 |
| $TTDI_2$ | 17 | 43 | 32 | 1 | 93 | 60 | 65 | 2 | 65 | 59 | 1 |

TABLE 18: <u>COMPARISON OF THE PERFORMANCES OF THE STABILITY INDICES DURING SEPTEMBER, 1988, 1989 AND 1990.</u>

| INDEX | YY | NN | YN | NY | TOTAL | CORRECT | FS % | PTI % | PTII % | IR | RANK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AI | 9 | 33 | 30 | 17 | 89 | 42 | 47 | 34 | 77 | -55 | 23 |
| AHI | 10 | 40 | 23 | 16 | 89 | 50 | 56 | 29 | 70 | -31 | 22 |
| ADI | 15 | 31 | 32 | 11 | 89 | 46 | 52 | 26 | 68 | -26 | 21 |
| $LI_1$ | 21 | 34 | 29 | 5 | 89 | 55 | 62 | 13 | 58 | 23 | 11 |
| $LHI_1$ | 21 | 35 | 29 | 4 | 89 | 56 | 63 | 10 | 58 | 33 | 4 |
| $LDI_1$ | 20 | 36 | 28 | 5 | 89 | 56 | 63 | 12 | 58 | 27 | 8 |
| $LI_2$ | 21 | 38 | 25 | 5 | 89 | 59 | 66 | 12 | 54 | 30 | 6 |
| $LHI_2$ | 18 | 41 | 22 | 8 | 89 | 59 | 66 | 16 | 55 | 18 | 13 |
| $LDI_2$ | 18 | 44 | 19 | 8 | 89 | 62 | 70 | 15 | 51 | 25 | 9 |
| $SI_1$ | 21 | 39 | 24 | 5 | 89 | 60 | 67 | 11 | 53 | 34 | 3 |
| $SHI_1$ | 20 | 43 | 20 | 6 | 89 | 63 | 71 | 12 | 50 | 35 | 2 |
| $SDI_1$ | 16 | 48 | 15 | 10 | 89 | 64 | 72 | 17 | 48 | 21 | 12 |
| $SI_2$ | 16 | 50 | 13 | 10 | 89 | 66 | 74 | 17 | 45 | 23 | 10 |
| $SHI_2$ | 16 | 54 | 9 | 10 | 89 | 70 | 79 | 16 | 36 | 31 | 5 |
| $SDI_2$ | 12 | 54 | 9 | 14 | 89 | 66 | 74 | 21 | 43 | 11 | 18 |
| $KI_1$ | 15 | 44 | 19 | 11 | 89 | 59 | 66 | 20 | 56 | 6 | 20 |
| $KI_2$ | 15 | 48 | 15 | 11 | 89 | 63 | 71 | 19 | 50 | 14 | 16 |
| $TTI_1$ | 21 | 28 | 35 | 5 | 89 | 49 | 55 | 15 | 62 | 10 | 19 |
| $TTHI_1$ | 21 | 32 | 31 | 5 | 89 | 53 | 60 | 14 | 60 | 18 | 14 |
| $TTDI_1$ | 20 | 39 | 24 | 6 | 89 | 59 | 66 | 13 | 55 | 27 | 7 |
| $TTI_2$ | 20 | 45 | 18 | 6 | 89 | 65 | 73 | 12 | 47 | 37 | 1 |
| $TTHI_2$ | 19 | 37 | 26 | 7 | 89 | 56 | 63 | 16 | 58 | 15 | 15 |
| $TTDI_2$ | 18 | 39 | 24 | 8 | 89 | 57 | 64 | 17 | 57 | 13 | 17 |

During this season, the dry northeast monsoon air is replacing the cool and somewhat moist southeast monsoon air while during the long rainy season, the more moist southeast monsoon air replaces the rather dry northeast monsoon air current. There is also the effect of extratropical disturbances e.g. the cold upper air trough during the northern hemisphere winter which at times, extends its influence to the region. The most successful Indices were the $LHI_1$ and $SHI_1$ with an IR of 50 and 37 respectively, as shown in Table 19. In addition, they performed consistently during the season. For example, the $LHI_1$ was ranked $1^{st}$ and $9^{th}$ in October and November respectively as shown in Tables 20 and 21. Out of the 179 days in the season, the $LHI_1$ predicted 48 days with no rainfall and was wrong only in one case which is a commendable peformance during such a season. As was the case during the long rainy season, the Indices not incorporating moisture in their evaluation performed relatively well. For example, the $LI_1$, $TTI_1$ and $SI_1$ were ranked $3^{rd}$, $4^{th}$ and $5^{th}$ respectively. An interesting observation during this season was that unlike in the other 3, the Indices evaluated using the 500mb level performed better than those using the 450mb level with only the exception of the "K" Index.

3.1.1.5 OVERALL PERFORMANCES OF THE INDICES

The overall results shown in Table 22 clearly show the $TTDI_2$ as the most reliable, and thus most suitable, Index during the whole period of study. Out of the 976 days in the period, it predicted a total of 418 days with no precipitation and was wrong only in 35 cases (i.e. 8% of the total predictions). It had an IR of 39 followed by the $SHI_2$

TABLE 19: COMPARISON OF THE PERFORMANCES OF THE STABILITY INDICES DURING THE SHORT RAINY SEASONS OF 1988, 1989 AND 1990.

| INDEX | YY | NN | YN | NY | TOTAL | CORRECT | FS % | PTI % | PTII % | IR | RANK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AI | 39 | 40 | 84 | 16 | 179 | 79 | 44 | 29 | 68 | -43 | 23 |
| AHI | 39 | 43 | 81 | 16 | 179 | 82 | 46 | 27 | 68 | -35 | 22 |
| ADI | 46 | 36 | 88 | 9 | 179 | 82 | 46 | 20 | 66 | -14 | 20 |
| $LI_1$ | 53 | 36 | 88 | 2 | 179 | 89 | 50 | 5 | 62 | 35 | 3 |
| $LHI_1$ | 54 | 47 | 77 | 1 | 179 | 101 | 56 | 2 | 59 | 50 | 1 |
| $LDI_1$ | 49 | 47 | 77 | 6 | 179 | 96 | 54 | 11 | 61 | 21 | 9 |
| $LI_2$ | 41 | 49 | 75 | 14 | 179 | 90 | 50 | 22 | 65 | -16 | 21 |
| $LHI_2$ | 44 | 51 | 73 | 11 | 179 | 95 | 53 | 18 | 62 | - 1 | 18 |
| $LDI_2$ | 44 | 60 | 64 | 11 | 179 | 104 | 58 | 15 | 59 | 13 | 12 |
| $SI_1$ | 51 | 42 | 82 | 4 | 179 | 93 | 52 | 9 | 62 | 25 | 5 |
| $SHI_1$ | 52 | 46 | 78 | 3 | 179 | 98 | 55 | 6 | 60 | 37 | 2 |
| $SDI_1$ | 45 | 67 | 52 | 15 | 179 | 112 | 63 | 18 | 54 | 9 | 13 |
| $SI_2$ | 43 | 50 | 74 | 12 | 179 | 93 | 52 | 19 | 63 | - 5 | 19 |
| $SHI_2$ | 46 | 50 | 73 | 10 | 179 | 96 | 54 | 17 | 61 | 3 | 17 |
| $SDI_2$ | 41 | 75 | 44 | 19 | 179 | 116 | 65 | 20 | 52 | 5 | 16 |
| $KI_1$ | 46 | 66 | 53 | 14 | 179 | 112 | 63 | 18 | 54 | 9 | 13 |
| $KI_2$ | 46 | 75 | 44 | 14 | 179 | 121 | 68 | 16 | 49 | 20 | 10 |
| $TTI_1$ | 56 | 48 | 71 | 4 | 179 | 104 | 58 | 8 | 56 | 34 | 4 |
| $TTHI_1$ | 52 | 55 | 64 | 8 | 179 | 107 | 60 | 13 | 55 | 21 | 8 |
| $TTDI_1$ | 51 | 62 | 57 | 9 | 179 | 113 | 63 | 13 | 53 | 24 | 6 |
| $TTI_2$ | 50 | 51 | 68 | 10 | 179 | 101 | 56 | 16 | 58 | 8 | 15 |
| $TTHI_2$ | 49 | 61 | 58 | 11 | 179 | 110 | 61 | 15 | 54 | 16 | 11 |
| $TTDI_2$ | 53 | 51 | 68 | 7 | 179 | 104 | 58 | 12 | 56 | 22 | 7 |

TABLE 20: COMPARISON OF THE PERFORMANCES OF THE STABILITY INDICES DURING OCTOBER,1988, 1989 AND 1990.

| INDEX | YY | NN | YN | NY | TOTAL | CORRECT | FS % | PTI % | PTII % | IR | RANK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AI | 18 | 22 | 36 | 13 | 89 | 40 | 45 | 37 | 67 | -66 | 22 |
| AHI | 19 | 23 | 35 | 12 | 89 | 42 | 47 | 34 | 65 | -55 | 21 |
| ADI | 22 | 13 | 45 | 9 | 89 | 35 | 39 | 41 | 67 | -84 | 23 |
| $LI_1$ | 31 | 18 | 40 | 0 | 89 | 49 | 55 | 0 | 56 | 55 | 2 |
| $LHI_1$ | 31 | 26 | 32 | 0 | 89 | 57 | 64 | 0 | 51 | 64 | 1 |
| $LDI_1$ | 25 | 27 | 31 | 6 | 89 | 52 | 58 | 18 | 55 | 4 | 9 |
| $LI_2$ | 24 | 22 | 36 | 7 | 89 | 46 | 52 | 24 | 60 | -20 | 20 |
| $LHI_2$ | 25 | 25 | 33 | 6 | 89 | 50 | 56 | 19 | 57 | - 1 | 12 |
| $LDI_2$ | 23 | 29 | 29 | 8 | 89 | 52 | 58 | 22 | 56 | - 8 | 16 |
| $SI_1$ | 29 | 21 | 37 | 2 | 89 | 50 | 56 | 9 | 56 | 29 | 5 |
| $SHI_1$ | 29 | 25 | 33 | 2 | 89 | 54 | 61 | 7 | 53 | 40 | 4 |
| $SDI_1$ | 20 | 36 | 22 | 11 | 89 | 56 | 63 | 23 | 52 | - 6 | 15 |
| $SI_2$ | 23 | 26 | 32 | 8 | 89 | 49 | 55 | 24 | 58 | -17 | 18 |
| $SHI_2$ | 23 | 27 | 30 | 9 | 89 | 50 | 56 | 25 | 57 | -19 | 19 |
| $SDI_2$ | 17 | 39 | 19 | 14 | 89 | 56 | 63 | 26 | 53 | -15 | 17 |
| $KI_1$ | 20 | 37 | 21 | 11 | 89 | 57 | 64 | 23 | 51 | - 5 | 14 |
| $KI_2$ | 20 | 40 | 18 | 11 | 89 | 60 | 67 | 22 | 47 | 1 | 11 |
| $TTI_1$ | 30 | 24 | 34 | 1 | 89 | 54 | 61 | 4 | 53 | 49 | 3 |
| $TTHI_1$ | 26 | 29 | 29 | 5 | 89 | 55 | 62 | 15 | 53 | 17 | 6 |
| $TTDI_1$ | 24 | 32 | 26 | 7 | 89 | 56 | 63 | 18 | 52 | 9 | 8 |
| $TTI_2$ | 26 | 22 | 36 | 5 | 89 | 48 | 54 | 19 | 58 | - 3 | 13 |
| $TTHI_2$ | 23 | 32 | 26 | 8 | 89 | 55 | 62 | 20 | 53 | 2 | 10 |
| $TTDI_2$ | 25 | 29 | 29 | 6 | 89 | 54 | 61 | 17 | 54 | 10 | 7 |

TABLE 21: <u>COMPARISON OF THE PERFORMANCES OF THE STABILITY INDICES DURING NOVEMBER, 1988, 1989 AND 1990.</u>

| INDEX | YY | NN | YN | NY | TOTAL | CORRECT | FS % | PTI % | PTII % | IR | RANK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AI | 21 | 18 | 48 | 3 | 90 | 39 | 43 | 14 | 70 | 1 | 20 |
| AHI | 20 | 20 | 46 | 4 | 90 | 40 | 44 | 17 | 70 | -7 | 22 |
| ADI | 24 | 15 | 51 | 0 | 90 | 39 | 43 | 0 | 68 | 43 | 5 |
| $LI_1$ | 22 | 18 | 48 | 2 | 90 | 40 | 44 | 10 | 69 | 14 | 17 |
| $LHI_1$ | 23 | 21 | 45 | 1 | 90 | 44 | 49 | 5 | 66 | 34 | 9 |
| $LDI_1$ | 24 | 20 | 46 | 0 | 90 | 44 | 49 | 0 | 66 | 49 | 1 |
| $LI_2$ | 17 | 27 | 39 | 7 | 90 | 44 | 49 | 21 | 70 | -14 | 23 |
| $LHI_2$ | 19 | 26 | 40 | 5 | 90 | 45 | 50 | 16 | 68 | 2 | 19 |
| $LDI_2$ | 21 | 31 | 35 | 3 | 90 | 52 | 58 | 9 | 63 | 31 | 12 |
| $SI_1$ | 22 | 21 | 45 | 2 | 90 | 43 | 48 | 9 | 67 | 21 | 16 |
| $SHI_1$ | 23 | 21 | 45 | 1 | 90 | 44 | 49 | 5 | 66 | 34 | 9 |
| $SDI_1$ | 25 | 31 | 30 | 4 | 90 | 56 | 62 | 11 | 55 | 29 | 13 |
| $SI_2$ | 20 | 24 | 42 | 4 | 90 | 44 | 49 | 14 | 68 | 7 | 18 |
| $SHI_2$ | 23 | 23 | 43 | 1 | 90 | 46 | 51 | 4 | 65 | 39 | 6 |
| $SDI_2$ | 24 | 36 | 25 | 5 | 90 | 60 | 67 | 12 | 51 | 31 | 11 |
| $KI_1$ | 26 | 29 | 32 | 3 | 90 | 55 | 61 | 9 | 55 | 34 | 7 |
| $KI_2$ | 26 | 35 | 26 | 3 | 90 | 61 | 68 | 8 | 50 | 44 | 3 |
| $TTI_1$ | 26 | 24 | 37 | 3 | 90 | 50 | 56 | 11 | 59 | 23 | 15 |
| $TTHI_1$ | 26 | 26 | 35 | 3 | 90 | 52 | 58 | 10 | 57 | 28 | 14 |
| $TTDI_1$ | 27 | 30 | 31 | 2 | 90 | 57 | 63 | 6 | 53 | 45 | 2 |
| $TTI_2$ | 24 | 29 | 32 | 5 | 90 | 53 | 59 | 21 | 57 | -4 | 21 |
| $TTHI_2$ | 26 | 29 | 32 | 3 | 90 | 55 | 61 | 9 | 55 | 34 | 7 |
| $TTDI_2$ | 28 | 22 | 39 | 1 | 90 | 50 | 56 | 4 | 58 | 44 | 4 |

with 33. The $SHI_2$ was very closely followed by $TTDI_1$ and $TTI_2$ each with an IR of 32. The overall result may be surprising at first glance due to the fact that the $TTDI_2$ was never ranked among the top 2 during any season. However, looking again at Tables 6, 10, 14 and 19 it should not be surprising at all, because it is observed that the $TTDI_2$, by far, performed more consistently than any other Index throughout the whole period of study, being ranked $3^{rd}$ in the warm dry, long rainy and cool and dry seasons and $7^{th}$ in the short rainy season. Even during the short rainy season, despite having been ranked $7^{th}$, it was ranked $6^{th}$ and $4^{th}$ in October and November respectively. This is a remarkable performance especially when compared to that of the other Indices. For example, the $SHI_2$, ranked $2^{nd}$ overall best, was ranked $2^{nd}$, $9^{th}$ $5^{th}$ and $17^{th}$ respectively, in the corresponding seasons. It should be noted that the $LI_1$, the only Index being used in the area of study, was ranked $19^{th}$ in the overall results. It is therefore recommended that the $TTDI_2$ be used alongside the two selected for each season, and if only two are required it should be used with the one selected as most suitable for each season. In case only one Index is required for use throughout the year, then it should be the $TTDI_2$.

TABLE 22: COMPARISON OF THE OVERALL PERFORMANCES OF THE STABILITY INDICES DURING 1988,1989 AND 1990.

| INDEX | YY | NN | YN | NY | TOTAL | CORRECT | FS % | PTI % | PTII % | IR | RANK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AI | 191 | 300 | 404 | 81 | 976 | 491 | 50 | 21 | 68 | -13 | 23 |
| AHI | 195 | 347 | 359 | 75 | 976 | 542 | 56 | 18 | 65 | 2 | 22 |
| ADI | 234 | 274 | 432 | 36 | 976 | 508 | 52 | 12 | 64 | 16 | 20 |
| $LI_1$ | 241 | 247 | 459 | 29 | 976 | 488 | 50 | 11 | 66 | 17 | 19 |
| $LHI_1$ | 240 | 298 | 409 | 29 | 976 | 538 | 55 | 9 | 63 | 28 | 10 |
| $LDI_1$ | 228 | 351 | 356 | 41 | 976 | 579 | 59 | 10 | 61 | 29 | 7 |
| $LI_2$ | 224 | 296 | 410 | 46 | 976 | 520 | 53 | 13 | 65 | 14 | 21 |
| $LHI_2$ | 228 | 340 | 366 | 42 | 976 | 568 | 58 | 11 | 62 | 25 | 15 |
| $LDI_2$ | 218 | 401 | 305 | 52 | 976 | 619 | 63 | 11 | 58 | 30 | 5 |
| $SI_1$ | 235 | 282 | 424 | 35 | 976 | 517 | 53 | 11 | 64 | 20 | 18 |
| $SHI_1$ | 237 | 323 | 383 | 33 | 976 | 560 | 57 | 9 | 62 | 30 | 6 |
| $SDI_1$ | 210 | 442 | 259 | 65 | 976 | 652 | 67 | 13 | 55 | 28 | 8 |
| $SI_2$ | 225 | 350 | 356 | 45 | 976 | 575 | 59 | 11 | 61 | 26 | 14 |
| $SHI_2$ | 226 | 384 | 321 | 45 | 976 | 610 | 63 | 10 | 59 | 33 | 2 |
| $SDI_2$ | 194 | 484 | 217 | 81 | 976 | 678 | 69 | 14 | 53 | 27 | 11 |
| $KI_1$ | 201 | 460 | 241 | 74 | 976 | 661 | 68 | 14 | 55 | 26 | 13 |
| $KI_2$ | 200 | 474 | 227 | 75 | 976 | 674 | 69 | 14 | 53 | 27 | 11 |
| $TTI_1$ | 240 | 285 | 416 | 35 | 976 | 525 | 54 | 11 | 63 | 21 | 17 |
| $TTHI_1$ | 228 | 370 | 331 | 47 | 976 | 598 | 61 | 11 | 59 | 28 | 9 |
| $TTDI_1$ | 222 | 413 | 288 | 53 | 976 | 635 | 65 | 11 | 56 | 32 | 3 |
| $TTI_2$ | 233 | 370 | 330 | 43 | 976 | 603 | 62 | 10 | 59 | 32 | 4 |
| $TTHI_2$ | 219 | 389 | 312 | 56 | 976 | 608 | 62 | 13 | 59 | 23 | 16 |
| $TTDI_2$ | 240 | 383 | 318 | 35 | 976 | 623 | 63 | 8 | 57 | 39 | 1 |

3.1.2 CATEGORY B - PREDICTION OF THE LIKELIHOOD OF PRECIPITATION.

The objective in this category was to select Indices which give the greatest number of correct predictions (i.e, with the highest forecasting skills) with the least possible errors. They could then be used as independent forecasting tools in comparison with or to complement the other forecasting guides being used to forecast late afternoon or early evening precipitation in the Nairobi and sorrounding area. Threshold values i.e, the values below or above which precipitation is likely are shown in Table 5.

3.1.2.1 THE WARM DRY SEASON

Most Indices performed quite well during this season with 16 having an Index Predictability (IP) above 30 and all,but one,a forecasting skill (FS) of at least 60% as shown in Table 23. It was difficult to select the most suitable among the 5 top ranked Indices because all had an IP ranging from 44.5 to 43.5 and FS of either 76% or 75%. In addition, the 5 performed almost equally consistently during the season with the $TTHI_2$ having the edge over the others having been ranked $4^{th}$, $1^{st}$ and 6th in December, January and February respectively, as shown in Tables 24 25 and 26. It was closely followed by the $TTHI_1$ which

*TABLE 23:* COMPARISON FO THE PERFORMANCES OF THE STABILITY INDICES DURING THE WARM DRY SEASONS OF 1988, 1989 AND 1990.

| INDEX | YY | NN | YN | NY | TOTAL | CORRECT | FS % | PTI % | PTII % | IP | RANK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AI | 37 | 139 | 68 | 27 | 271 | 176 | 65 | 16 | 65 | 24.5 | 19 |
| AHI | 44 | 145 | 62 | 20 | 271 | 189 | 70 | 12 | 58 | 35 | 12 |
| ADI | 46 | 152 | 55 | 18 | 271 | 198 | 73 | 11 | 54 | 40.5 | 8 |
| $LI_1$ | 34 | 126 | 81 | 30 | 271 | 160 | 59 | 19 | 70 | 14.5 | 23 |
| $LHI_1$ | 45 | 137 | 70 | 19 | 271 | 182 | 67 | 12 | 61 | 30.5 | 15 |
| $LDI_1$ | 46 | 137 | 70 | 18 | 271 | 183 | 68 | 12 | 60 | 32 | 14 |
| $LI_2$ | 24 | 150 | 57 | 40 | 271 | 174 | 64 | 21 | 70 | 18.5 | 21 |
| $LHI_2$ | 39 | 157 | 50 | 25 | 271 | 196 | 72 | 14 | 56 | 37 | 10 |
| $LDI_2$ | 43 | 145 | 62 | 21 | 271 | 188 | 69 | 13 | 59 | 33 | 13 |
| $SI_1$ | 41 | 121 | 86 | 23 | 271 | 162 | 60 | 15 | 68 | 18.5 | 22 |
| $SHI_1$ | 49 | 129 | 78 | 15 | 271 | 178 | 66 | 10 | 61 | 30.5 | 16 |
| $SDI_1$ | 39 | 161 | 46 | 25 | 271 | 200 | 74 | 13 | 54 | 40.5 | 7 |
| $SI_2$ | 39 | 139 | 68 | 25 | 271 | 178 | 66 | 15 | 64 | 26.5 | 18 |
| $SHI_2$ | 44 | 148 | 59 | 20 | 271 | 192 | 71 | 12 | 57 | 36.5 | 11 |
| $SDI_2$ | 36 | 170 | 37 | 28 | 271 | 206 | 76 | 14 | 51 | 43.5 | 4 |
| $KI_1$ | 43 | 154 | 53 | 21 | 271 | 197 | 73 | 12 | 55 | 39.5 | 9 |
| $KI_2$ | 40 | 163 | 44 | 24 | 271 | 203 | 75 | 13 | 52 | 42.5 | 6 |
| $TTI_1$ | 46 | 124 | 83 | 18 | 271 | 170 | 63 | 13 | 64 | 24.5 | 20 |
| $TTHI_1$ | 47 | 157 | 50 | 17 | 271 | 204 | 75 | 10 | 52 | 44 | 2 |
| $TTDI_1$ | 46 | 157 | 50 | 18 | 271 | 203 | 75 | 10 | 52 | 44 | 2 |
| $TTI_2$ | 37 | 146 | 61 | 27 | 271 | 183 | 68 | 16 | 62 | 29 | 17 |
| $TTHI_2$ | 42 | 164 | 43 | 22 | 271 | 206 | 76 | 12 | 51 | 44.5 | 1 |
| $TTDI_2$ | 46 | 156 | 51 | 18 | 271 | 202 | 75 | 10 | 53 | 43.5 | 5 |

TABLE 24: COMPARISON OF THE PERFORMANCES OF THE STABILITY INDICES DURING DECEMBER, 1988, 1989 AND 1990.

| INDEX | YY | NN | YN | NY | TOTAL | CORRECT | FS % | PTI % | PTII % | IP | RANK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AI | 19 | 29 | 35 | 10 | 93 | 48 | 51 | 26 | 65 | 5.5 | 23 |
| AHI | 22 | 29 | 35 | 7 | 93 | 51 | 55 | 19 | 61 | 15 | 16 |
| ADI | 21 | 34 | 30 | 8 | 93 | 55 | 59 | 19 | 59 | 20 | 10 |
| $LI_1$ | 16 | 40 | 24 | 13 | 93 | 56 | 60 | 25 | 60 | 17.5 | 13 |
| $LHI_1$ | 20 | 43 | 21 | 9 | 93 | 63 | 68 | 17 | 51 | 34 | 1 |
| $LDI_1$ | 17 | 36 | 28 | 12 | 93 | 53 | 57 | 25 | 62 | 13.5 | 18 |
| $LI_2$ | 9 | 47 | 17 | 20 | 93 | 56 | 60 | 30 | 65 | 12.5 | 19 |
| $LHI_2$ | 15 | 46 | 18 | 14 | 93 | 61 | 66 | 23 | 51 | 29 | 2 |
| $LDI_2$ | 15 | 38 | 26 | 14 | 93 | 53 | 57 | 27 | 63 | 12 | 20 |
| $SI_1$ | 15 | 39 | 25 | 14 | 93 | 54 | 58 | 22 | 63 | 15.5 | 15 |
| $SHI_1$ | 20 | 37 | 27 | 9 | 93 | 57 | 61 | 20 | 57 | 22.5 | 8 |
| $SDI_1$ | 14 | 43 | 21 | 15 | 93 | 57 | 61 | 26 | 60 | 18 | 12 |
| $SI_2$ | 14 | 41 | 23 | 15 | 93 | 55 | 59 | 27 | 62 | 14.5 | 17 |
| $SHI_2$ | 17 | 42 | 22 | 12 | 93 | 59 | 63 | 22 | 56 | 24 | 4 |
| $SDI_2$ | 12 | 49 | 15 | 17 | 93 | 61 | 66 | 26 | 56 | 25 | 3 |
| $KI_1$ | 15 | 38 | 26 | 14 | 93 | 53 | 57 | 27 | 63 | 12 | 20 |
| $KI_2$ | 15 | 44 | 20 | 14 | 93 | 59 | 63 | 24 | 57 | 22.5 | 7 |
| $TTI_1$ | 17 | 38 | 26 | 12 | 93 | 55 | 59 | 24 | 60 | 17 | 14 |
| $TTHI_1$ | 19 | 39 | 25 | 10 | 93 | 58 | 63 | 20 | 57 | 23.5 | 6 |
| $TTDI_1$ | 16 | 41 | 23 | 13 | 93 | 57 | 61 | 24 | 59 | 19.5 | 11 |
| $TTI_2$ | 12 | 39 | 25 | 17 | 93 | 51 | 55 | 30 | 68 | 6 | 22 |
| $TTHI_2$ | 17 | 42 | 22 | 12 | 93 | 59 | 63 | 22 | 56 | 24 | 4 |
| $TTDI_2$ | 17 | 41 | 23 | 12 | 93 | 58 | 62 | 23 | 58 | 21.5 | 9 |

TABLE 25: COMPARISON OF THE PERFORMANCES OF THE STABILITY INDICES DURING JANUARY,1988, 1989 AND 1990.

| INDEX | YY | NN | YN | NY | TOTAL | CORRECT | FS % | PTI % | PTII % | IP | RANK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AI | 8 | 52 | 20 | 13 | 93 | 60 | 65 | 20 | 71 | 19.5 | 22 |
| AHI | 11 | 57 | 15 | 10 | 93 | 68 | 73 | 15 | 58 | 36.5 | 16 |
| ADI | 14 | 55 | 17 | 7 | 93 | 69 | 74 | 11 | 55 | 41 | 11 |
| $LI_1$ | 11 | 42 | 30 | 10 | 93 | 53 | 57 | 19 | 73 | 11 | 23 |
| $LHI_1$ | 18 | 49 | 23 | 3 | 93 | 67 | 72 | 6 | 56 | 41 | 12 |
| $LDI_1$ | 17 | 46 | 26 | 4 | 93 | 63 | 68 | 8 | 60 | 34 | 19 |
| $LI_2$ | 9 | 58 | 14 | 12 | 93 | 67 | 72 | 17 | 61 | 33 | 20 |
| $LHI_2$ | 15 | 57 | 15 | 6 | 93 | 72 | 77 | 10 | 50 | 47 | 6 |
| $LDI_2$ | 16 | 50 | 22 | 5 | 93 | 66 | 71 | 9 | 58 | 37.5 | 14 |
| $SI_1$ | 15 | 44 | 28 | 6 | 93 | 59 | 63 | 12 | 65 | 24.5 | 21 |
| $SHI_1$ | 18 | 47 | 25 | 3 | 93 | 65 | 70 | 6 | 58 | 38 | 13 |
| $SDI_1$ | 16 | 55 | 17 | 5 | 93 | 71 | 76 | 8 | 52 | 46 | 7 |
| $SI_2$ | 14 | 53 | 19 | 7 | 93 | 67 | 72 | 12 | 58 | 37 | 15 |
| $SHI_2$ | 17 | 53 | 19 | 4 | 93 | 70 | 75 | 7 | 53 | 45 | 8 |
| $SDI_2$ | 15 | 59 | 13 | 6 | 93 | 74 | 80 | 9 | 46 | 52.5 | 2 |
| $KI_1$ | 16 | 54 | 18 | 5 | 93 | 70 | 75 | 8 | 53 | 44.5 | 9 |
| $KI_2$ | 14 | 56 | 16 | 7 | 93 | 70 | 75 | 11 | 53 | 43 | 10 |
| $TTI_1$ | 18 | 45 | 27 | 3 | 93 | 63 | 68 | 6 | 60 | 35 | 18 |
| $TTHI_1$ | 17 | 56 | 16 | 4 | 93 | 73 | 78 | 7 | 48 | 50.5 | 3 |
| $TTDI_1$ | 18 | 54 | 18 | 3 | 93 | 72 | 77 | 5 | 50 | 49.5 | 4 |
| $TTI_2$ | 15 | 51 | 21 | 6 | 93 | 66 | 71 | 11 | 58 | 36.5 | 17 |
| $TTHI_2$ | 15 | 60 | 12 | 6 | 93 | 75 | 81 | 9 | 44 | 54.5 | 1 |
| $TTDI_2$ | 18 | 54 | 18 | 3 | 93 | 72 | 77 | 5 | 50 | 49.5 | 4 |

TABLE 26: <u>COMPARISON OF THE PERFORMANCES OF THE STABILITY INDICES DURING FEBRUARY 1988, 1989 AND 1990.</u>

| INDEX | YY | NN | YN | NY | TOTAL | CORRECT | FS % | PTI % | PTII % | IP | RANK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AI | 10 | 58 | 13 | 4 | 85 | 68 | 80 | 6 | 57 | 48.5 | 12 |
| AHI | 11 | 59 | 12 | 3 | 85 | 70 | 82 | 5 | 52 | 53.5 | 10 |
| ADI | 11 | 63 | 8 | 3 | 85 | 74 | 87 | 5 | 42 | 63.5 | 3 |
| $LI_1$ | 7 | 44 | 27 | 7 | 85 | 51 | 60 | 14 | 79 | 13.5 | 22 |
| $LHI_1$ | 7 | 45 | 26 | 7 | 85 | 52 | 61 | 13 | 79 | 15 | 21 |
| $LDI_1$ | 12 | 55 | 16 | 2 | 85 | 67 | 79 | 4 | 57 | 48.5 | 13 |
| $LI_2$ | 6 | 45 | 26 | 8 | 85 | 51 | 60 | 15 | 81 | 12 | 23 |
| $LHI_2$ | 9 | 54 | 17 | 5 | 85 | 63 | 74 | 8 | 65 | 37.5 | 16 |
| $LDI_2$ | 12 | 57 | 14 | 2 | 85 | 69 | 81 | 3 | 54 | 52.5 | 11 |
| $SI_1$ | 11 | 38 | 33 | 3 | 85 | 49 | 58 | 7 | 75 | 17 | 20 |
| $SHI_1$ | 11 | 45 | 26 | 3 | 85 | 56 | 66 | 6 | 70 | 28 | 17 |
| $SDI_1$ | 9 | 63 | 8 | 5 | 85 | 72 | 85 | 7 | 47 | 58 | 8 |
| $SI_2$ | 11 | 45 | 26 | 3 | 85 | 56 | 66 | 6 | 70 | 28 | 17 |
| $SHI_2$ | 10 | 53 | 18 | 4 | 85 | 63 | 74 | 7 | 64 | 38.5 | 15 |
| $SDI_2$ | 9 | 62 | 9 | 5 | 85 | 71 | 84 | 7 | 50 | 55.5 | 9 |
| $KI_1$ | 12 | 62 | 9 | 2 | 85 | 74 | 87 | 3 | 43 | 64 | 1 |
| $KI_2$ | 11 | 63 | 8 | 3 | 85 | 74 | 87 | 5 | 42 | 63.5 | 3 |
| $TTI_1$ | 11 | 41 | 30 | 3 | 85 | 52 | 61 | 7 | 73 | 21 | 19 |
| $TTHI_1$ | 11 | 62 | 9 | 3 | 85 | 73 | 86 | 5 | 45 | 61 | 5 |
| $TTDI_1$ | 12 | 62 | 9 | 2 | 85 | 74 | 87 | 3 | 43 | 64 | 1 |
| $TTI_2$ | 10 | 56 | 15 | 4 | 85 | 66 | 78 | 7 | 60 | 44.5 | 14 |
| $TTHI_2$ | 10 | 62 | 9 | 4 | 85 | 72 | 85 | 6 | 47 | 58.5 | 6 |
| $TTDI_2$ | 11 | 61 | 10 | 3 | 85 | 72 | 85 | 5 | 48 | 58.5 | 6 |

was ranked $6^{th}$, $3^{rd}$ and $5^{th}$ respectively in the corresponding months. The $SDI_2$ and $TTDI_1$ were ranked $3^{rd}$, $2^{nd}$, $9^{th}$ and $11^{th}$, $4^{th}$, $1^{st}$ respectively in the corresponding months. Since the $TTHI_2$ and $TTHI_1$ are essentially the same Indices, the $TTHI_2$ and $SDI_2$ were selected for this season. It should be recalled that the $TTHI_2$ was ranked overall best during the same season in category A and the $SHI_2$, a sister Index to $SDI_2$, was then ranked $2^{nd}$. It should also be noted that like in cateogry A, the $LI_1$ was ranked $23^{rd}$.

3.1.2.2 THE LONG RAINY SEASON

In general, the Indices performed reasonably well unlike in category A. As shown in Table 27, 9 Indices had an IP of at least 30 and 18 with an FS above 60%. The most outstanding performance was that of the $TTHI_2$ with an IP of 39.5 and FS of 70%. In addition, it performed most consistently during the season having ranked $2^{nd}$, $4^{th}$ and $5^{th}$ in March, April and May respectively, as shown in Tables 28, 29 and 30. The $KI_1$ and $KI_2$ were ranked $2^{nd}$ and $3^{rd}$ with an IP of 36.5 and 36 respectively, and each with an FS of 68%. The two also performed almost equally consistently being ranked $7^{th}$, $5^{th}$, $1^{st}$ and $11^{th}$, $2^{nd}$, $2^{nd}$ respectively, in March, April and May.

*TABLE 27:* <u>COMPARISON OF THE PERFORMANCES OF THE STABILITY INDICES DURING THE LONG RAINY SEASONS OF 1988 AND 1990.</u>

| INDEX | YY | NN | YN | NY | TOTAL | CORRECT | FS % | PTI % | PTII % | IP | RANK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AI | 55 | 32 | 66 | 31 | 184 | 87 | 47 | 49 | 55 | - 5 | 23 |
| AHI | 52 | 41 | 57 | 34 | 184 | 93 | 51 | 45 | 52 | 2.5 | 22 |
| ADI | 53 | 60 | 38 | 33 | 184 | 113 | 61 | 35 | 42 | 22.5 | 18 |
| $LI_1$ | 46 | 62 | 36 | 40 | 184 | 108 | 59 | 39 | 44 | 17.5 | 20 |
| $LHI_1$ | 63 | 59 | 39 | 23 | 184 | 122 | 66 | 28 | 38 | 33 | 6 |
| $LDI_1$ | 61 | 57 | 41 | 25 | 184 | 118 | 64 | 30 | 40 | 29 | 10 |
| $LI_2$ | 49 | 66 | 32 | 37 | 184 | 115 | 63 | 36 | 40 | 25 | 17 |
| $LHI_2$ | 60 | 65 | 33 | 26 | 184 | 125 | 68 | 29 | 35 | 36 | 3 |
| $LDI_2$ | 57 | 58 | 40 | 29 | 184 | 115 | 63 | 33 | 41 | 26 | 11 |
| $SI_1$ | 61 | 47 | 51 | 25 | 184 | 108 | 59 | 35 | 46 | 18.5 | 19 |
| $SHI_1$ | 67 | 47 | 51 | 19 | 184 | 114 | 62 | 29 | 43 | 26 | 16 |
| $SDI_1$ | 54 | 62 | 36 | 32 | 184 | 116 | 63 | 34 | 40 | 26 | 11 |
| $SI_2$ | 58 | 49 | 49 | 28 | 184 | 107 | 58 | 36 | 46 | 17 | 21 |
| $SHI_2$ | 70 | 53 | 45 | 16 | 184 | 123 | 67 | 23 | 39 | 36 | 5 |
| $SDI_2$ | 50 | 66 | 32 | 36 | 184 | 116 | 63 | 35 | 39 | 26 | 11 |
| $KI_1$ | 59 | 67 | 31 | 27 | 184 | 126 | 68 | 29 | 34 | 36.5 | 2 |
| $KI_2$ | 59 | 66 | 32 | 27 | 184 | 125 | 68 | 29 | 35 | 36 | 3 |
| $TTI_1$ | 58 | 57 | 41 | 28 | 184 | 115 | 63 | 33 | 41 | 26 | 11 |
| $TTHI_1$ | 58 | 64 | 34 | 28 | 184 | 122 | 66 | 30 | 37 | 32.5 | 7 |
| $TTDI_1$ | 51 | 65 | 33 | 35 | 184 | 116 | 63 | 35 | 39 | 26 | 11 |
| $TTI_2$ | 55 | 65 | 33 | 31 | 184 | 120 | 65 | 32 | 38 | 30 | 8 |
| $TTHI_2$ | 57 | 71 | 27 | 29 | 184 | 128 | 70 | 29 | 32 | 39.5 | 1 |
| $TTDI_2$ | 56 | 64 | 34 | 30 | 184 | 120 | 65 | 32 | 38 | 30 | 8 |

TABLE 28: COMPARISON OF THE PERFORMANCES OF THE STABILITY INDICES DURING MARCH,1988 AND 1990.

| INDEX | YY | NN | YN | NY | TOTAL | CORRECT | FS % | PTI % | PTII % | IP | RANK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AI | 17 | 16 | 17 | 12 | 62 | 33 | 53 | 43 | 50 | 6.5 | 23 |
| AHI | 18 | 18 | 15 | 11 | 62 | 36 | 58 | 38 | 45 | 16.5 | 21 |
| ADI | 19 | 22 | 11 | 10 | 62 | 41 | 66 | 31 | 37 | 32 | 10 |
| $LI_1$ | 18 | 18 | 15 | 11 | 62 | 36 | 58 | 38 | 45 | 16.5 | 21 |
| $LHI_1$ | 25 | 18 | 15 | 4 | 62 | 43 | 69 | 18 | 38 | 41 | 5 |
| $LDI_1$ | 21 | 20 | 13 | 8 | 62 | 41 | 66 | 29 | 38 | 32.5 | 9 |
| $LI_2$ | 18 | 19 | 14 | 11 | 62 | 37 | 60 | 37 | 44 | 19.5 | 19 |
| $LHI_2$ | 26 | 20 | 13 | 3 | 62 | 46 | 74 | 13 | 33 | 51 | 1 |
| $LDI_2$ | 21 | 17 | 16 | 8 | 62 | 38 | 61 | 32 | 43 | 23.5 | 16 |
| $SI_1$ | 23 | 15 | 18 | 6 | 62 | 38 | 61 | 29 | 44 | 24.5 | 15 |
| $SHI_1$ | 25 | 15 | 18 | 4 | 62 | 40 | 65 | 21 | 42 | 33.5 | 8 |
| $SDI_1$ | 18 | 21 | 2 | 11 | 62 | 39 | 63 | 34 | 40 | 26 | 13 |
| $SI_2$ | 21 | 15 | 18 | 8 | 62 | 36 | 58 | 35 | 46 | 17.5 | 20 |
| $SHI_2$ | 26 | 17 | 16 | 3 | 62 | 43 | 69 | 15 | 38 | 38.5 | 6 |
| $SDI_2$ | 17 | 21 | 12 | 12 | 62 | 38 | 61 | 36 | 41 | 22.5 | 18 |
| $KI_1$ | 21 | 20 | 13 | 9 | 62 | 42 | 68 | 28 | 36 | 36 | 7 |
| $KI_2$ | 20 | 20 | 13 | 9 | 62 | 40 | 65 | 31 | 39 | 30 | 11 |
| $TTI_1$ | 24 | 20 | 13 | 5 | 62 | 44 | 71 | 20 | 35 | 43.5 | 3 |
| $TTHI_1$ | 22 | 22 | 11 | 7 | 62 | 44 | 71 | 24 | 33 | 42.5 | 4 |
| $TTDI_1$ | 18 | 21 | 12 | 11 | 62 | 39 | 63 | 34 | 40 | 26 | 13 |
| $TTI_2$ | 21 | 19 | 14 | 8 | 62 | 40 | 65 | 30 | 40 | 30 | 11 |
| $TTHI_2$ | 22 | 24 | 9 | 7 | 62 | 46 | 74 | 23 | 29 | 48 | 2 |
| $TTDI_2$ | 20 | 18 | 15 | 9 | 62 | 38 | 61 | 33 | 43 | 23 | 17 |

TABLE 29: COMPARISON OF THE PERFORMANCES OF THE STABILITY INDICES DURING APRIL, 1988 AND 1990.

| INDEX | YY | NN | YN | NY | TOTAL | CORRECT | FS % | PTI % | PTII % | IP | RANK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AI | 20 | 7 | 20 | 13 | 60 | 27 | 45 | 65 | 50 | - 12.5 | 22 |
| AHI | 20 | 7 | 20 | 13 | 60 | 27 | 45 | 65 | 50 | - 12.5 | 22 |
| ADI | 17 | 15 | 12 | 16 | 60 | 32 | 53 | 52 | 41 | 6.5 | 21 |
| $LI_1$ | 20 | 16 | 11 | 13 | 60 | 36 | 60 | 45 | 35 | 20 | 17 |
| $LHI_1$ | 26 | 14 | 13 | 7 | 60 | 40 | 67 | 33 | 33 | 34 | 7 |
| $LDI_1$ | 25 | 13 | 14 | 8 | 60 | 38 | 63 | 38 | 36 | 26 | 15 |
| $LI_2$ | 21 | 17 | 10 | 12 | 60 | 38 | 63 | 41 | 32 | 26.5 | 14 |
| $LHI_2$ | 25 | 16 | 11 | 8 | 60 | 41 | 68 | 33 | 31 | 36 | 5 |
| $LDI_2$ | 25 | 15 | 12 | | 60 | 40 | 67 | 35 | 32 | 33.5 | 8 |
| $SI_1$ | 24 | 11 | 16 | 9 | 60 | 35 | 58 | 45 | 40 | 15.5 | 18 |
| $SHI_1$ | 29 | 10 | 17 | 4 | 60 | 39 | 65 | 29 | 37 | 32 | 9 |
| $SDI_1$ | 24 | 15 | 12 | 9 | 60 | 39 | 65 | 38 | 33 | 29.5 | 13 |
| $SI_2$ | 23 | 10 | 17 | 10 | 60 | 33 | 55 | 50 | 43 | 8.5 | 20 |
| $SHI_2$ | 31 | 12 | 15 | 2 | 60 | 43 | 72 | 14 | 33 | 48.5 | 1 |
| $SDI_2$ | 22 | 17 | 10 | 11 | 60 | 39 | 65 | 39 | 30 | 30.5 | 10 |
| $KI_1$ | 24 | 17 | 10 | 9 | 60 | 41 | 68 | 35 | 29 | 36 | 5 |
| $KI_2$ | 25 | 18 | 9 | 8 | 60 | 43 | 72 | 31 | 26 | 43.5 | 2 |
| $TTI_1$ | 22 | 11 | 16 | 11 | 60 | 33 | 55 | 50 | 42 | 9 | 19 |
| $TTHI_1$ | 25 | 14 | 13 | 8 | 60 | 39 | 65 | 36 | 34 | 30 | 12 |
| $TTDI_1$ | 22 | 16 | 11 | 11 | 60 | 38 | 63 | 41 | 33 | 26 | 15 |
| $TTI_2$ | 22 | 17 | 10 | 11 | 60 | 39 | 65 | 39 | 30 | 30.5 | 10 |
| $TTHI_2$ | 25 | 17 | 10 | 8 | 60 | 42 | 70 | 32 | 29 | 39.5 | 4 |
| $TTDI_2$ | 25 | 18 | 9 | 8 | 60 | 43 | 72 | 31 | 26 | 43.5 | 2 |

TABLE 30: COMPARISON OF THE PERFORMANCES OF THE STABILITY INDICES DURING MAY, 1988 AND 1990.

| INDEX | YY | NN | YN | NY | TOTAL | CORRECT | FS % | PTI % | PTII % | IP | RANK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AI | 18 | 9 | 29 | 6 | 62 | 27 | 44 | 40 | 61 | - 6.5 | 23 |
| AHI | 14 | 16 | 22 | 10 | 62 | 30 | 48 | 38 | 61 | - 1.5 | 22 |
| ADI | 17 | 23 | 15 | 7 | 62 | 40 | 65 | 23 | 47 | 30 | 4 |
| $LI_1$ | 8 | 28 | 10 | 16 | 62 | 36 | 58 | 36 | 56 | 12 | 20 |
| $LHI_1$ | 12 | 27 | 11 | 12 | 62 | 39 | 63 | 31 | 50 | 22.5 | 12 |
| $LDI_1$ | 15 | 27 | 11 | 12 | 62 | 39 | 63 | 27 | 48 | 25.5 | 7 |
| $LI_2$ | 10 | 30 | 8 | 14 | 62 | 40 | 65 | 33 | 44 | 27 | 5 |
| $LHI_2$ | 9 | 29 | 9 | 15 | 62 | 38 | 61 | 34 | 50 | 19 | 16 |
| $LDI_2$ | 11 | 26 | 12 | 13 | 62 | 37 | 60 | 33 | 52 | 17.5 | 18 |
| $SI_1$ | 14 | 21 | 17 | 10 | 62 | 35 | 56 | 32 | 55 | 12.5 | 19 |
| $SHI_1$ | 13 | 22 | 16 | 11 | 62 | 35 | 56 | 33 | 55 | 12 | 21 |
| $SDI_1$ | 12 | 26 | 12 | 12 | 62 | 38 | 61 | 32 | 50 | 20 | 14 |
| $SI_2$ | 14 | 24 | 14 | 10 | 62 | 38 | 61 | 29 | 50 | 21.5 | 13 |
| $SHI_2$ | 13 | 24 | 14 | 11 | 62 | 37 | 60 | 31 | 52 | 18.5 | 17 |
| $SDI_2$ | 11 | 28 | 10 | 13 | 62 | 39 | 63 | 22 | 48 | 23 | 8 |
| $KI_1$ | 14 | 29 | 9 | 10 | 62 | 43 | 69 | 26 | 39 | 36.5 | 1 |
| $KI_2$ | 14 | 28 | 10 | 10 | 62 | 42 | 68 | 26 | 42 | 34 | 2 |
| $TTI_1$ | 12 | 26 | 12 | 12 | 62 | 38 | 61 | 32 | 50 | 20 | 14 |
| $TTHI_1$ | 11 | 28 | 10 | 13 | 62 | 39 | 63 | 32 | 48 | 23 | 8 |
| $TTDI_1$ | 11 | 28 | 10 | 13 | 62 | 39 | 63 | 32 | 48 | 23 | 8 |
| $TTI_2$ | 12 | 29 | 9 | 12 | 62 | 41 | 66 | 29 | 43 | 30 | 3 |
| $TTHI_2$ | 10 | 30 | 8 | 14 | 62 | 40 | 65 | 32 | 44 | 27 | 5 |
| $TTDI_2$ | 11 | 28 | 10 | 13 | 62 | 39 | 63 | 32 | 48 | 23 | 8 |

Since $KI_1$ and $KI_2$ are basically the same Indices, either could be selected together with the $TTHI_2$ as the most suitable for this season. It's noteworthy that the $TTI_2$ from which the $TTHI_2$ is derived was among the two selected for the same season in category A.

### 3.1.2.3 THE COOL AND DRY SEASON

Like in category A, this is the season when most Indices perform their best. As observed in Table 31, all the Indices but 3, had an IP above 30,of which,15 were greater than 40. Again all but 3, had an FS above 75%,of which,13 were at least 80%. Unlike in category A, it was not difficult to select the Index with the best seasonal performance. Evidently, the $KI_2$ with and IP of 54 and FS 82% performed overall best. In addition, it had the most consistent performance during the season being ranked $2^{nd}$, $1^{st}$, $14^{th}$ and $3^{rd}$ in June, July, August and September respectively as shown in Tables 32, 33, 34 and 35. It is important to note that, though ranked $14^{th}$ in August, it had an FS of 80% as compared to the overall best Index during the month which had one of 83%. Though it was relatively easy to select the most suitable Index, it was not so for the second best as the next 4 performed with nearly the same accuracy and consistency. However,

TABLE 31: COMPARISON OF THE PERFORMANCES OF THE STABILITY INDICES DURING THE COOLD AND DRY SEASONS OF 1988, 1989 AND 1990.

| INDEX | YY | NN | YN | NY | TOTAL | CORRECT | FS % | PTI % | PTII % | IP | RANK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AI | 17 | 182 | 95 | 48 | 342 | 199 | 58 | 21 | 85 | 5 | 23 |
| AHI | 16 | 212 | 65 | 49 | 342 | 228 | 67 | 19 | 80 | 17.5 | 22 |
| ADI | 19 | 216 | 62 | 45 | 342 | 235 | 69 | 17 | 77 | 22 | 21 |
| $LI_1$ | 21 | 244 | 33 | 44 | 342 | 265 | 77 | 15 | 61 | 39 | 17 |
| $LHI_1$ | 24 | 252 | 25 | 41 | 342 | 276 | 81 | 14 | 51 | 48.5 | 2 |
| $LDI_1$ | 28 | 247 | 30 | 37 | 342 | 275 | 80 | 13 | 52 | 47.5 | 3 |
| $LI_2$ | 13 | 246 | 31 | 52 | 342 | 259 | 76 | 17 | 70 | 32.5 | 20 |
| $LHI_2$ | 18 | 252 | 25 | 47 | 342 | 270 | 79 | 16 | 58 | 42 | 15 |
| $LDI_2$ | 23 | 250 | 27 | 42 | 342 | 273 | 80 | 14 | 54 | 46 | 7 |
| $SI_1$ | 17 | 255 | 22 | 48 | 342 | 272 | 80 | 16 | 56 | 44 | 11 |
| $SHI_1$ | 20 | 246 | 31 | 45 | 342 | 266 | 78 | 15 | 61 | 40 | 16 |
| $SDI_1$ | 14 | 262 | 15 | 51 | 342 | 276 | 81 | 16 | 52 | 47 | 4 |
| $SI_2$ | 12 | 261 | 16 | 53 | 342 | 273 | 80 | 17 | 57 | 43 | 13 |
| $SHI_2$ | 16 | 256 | 21 | 49 | 342 | 272 | 80 | 16 | 58 | 43 | 13 |
| $SDI_2$ | 12 | 264 | 13 | 53 | 342 | 276 | 81 | 17 | 52 | 46.5 | 6 |
| $KI_1$ | 14 | 262 | 15 | 51 | 342 | 276 | 81 | 16 | 52 | 47 | 4 |
| $KI_2$ | 12 | 269 | 8 | 53 | 342 | 281 | 82 | 16 | 40 | 54 | 1 |
| $TTI_1$ | 25 | 244 | 33 | 40 | 342 | 269 | 79 | 14 | 57 | 43.5 | 12 |
| $TTHI_1$ | 21 | 234 | 43 | 44 | 342 | 255 | 75 | 16 | 67 | 33.5 | 19 |
| $TTDI_1$ | 19 | 253 | 24 | 46 | 324 | 272 | 80 | 15 | 56 | 44.5 | 10 |
| $TTI_2$ | 20 | 353 | 24 | 45 | 342 | 273 | 80 | 15 | 55 | 45 | 9 |
| $TTHI_2$ | 18 | 241 | 36 | 47 | 342 | 259 | 76 | 16 | 67 | 34.5 | 18 |
| $TTDI_2$ | 22 | 252 | 25 | 43 | 342 | 274 | 80 | 15 | 53 | 46 | 7 |

TABLE 32: COMPARISON OF THE PERFORMANCES OF THE STABILITY INDICES DURING JUNE, 1988, 1989 AND 1990.

| INDEX | YY | NN | YN | NY | TOTAL | CORRECT | FS % | PTI % | PTII % | IP | RANK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AI | 2 | 38 | 24 | 3 | 67 | 40 | 60 | 7 | 92 | 10.5 | 23 |
| AHI | 2 | 48 | 14 | 3 | 67 | 50 | 75 | 6 | 88 | 28 | 22 |
| ADI | 1 | 51 | 11 | 4 | 67 | 52 | 78 | 7 | 92 | 28.5 | 21 |
| $LI_1$ | 1 | 55 | 7 | 4 | 67 | 56 | 84 | 7 | 88 | 36.5 | 18 |
| $LHI_1$ | 2 | 57 | 5 | 3 | 67 | 59 | 88 | 5 | 71 | 50 | 9 |
| $LDI_1$ | 2 | 58 | 4 | 3 | 67 | 60 | 90 | 5 | 67 | 54 | 7 |
| $LI_2$ | 1 | 54 | 8 | 4 | 67 | 55 | 82 | 7 | 89 | 34 | 20 |
| $LHI_2$ | 2 | 57 | 5 | 3 | 67 | 59 | 88 | 5 | 71 | 50 | 9 |
| $LDI_2$ | 1 | 58 | 4 | 4 | 67 | 59 | 88 | 6 | 80 | 45 | 14 |
| $SI_1$ | 2 | 57 | 5 | 3 | 67 | 59 | 88 | 5 | 71 | 50 | 9 |
| $SHI_1$ | 2 | 56 | 6 | 3 | 67 | 58 | 87 | 5 | 75 | 47 | 12 |
| $SDI_1$ | 1 | 58 | 4 | 4 | 67 | 59 | 88 | 6 | 80 | 45 | 14 |
| $SI_2$ | 0 | 60 | 2 | 5 | 67 | 60 | 90 | 8 | 100 | 36 | 19 |
| $SHI_2$ | 3 | 58 | 4 | 2 | 67 | 61 | 91 | 3 | 57 | 61 | 3 |
| $SDI_2$ | 2 | 59 | 3 | 3 | 67 | 61 | 91 | 5 | 60 | 58.5 | 5 |
| $KI_1$ | 2 | 58 | 4 | 3 | 67 | 60 | 90 | 5 | 67 | 54 | 7 |
| $KI_2$ | 2 | 60 | 2 | 3 | 67 | 62 | 93 | 5 | 50 | 65.5 | 2 |
| $TTI_1$ | 2 | 56 | 6 | 3 | 67 | 58 | 87 | 5 | 75 | 47 | 12 |
| $TTHI_1$ | 3 | 58 | 4 | 2 | 67 | 61 | 91 | 3 | 57 | 61 | 3 |
| $TTDI_1$ | 1 | 57 | 5 | 4 | 67 | 58 | 87 | 7 | 83 | 42 | 16 |
| $TTI_2$ | 1 | 57 | 5 | 4 | 67 | 58 | 87 | 7 | 83 | 42 | 16 |
| $TTHI_2$ | 3 | 59 | 3 | 2 | 67 | 62 | 93 | 3 | 50 | 66.5 | 1 |
| $TTDI_2$ | 2 | 59 | 3 | 3 | 67 | 61 | 91 | 5 | 60 | 58.5 | 5 |

TABLE 33: COMPARISON OF THE PERFORMANCES OF THE STABILITY INDICES DURING JULY , 1988, 1989 AND 1990.

| INDEX | YY | NN | YN | NY | TOTAL | CORRECT | FS % | PTI % | PTII % | IP | RANK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AI | 4 | 53 | 24 | 12 | 93 | 57 | 61 | 18 | 86 | 9 | 23 |
| AHI | 3 | 58 | 19 | 13 | 93 | 61 | 66 | 18 | 86 | 14 | 22 |
| ADI | 4 | 59 | 19 | 11 | 93 | 63 | 68 | 16 | 83 | 18.5 | 20 |
| $LI_1$ | 2 | 66 | 11 | 14 | 93 | 68 | 73 | 18 | 85 | 21.5 | 16 |
| $LHI_1$ | 3 | 72 | 15 | 13 | 93 | 75 | 81 | 15 | 63 | 42 | 2 |
| $LDI_1$ | 5 | 69 | 8 | 11 | 93 | 74 | 80 | 14 | 62 | 42 | 3 |
| $LI_2$ | 1 | 69 | 8 | 15 | 93 | 70 | 75 | 18 | 89 | 21.5 | 15 |
| $LHI_2$ | 2 | 70 | 7 | 14 | 93 | 72 | 77 | 17 | 78 | 29.5 | 12 |
| $LDI_2$ | 3 | 68 | 9 | 13 | 93 | 71 | 76 | 16 | 75 | 30.5 | 11 |
| $SI_1$ | 1 | 68 | 9 | 15 | 93 | 69 | 74 | 18 | 90 | 20 | 19 |
| $SHI_1$ | 2 | 66 | 11 | 14 | 93 | 68 | 73 | 18 | 85 | 21.5 | 16 |
| $SDI_1$ | 1 | 72 | 5 | 15 | 93 | 73 | 78 | 17 | 83 | 28 | 13 |
| $SI_2$ | 3 | 70 | 6 | 14 | 93 | 73 | 78 | 17 | 67 | 36 | 8 |
| $SHI_2$ | 2 | 71 | 6 | 14 | 93 | 73 | 78 | 16 | 75 | 32.5 | 10 |
| $SDI_2$ | 2 | 72 | 5 | 14 | 93 | 74 | 80 | 16 | 71 | 36.5 | 7 |
| $KI_1$ | 2 | 73 | 4 | 14 | 93 | 75 | 81 | 16 | 67 | 39.5 | 6 |
| $KI_2$ | 2 | 76 | 1 | 14 | 93 | 78 | 84 | 16 | 33 | 59.5 | 1 |
| $TTI_1$ | 4 | 62 | 15 | 12 | 93 | 66 | 71 | 16 | 79 | 23.5 | 14 |
| $TTHI_1$ | 3 | 61 | 16 | 13 | 93 | 64 | 69 | 18 | 84 | 18 | 21 |
| $TTDI_1$ | 4 | 67 | 10 | 12 | 93 | 71 | 76 | 15 | 71 | 33 | 9 |
| $TTI_2$ | 5 | 69 | 8 | 11 | 93 | 74 | 80 | 14 | 62 | 42 | 3 |
| $TTHI_2$ | 3 | 63 | 14 | 13 | 93 | 66 | 71 | 17 | 82 | 21.5 | 18 |
| $TTDI_2$ | 5 | 69 | 8 | 11 | 93 | 74 | 80 | 14 | 62 | 42 | 3 |

TABLE 34: COMPARISON OF THE PERFORMANCES OF THE STABILITY INDICES DURING AUGUST, 1988, 1989 AND 1990.

| INDEX | YY | NN | YN | NY | TOTAL | CORRECT | FS % | PTI % | PTII % | IP | RANK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AI | 6 | 48 | 27 | 12 | 93 | 54 | 58 | 20 | 82 | 7 | 23 |
| AHI | 6 | 53 | 22 | 12 | 93 | 59 | 63 | 18 | 79 | 14.5 | 22 |
| ADI | 7 | 55 | 20 | 11 | 93 | 62 | 67 | 17 | 74 | 21.5 | 21 |
| $LI_1$ | 6 | 69 | 6 | 12 | 93 | 75 | 81 | 15 | 50 | 48.5 | 5 |
| $LHI_1$ | 5 | 70 | 5 | 13 | 93 | 75 | 81 | 16 | 50 | 48 | 6 |
| $LDI_1$ | 10 | 65 | 10 | 8 | 93 | 75 | 81 | 11 | 50 | 50.5 | 3 |
| $LI_2$ | 4 | 66 | 9 | 14 | 93 | 70 | 75 | 18 | 69 | 31.5 | 18 |
| $LHI_2$ | 4 | 68 | 7 | 14 | 93 | 72 | 77 | 17 | 64 | 36.5 | 17 |
| $LDI_2$ | 7 | 67 | 8 | 11 | 93 | 74 | 80 | 14 | 53 | 46.5 | 12 |
| $SI_1$ | 4 | 73 | 2 | 14 | 93 | 77 | 83 | 16 | 33 | 58.5 | 1 |
| $SHI_1$ | 4 | 71 | 4 | 14 | 93 | 75 | 81 | 16 | 50 | 48 | 6 |
| $SDI_1$ | 3 | 72 | 3 | 15 | 93 | 75 | 81 | 17 | 50 | 47.5 | 11 |
| $SI_2$ | 3 | 73 | 3 | 14 | 93 | 76 | 82 | 16 | 50 | 49 | 4 |
| $SHI_2$ | 4 | 69 | 6 | 14 | 93 | 73 | 78 | 17 | 60 | 39.5 | 16 |
| $SDI_2$ | 3 | 71 | 4 | 15 | 93 | 74 | 80 | 17 | 57 | 43 | 13 |
| $KI_1$ | 4 | 71 | 4 | 14 | 93 | 75 | 81 | 16 | 50 | 48 | 6 |
| $KI_2$ | 2 | 72 | 3 | 16 | 93 | 74 | 80 | 18 | 60 | 41 | 14 |
| $TTI_1$ | 4 | 72 | 3 | 14 | 93 | 76 | 82 | 16 | 43 | 52.5 | 2 |
| $TTHI_1$ | 4 | 66 | 9 | 14 | 93 | 70 | 75 | 18 | 69 | 31.5 | 18 |
| $TTDI_1$ | 4 | 71 | 4 | 14 | 93 | 75 | 81 | 16 | 50 | 48 | 6 |
| $TTI_2$ | 4 | 71 | 4 | 14 | 93 | 75 | 81 | 16 | 50 | 48 | 6 |
| $TTHI_2$ | 2 | 66 | 9 | 16 | 93 | 68 | 73 | 20 | 82 | 22 | 20 |
| $TTDI_2$ | 5 | 68 | 7 | 13 | 93 | 73 | 78 | 16 | 58 | 41 | 15 |

TABLE 35: COMPARISON OF THE PERFORMANCES OF THE STABILITY INDICES DURING SEPTEMBER, 1988, 1989 AND 1990.

| INDEX | YY | NN | YN | NY | TOTAL | CORRECT | FS % | PTI % | PTII % | IP | RANK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AI | 5 | 43 | 20 | 21 | 89 | 48 | 54 | 33 | 80 | - 2.5 | 23 |
| AHI | 5 | 53 | 10 | 21 | 89 | 58 | 65 | 28 | 67 | 17.5 | 22 |
| ADI | 7 | 51 | 12 | 19 | 89 | 58 | 65 | 27 | 63 | 20 | 21 |
| $LI_1$ | 12 | 54 | 9 | 14 | 89 | 66 | 74 | 21 | 43 | 42 | 14 |
| $LHI_1$ | 14 | 53 | 10 | 12 | 89 | 67 | 75 | 18 | 42 | 45 | 8 |
| $LDI_1$ | 11 | 55 | 8 | 15 | 89 | 66 | 74 | 21 | 42 | 42.5 | 11 |
| $LI_2$ | 7 | 57 | 6 | 19 | 89 | 64 | 72 | 25 | 46 | 36.5 | 17 |
| $LHI_2$ | 10 | 57 | 6 | 16 | 89 | 67 | 75 | 22 | 38 | 45 | 8 |
| $LDI_2$ | 12 | 57 | 6 | 14 | 89 | 69 | 78 | 20 | 33 | 51.5 | 3 |
| $SI_1$ | 10 | 57 | 6 | 16 | 89 | 67 | 75 | 22 | 38 | 45 | 7 |
| $SHI_1$ | 12 | 53 | 10 | 14 | 89 | 65 | 73 | 21 | 45 | 40 | 15 |
| $SDI_1$ | 9 | 60 | 3 | 17 | 89 | 69 | 78 | 22 | 25 | 54.5 | 1 |
| $SI_2$ | 6 | 58 | 5 | 20 | 89 | 64 | 72 | 26 | 45 | 36.5 | 17 |
| $SHI_2$ | 7 | 58 | 5 | 19 | 89 | 65 | 73 | 25 | 42 | 39.5 | 16 |
| $SDI_2$ | 5 | 62 | 1 | 21 | 89 | 67 | 75 | 25 | 17 | 54 | 2 |
| $KI_1$ | 6 | 60 | 3 | 20 | 89 | 66 | 74 | 25 | 33 | 45 | 10 |
| $KI_2$ | 6 | 61 | 2 | 20 | 89 | 67 | 75 | 25 | 25 | 50 | 5 |
| $TTI_1$ | 15 | 54 | 9 | 11 | 89 | 69 | 78 | 17 | 38 | 50.5 | 4 |
| $TTHI_1$ | 11 | 49 | 14 | 15 | 89 | 60 | 67 | 23 | 56 | 27.5 | 20 |
| $TTDI_1$ | 10 | 58 | 5 | 16 | 89 | 68 | 76 | 22 | 33 | 48.5 | 6 |
| $TTI_2$ | 10 | 56 | 7 | 16 | 89 | 66 | 74 | 22 | 41 | 42.5 | 11 |
| $TTHI_2$ | 10 | 53 | 10 | 16 | 89 | 63 | 71 | 23 | 50 | 34.5 | 19 |
| $TTDI_2$ | 10 | 56 | 7 | 16 | 89 | 66 | 74 | 22 | 41 | 42.5 | 11 |

the $LHI_1$ had an edge over the others having been ranked overall second with an IP and FS of 48.5 and 81% respectively, in addition to being 9th, 2nd, 6th and 8th in June, July, August and September respectively. It should be noted that there was no significant difference between the performances of the $LHI_1$ and $LDI_1$ and therefore either could have been selected. The $LDI_1$ had an IP and FS of 47.5 and 80% respectively and was ranked 7th, 3rd, 3rd and 11th in June, July, August and September respectively. It should also be noted that the $LDI_2$, which is basically the same as $LDI_1$, was ranked overall best for the same season in category A.

### 3.1.2.4 THE SHORT RAINY SEASON

Generally, the Indices performed reasonably well unlike in category A. As seen in Table 36, 15 Indices had an IP greater than 30% and all, but 3, an FS above 60%. Like in category A, the Indices evaluated using the 500mb level generally performed better than their counterparts using the 450mb level. It was relatively hard to select the best two from the 4 top ranked Indices as all had an IP ranging from 37.5 to 41.5 and FS from 71% to 73%. However, by taking consistency into account, the $TTHI_1$ had an edge over the others, having been ranked 8th and 2nd in October and November respectively, as shown

TABLE 36: COMPARISON OF THE PERFORMANCES OF THE STABILITY INDICES DURING THE SHORT RAINY SEASONS OF 1988, 1989 AND 1990.

| INDEX | YY | NN | YN | NY | TOTAL | CORRECT | FS % | PTI % | PTII % | IP | RANK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AI | 31 | 60 | 64 | 24 | 179 | 91 | 51 | 29 | 67 | 3 | 23 |
| AHI | 31 | 71 | 53 | 24 | 179 | 102 | 57 | 25 | 63 | 13 | 22 |
| ADI | 34 | 72 | 52 | 21 | 179 | 106 | 59 | 23 | 60 | 17.5 | 19 |
| $LI_1$ | 22 | 103 | 21 | 33 | 179 | 125 | 70 | 24 | 49 | 33.5 | 8 |
| $LHI_1$ | 33 | 97 | 27 | 22 | 179 | 130 | 73 | 18 | 45 | 41.5 | 1 |
| $LDI_1$ | 34 | 90 | 34 | 21 | 179 | 124 | 69 | 19 | 50 | 34.5 | 7 |
| $LI_2$ | 11 | 103 | 21 | 44 | 179 | 114 | 64 | 30 | 66 | 16 | 21 |
| $LHI_2$ | 25 | 101 | 23 | 30 | 179 | 126 | 70 | 23 | 48 | 34.5 | 6 |
| $LDI_2$ | 29 | 94 | 30 | 26 | 179 | 123 | 69 | 22 | 51 | 32.5 | 11 |
| $SI_1$ | 32 | 87 | 37 | 23 | 179 | 119 | 66 | 21 | 54 | 28.5 | 16 |
| $SHI_1$ | 37 | 82 | 42 | 18 | 179 | 119 | 66 | 18 | 53 | 30.5 | 15 |
| $SDI_1$ | 31 | 92 | 32 | 24 | 179 | 123 | 69 | 21 | 51 | 33 | 9 |
| $SI_2$ | 19 | 95 | 29 | 36 | 179 | 114 | 64 | 27 | 60 | 20.5 | 18 |
| $SHI_2$ | 25 | 92 | 32 | 30 | 179 | 117 | 65 | 25 | 56 | 24.5 | 17 |
| $SDI_2$ | 25 | 99 | 25 | 30 | 179 | 124 | 69 | 23 | 50 | 32.5 | 11 |
| $KI_1$ | 31 | 91 | 27 | 30 | 179 | 122 | 68 | 25 | 47 | 32 | 14 |
| $KI_2$ | 25 | 98 | 26 | 30 | 179 | 123 | 69 | 23 | 51 | 32 | 13 |
| $TTI_1$ | 35 | 87 | 37 | 20 | 179 | 122 | 68 | 19 | 51 | 33 | 10 |
| $TTHI_1$ | 34 | 95 | 29 | 21 | 179 | 129 | 72 | 18 | 46 | 40 | 2 |
| $TTDI_1$ | 33 | 94 | 30 | 24 | 179 | 127 | 71 | 19 | 48 | 37.5 | 4 |
| $TTI_2$ | 17 | 95 | 29 | 38 | 179 | 112 | 63 | 29 | 63 | 17 | 20 |
| $TTHI_2$ | 30 | 98 | 26 | 25 | 179 | 128 | 72 | 20 | 46 | 39 | 3 |
| $TTDI_2$ | 29 | 96 | 28 | 26 | 179 | 125 | 70 | 21 | 49 | 35 | 5 |

TABLE 37: COMPARISON OF THE PERFORMANCES OF THE STABILITY INDICES DURING OCTOBER, 1988, 1989, AND 1990.

| INDEX | YY | NN | YN | NY | TOTAL | CORRECT | FS % | PTI % | PTII % | IP | RANK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AI | 12 | 35 | 23 | 19 | 89 | 47 | 53 | 35 | 66 | 2.5 | 23 |
| AHI | 13 | 43 | 15 | 18 | 89 | 56 | 63 | 30 | 54 | 21 | 17 |
| ADI | 14 | 39 | 19 | 17 | 89 | 53 | 60 | 30 | 58 | 16 | 20 |
| $LI_1$ | 15 | 53 | 5 | 16 | 89 | 68 | 76 | 23 | 25 | 52 | 2 |
| $LHI_1$ | 20 | 50 | 8 | 11 | 89 | 70 | 79 | 17 | 29 | 56 | 1 |
| $LDI_1$ | 19 | 49 | 9 | 12 | 89 | 68 | 76 | 20 | 32 | 50 | 3 |
| $LI_2$ | 7 | 48 | 10 | 24 | 89 | 55 | 62 | 33 | 59 | 16 | 19 |
| $LHI_2$ | 13 | 50 | 8 | 18 | 89 | 63 | 71 | 26 | 38 | 39 | 7 |
| $LDI_2$ | 16 | 47 | 11 | 15 | 89 | 63 | 71 | 24 | 41 | 38.5 | 8 |
| $SI_1$ | 19 | 44 | 14 | 12 | 89 | 63 | 71 | 21 | 42 | 39.5 | 6 |
| $SHI_1$ | 20 | 42 | 16 | 11 | 89 | 62 | 70 | 21 | 44 | 37.5 | 11 |
| $SDI_1$ | 15 | 47 | 11 | 16 | 89 | 62 | 70 | 25 | 42 | 36.5 | 12 |
| $SI_2$ | 7 | 46 | 12 | 24 | 89 | 53 | 60 | 34 | 63 | 11.5 | 22 |
| $SHI_2$ | 11 | 44 | 14 | 20 | 89 | 55 | 62 | 30 | 56 | 19 | 18 |
| $SDI_2$ | 9 | 49 | 9 | 22 | 89 | 58 | 65 | 31 | 50 | 24.5 | 15 |
| $KI_1$ | 15 | 48 | 10 | 16 | 89 | 63 | 71 | 25 | 40 | 38.5 | 8 |
| $KI_2$ | 10 | 50 | 8 | 21 | 89 | 60 | 67 | 30 | 44 | 30 | 14 |
| $TTI_1$ | 22 | 42 | 16 | 9 | 89 | 64 | 72 | 18 | 42 | 42 | 5 |
| $TTHI_1$ | 15 | 48 | 10 | 16 | 89 | 63 | 71 | 25 | 40 | 38.5 | 8 |
| $TTDI_1$ | 17 | 49 | 9 | 14 | 89 | 66 | 74 | 22 | 35 | 45.5 | 4 |
| $TTI_2$ | 8 | 45 | 13 | 23 | 89 | 53 | 60 | 34 | 62 | 12 | 21 |
| $TTHI_2$ | 12 | 46 | 12 | 19 | 89 | 58 | 65 | 29 | 50 | 22.5 | 16 |
| $TTDI_2$ | 12 | 48 | 10 | 19 | 89 | 60 | 67 | 28 | 45 | 30.5 | 13 |

TABLE 38: COMPARISON OF THE PERFORMANCES OF THE STABILITY INDICES DURING NOVEMBER, 1988, 1989, AND 1990.

| INDEX | YY | NN | YN | NY | TOTAL | CORRECT | FS % | PTI % | PTII % | IP | RANK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AI | 19 | 25 | 41 | 5 | 90 | 44 | 49 | 17 | 68 | 6.5 | 23 |
| AHI | 18 | 28 | 38 | 6 | 90 | 46 | 51 | 18 | 68 | 8 | 22 |
| ADI | 20 | 33 | 33 | 4 | 90 | 53 | 59 | 11 | 62 | 22.5 | 17 |
| $LI_1$ | 7 | 50 | 16 | 17 | 90 | 57 | 63 | 25 | 70 | 15.5 | 21 |
| $LHI_1$ | 13 | 47 | 19 | 11 | 90 | 60 | 67 | 19 | 59 | 28 | 11 |
| $LDI_1$ | 15 | 41 | 25 | 9 | 90 | 56 | 62 | 18 | 63 | 21.5 | 18 |
| $LI_2$ | 4 | 55 | 11 | 20 | 90 | 59 | 66 | 27 | 73 | 16 | 20 |
| $LHI_2$ | 12 | 51 | 15 | 12 | 90 | 63 | 70 | 19 | 56 | 32.5 | 6 |
| $LDI_2$ | 13 | 47 | 19 | 11 | 90 | 60 | 67 | 19 | 59 | 28 | 11 |
| $SI_1$ | 13 | 43 | 23 | 11 | 90 | 56 | 62 | 20 | 64 | 20 | 19 |
| $SHI_1$ | 17 | 40 | 26 | 7 | 90 | 57 | 63 | 15 | 60 | 25.5 | 14 |
| $SDI_1$ | 16 | 45 | 21 | 8 | 90 | 61 | 68 | 15 | 57 | 32 | 8 |
| $SI_2$ | 12 | 49 | 17 | 12 | 90 | 61 | 68 | 20 | 59 | 28.5 | 10 |
| $SHI_2$ | 14 | 48 | 18 | 10 | 90 | 62 | 69 | 17 | 56 | 32.5 | 7 |
| $SDI_2$ | 16 | 50 | 16 | 8 | 90 | 66 | 73 | 14 | 50 | 41 | 3 |
| $KI_1$ | 16 | 43 | 17 | 14 | 90 | 59 | 66 | 25 | 52 | 27.5 | 13 |
| $KI_2$ | 15 | 48 | 18 | 9 | 90 | 63 | 70 | 16 | 55 | 34.5 | 5 |
| $TTI_1$ | 13 | 45 | 21 | 11 | 90 | 58 | 64 | 20 | 62 | 23 | 15 |
| $TTHI_1$ | 19 | 47 | 19 | 5 | 90 | 66 | 73 | 10 | 50 | 43 | 2 |
| $TTDI_1$ | 16 | 45 | 21 | 8 | 90 | 61 | 68 | 15 | 57 | 32 | 8 |
| $TTI_2$ | 9 | 50 | 16 | 15 | 90 | 59 | 66 | 23 | 64 | 22.5 | 16 |
| $TTHI_2$ | 18 | 52 | 14 | 6 | 90 | 70 | 78 | 10 | 44 | 51 | 1 |
| $TTDI_2$ | 17 | 48 | 18 | 7 | 90 | 65 | 72 | 13 | 51 | 40 | 4 |

in Tables 37 and 38. Though the $LHI_1$ and $TTHI_1$ were ranked overall best and second respectively, in the seasonal results, the latter was more consistent considering that the $LHI_1$ was ranked $1^{st}$ and $11^{th}$ in October and November respectively. Therefore the $TTHI_1$ and $LHI_1$ were selected for this season. It's noteworthy that the $LHI_1$ was ranked overall best during the same season in category A. It is also observed from Table 36 that there was no singificant difference in the performances of $TTHI_1$ and $TTHI_2$ and therefore either could have been selected.

3.1.2.5 OVERALL PERFORMANCES OF THE INDICES

The overall results are shown in Table 39. The performances of the 9 top ranked Indices were so close that it was quite difficult to select the best two among them. The 9 Indices had an IP ranging from 40 to 43.5 and FS from 73% to 75%. The selection was based on consistency. Even then, the performances were still very close particularly, betweent he $KI_2$, $TTDI_2$, $LHI_1$ and $TTHI_2$ as shown in Table 40. However, if one Index has to be selected for use throughout the year, then the $KI_2$, which just managed to have an edge over the others, should be the one. On the other hand, it is observed from Table 40 that the exclusion of the warm dry season would favour the $LHI_1$ into being the most suitable, and that of the cool and dry season favours the $TTHI_2$ while that of the short rainy season would favour the $KI_2$. Therefore, if a minimum number of Indices is required for use throughout the year, then the most logical decision to make is that the $KI_2$ and $TTHI_2$ be used throughout the year except during the short rainy and cool and dry seasons when respectively, the $LHI_1$ should be substituted for each. Tables 41 and 42 were constructed to justify this decision. Table 41 shows the overall performances of the Indices during the whole period of study with the exclusion of the short rainy season. It is clear from the table that the $kI_2$ is the undisputed overall best followed by $KI_1$ and $TTDI_2$. Table 42 shows the overall performances of the Indices with the exclusion of the cool and dry season. The table clearly shows the $TTHI_2$ as the overall best followed respectively, by the $TTHI_1$ and $TTDI_2$. Since the $KI_1$ and $KI_2$ are basically the same just as the $TTHI_1$ and $TTHI_2$ are, it leaves the $TTDI_2$ as the overall second best according to tables 41 and 42. Moreover, the $TTDI_2$ was ranked second best in the overall results shown in Table 39 and in addition, Table 40 portrays it as the most consistent single Index throughout the four seasons of the year. It is therefore recommended that the $TTDI_2$ be used throughout the year alongside those already selected for each season. It's noteworthy that the $TTDI_2$ was ranked the overall best in category A.

TABLE 39: COMPARISON OF THE OVERALL PERFORMANCES OF THE STABILITY INDICES DURING 1988, 1989 AND 1990.

| INDEX | YY | NN | YN | NY | TOTAL | CORRECT | FS % | PTI % | PTII % | IP | RANK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AI | 140 | 413 | 293 | 130 | 976 | 553 | 57 | 24 | 68 | 11 | 23 |
| AHI | 143 | 469 | 237 | 127 | 976 | 612 | 63 | 21 | 62 | 21.5 | 22 |
| ADI | 152 | 500 | 207 | 117 | 976 | 652 | 67 | 19 | 58 | 28.5 | 18 |
| $LI_1$ | 123 | 535 | 171 | 147 | 976 | 658 | 67 | 22 | 58 | 27 | 19 |
| $LHI_1$ | 165 | 545 | 161 | 105 | 976 | 710 | 73 | 16 | 49 | 40.5 | 7 |
| $LDI_1$ | 169 | 531 | 175 | 101 | 976 | 700 | 72 | 16 | 51 | 38.5 | 11 |
| $LI_2$ | 97 | 565 | 141 | 173 | 976 | 662 | 68 | 23 | 59 | 27 | 20 |
| $LHI_2$ | 142 | 575 | 131 | 128 | 976 | 717 | 73 | 18 | 48 | 40 | 8 |
| $LDI_2$ | 152 | 547 | 159 | 118 | 976 | 699 | 72 | 18 | 51 | 37.5 | 13 |
| $SI_1$ | 151 | 510 | 196 | 119 | 976 | 661 | 68 | 19 | 56 | 30.5 | 17 |
| $SHI_1$ | 173 | 504 | 202 | 97 | 976 | 677 | 69 | 16 | 54 | 34 | 14 |
| $SDI_1$ | 138 | 577 | 129 | 132 | 976 | 715 | 73 | 19 | 48 | 39.5 | 10 |
| $SI_2$ | 128 | 544 | 162 | 142 | 976 | 672 | 69 | 21 | 56 | 30.5 | 16 |
| $SHI_2$ | 155 | 549 | 157 | 115 | 976 | 704 | 72 | 17 | 50 | 38.5 | 11 |
| $SDI_2$ | 123 | 599 | 107 | 147 | 976 | 722 | 74 | 20 | 47 | 40.5 | 5 |
| $KI_1$ | 147 | 574 | 126 | 129 | 976 | 721 | 74 | 18 | 46 | 42 | 2 |
| $KI_2$ | 136 | 596 | 110 | 134 | 976 | 732 | 75 | 18 | 45 | 43.5 | 1 |
| $TTI_1$ | 164 | 512 | 194 | 106 | 976 | 676 | 69 | 17 | 54 | 33.5 | 16 |
| $TTHI_1$ | 160 | 550 | 156 | 110 | 976 | 710 | 73 | 17 | 49 | 40 | 8 |
| $TTDI_1$ | 149 | 569 | 137 | 121 | 976 | 718 | 74 | 18 | 49 | 40.5 | 5 |
| $TTI_2$ | 129 | 559 | 147 | 141 | 976 | 688 | 70 | 20 | 53 | 33.5 | 15 |
| $TTHI_2$ | 147 | 574 | 132 | 123 | 976 | 721 | 74 | 18 | 47 | 41.5 | 4 |
| $TTDI_2$ | 153 | 568 | 138 | 117 | 976 | 721 | 74 | 17 | 47 | 42 | 2 |

TABLE 40: <u>COMPARISON OF THE CONSISTENCY OF THE PERFORMANCES OF THE 9 TOP RANKED STABILITY INDICES DURING 1988, 1989 AND 1990</u>.

| | INDEX AND RANK | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| SEASON | $KI_2$ | $TTHI_2$ | $TTDI_2$ | $KI_1$ | $SDI_2$ | $TTDI_1$ | $TTHI_1$ | $LHI_1$ | $LHI_2$ |
| WARM DRY | 6 | 1 | 5 | 9 | 4 | 2 | 2 | 15 | 10 |
| LONG RAINY | 3 | 1 | 8 | 2 | 11 | 11 | 7 | 6 | 3 |
| COOL AND DRY | 1 | 18 | 7 | 4 | 6 | 10 | 19 | 2 | 15 |
| SHORT RAINY | 13 | 3 | 5 | 14 | 11 | 4 | 2 | 1 | 6 |
| RANK SUM | 23 | 23 | 25 | 29 | 32 | 27 | 30 | 24 | 34 |

TABLE 41: COMPARISON OF OVERALL PERFORMANCES OF THE INDICES DURING THE WARM DRY, LONG RAINY AND COOL AND DRY SEASONS OF 1988, 1989 AND 1990.

| INDEX | YY | NN | YN | NY | TOTAL | CORRECT | FS % | PTI % | PTII % | IP | RANK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AI | 109 | 353 | 229 | 106 | 797 | 462 | 58 | 23 | 68 | 12.5 | 23 |
| AHI | 112 | 398 | 184 | 103 | 797 | 510 | 64 | 21 | 62 | 22.5 | 22 |
| ADI | 118 | 428 | 155 | 96 | 797 | 546 | 69 | 18 | 57 | 31.5 | 18 |
| $LI_1$ | 101 | 432 | 150 | 114 | 797 | 533 | 67 | 21 | 60 | 26.5 | 21 |
| $LHI_1$ | 132 | 448 | 134 | 83 | 797 | 580 | 73 | 16 | 50 | 40 | 10 |
| $LDI_1$ | 135 | 441 | 141 | 80 | 797 | 576 | 72 | 15 | 51 | 39 | 12 |
| $LI_2$ | 86 | 462 | 120 | 129 | 797 | 548 | 69 | 22 | 58 | 29 | 20 |
| $LHI_2$ | 117 | 474 | 108 | 98 | 797 | 591 | 74 | 17 | 48 | 41.5 | 5 |
| $LDI_2$ | 123 | 453 | 129 | 92 | 797 | 576 | 72 | 17 | 51 | 38 | 13 |
| $SI_1$ | 119 | 423 | 159 | 96 | 797 | 542 | 68 | 18 | 57 | 30.5 | 19 |
| $SHI_1$ | 136 | 422 | 160 | 79 | 797 | 558 | 70 | 16 | 54 | 35 | 15 |
| $SDI_1$ | 107 | 485 | 97 | 108 | 797 | 592 | 74 | 18 | 48 | 41 | 9 |
| $SI_2$ | 109 | 449 | 133 | 106 | 797 | 558 | 70 | 19 | 55 | 33 | 17 |
| $SHI_2$ | 130 | 457 | 125 | 85 | 797 | 587 | 74 | 16 | 49 | 41.5 | 5 |
| $SDI_2$ | 98 | 500 | 82 | 117 | 797 | 598 | 75 | 19 | 46 | 42.5 | 4 |
| $KI_1$ | 116 | 483 | 99 | 99 | 797 | 599 | 75 | 17 | 46 | 43.5 | 2 |
| $KI_2$ | 111 | 498 | 84 | 104 | 797 | 609 | 76 | 17 | 43 | 46 | 1 |
| $TTI_1$ | 129 | 425 | 157 | 86 | 797 | 554 | 70 | 17 | 55 | 34 | 16 |
| $TTHI_1$ | 126 | 455 | 127 | 89 | 797 | 581 | 73 | 16 | 50 | 40 | 10 |
| $TTDI_1$ | 116 | 475 | 107 | 99 | 797 | 591 | 74 | 17 | 48 | 41.5 | 5 |
| $TTI_2$ | 112 | 464 | 118 | 103 | 797 | 576 | 72 | 18 | 51 | 37.5 | 14 |
| $TTHI_2$ | 117 | 476 | 106 | 98 | 797 | 593 | 74 | 17 | 48 | 41.5 | 5 |
| $TTDI_2$ | 124 | 472 | 110 | 91 | 797 | 596 | 75 | 16 | 47 | 43.5 | 2 |

TABLE 42: COMPARISON OF THE OVERALL PERFORMANCES OF THE INDICES DURING THE WARM DRY, LONG RAINY AND SHORT RAINY SEASONS OF 1988, 1989 AND 1990.

| INDEX | YY | NN | YN | NY | TOTAL | CORRECT | FS % | PTI % | PTII % | IP | RANK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AI | 123 | 231 | 198 | 82 | 634 | 354 | 56 | 26 | 62 | 12 | 23 |
| AHI | 127 | 257 | 172 | 78 | 634 | 384 | 61 | 23 | 58 | 20.5 | 21 |
| ADI | 133 | 284 | 145 | 72 | 634 | 417 | 66 | 20 | 52 | 30 | 14 |
| $LI_1$ | 102 | 291 | 138 | 103 | 634 | 393 | 62 | 26 | 58 | 20 | 22 |
| $LHI_1$ | 141 | 293 | 136 | 64 | 634 | 434 | 68 | 18 | 49 | 34.5 | 10 |
| $LDI_1$ | 141 | 284 | 145 | 64 | 634 | 425 | 67 | 18 | 51 | 32.5 | 12 |
| $LI_2$ | 84 | 319 | 110 | 121 | 634 | 403 | 64 | 28 | 57 | 21.5 | 20 |
| $LHI_2$ | 124 | 323 | 106 | 81 | 634 | 447 | 71 | 20 | 46 | 38 | 5 |
| $LDI_2$ | 129 | 297 | 132 | 76 | 634 | 426 | 67 | 20 | 51 | 31.5 | 13 |
| $SI_1$ | 134 | 255 | 174 | 71 | 634 | 389 | 61 | 22 | 56 | 22 | 19 |
| $SHI_1$ | 153 | 258 | 171 | 52 | 634 | 411 | 65 | 17 | 53 | 30 | 15 |
| $SDI_1$ | 124 | 315 | 114 | 81 | 634 | 439 | 69 | 20 | 48 | 35 | 9 |
| $SI_2$ | 116 | 283 | 146 | 89 | 634 | 399 | 63 | 24 | 56 | 23 | 18 |
| $SHI_2$ | 139 | 293 | 136 | 66 | 634 | 432 | 68 | 18 | 49 | 34.5 | 10 |
| $SDI_2$ | 111 | 335 | 94 | 94 | 634 | 446 | 70 | 22 | 46 | 36 | 8 |
| $KI_1$ | 133 | 312 | 111 | 78 | 634 | 445 | 70 | 20 | 45 | 37.5 | 6 |
| $KI_2$ | 124 | 327 | 102 | 81 | 634 | 451 | 71 | 20 | 45 | 38.5 | 3 |
| $TTI_1$ | 139 | 268 | 161 | 66 | 634 | 407 | 64 | 20 | 54 | 27 | 16 |
| $TTHI_1$ | 139 | 316 | 113 | 66 | 634 | 455 | 72 | 17 | 45 | 39.5 | 2 |
| $TTDI_1$ | 130 | 316 | 113 | 75 | 634 | 446 | 70 | 19 | 47 | 37 | 7 |
| $TTI_2$ | 109 | 306 | 123 | 96 | 634 | 415 | 65 | 24 | 53 | 26.5 | 17 |
| $TTHI_2$ | 129 | 333 | 96 | 76 | 634 | 462 | 73 | 19 | 43 | 42 | 1 |
| $TTDI_2$ | 131 | 316 | 113 | 74 | 634 | 447 | 71 | 19 | 46 | 38.5 | 3 |

### 3.1.2.6 GENERAL OBSERVATIONS

It was observed that the moisture incorporating Indices, on the whole, performed better than those whose evaluation is based purely on atmospheric stability, the difference being greatest during the warm dry season. The main reason for this is that, however unstable the atmosphere may be, no cumulus clouds will form in the absence of sufficient moisture. Even if there was sufficient moisture in the lower levels to allow cloud formation, the relatively dry environmental air would be entrained into the ascending saturated cloud layer in the middle and upper levels causing erosion of the cloud. On the other hand, if there is sufficient moisture in the middle and upper levels, the erosion is greatly reduced and cloud growth is enhanced. However, care must be taken in using the moisture incorporating Indices particularly during wet periods experienced mainly in the rainy seasons. These Indices could be quite misleading as already discussed in section 3.1.1.2. In addition, it was observed that there are some occasions when the middle levels of the atmosphere are relatively dry compared to the lower and upper levels. In such a situation, the Indices evaluated using the dew point temeprature depressions at 650mb and 600mb levels may be unrepresentative. The converse could also happen i.e, the middle levels may be relatively moist compared to the lower and upper levels. In a similar manner, the relative humidity at the standard levels of 700mb, 600mb or 500mb may be relatively low at some or all of them compared to that in the intermediate layers of the atmosphere, thus, rendering the Indices incorporating the mean relative humidity unpresentative. Occasionally, the converse also occurs i.e, the relative humidity at some or all the standard levels may be high compared to that of the intermediate levels.

It was observed that the Indices evaluated using the 450mb level generally performed better than their counterparts using the 500mb level, except, during the short rainy season. However, the difference in the performances was generally small and sometimes, e.g, in the case of the "K" Index, insignificant. This could be useful in the event of data missing at one of the levels or obtaining an anomalous Index value when the level is used. In such a case, the alternative level may be used. It was observed that anomalous values do occasionally occur e.g, when a pronounced temperature inversion is present at or near the reference level being used.

It was also noted that the "K" and "Total Totals" Indices have the advantage that their evalaution does not require a plotted sounding and are therefore relatively cheaper, easier and quicker to use in addition to being more accurate as the probability of making computational errors is greatly reduced. It is therefore not surprising that the two were the most successful during the whole period of study.

The Lifted Index ($LI_1$), the only one being used in the area of study, was found unsuitable for use in its present form. However, its modification, the Lifted-Humidity Index ($LHI_1$), may be used satisfactorily during the short rainy and cool and dry seasons.

The Area Index (AI), particularly its modification, the Area-dew point depression Index (ADI), performed much better during the warm dry season than in any other. This may be attributed to the two basic assumptions in its evaluation namely, that the mean mixing ratio of the lowest 100mb layer remains constant from the time of the 2300z ascent to that of the onset of convection during the day, and that the mixing due to the thermal convection leads to the moisture being distributed evenly throughout the layer. These assumptions approximate to the reality when there is minimal diurnal variation in the moisture content of the lower atmosphere and when there is sufficient diurnal surface heating to cause the desired mixing. This is often the case during the warm dry season and hence the comparatively better performance of the Area

Index especially during February. During the rainy seasons, the diurnal moisture content of the atmosphere varies greatly as there is usually abundant moisture and the ground is often wet. Therefore, moisture is readily evaporated into the atmosphere during the day at a rate which depends on the intensity of the diurnal surface heating, humidity in the lower atmosphere and surface wind speed. During the cool and dry season, the diurnal surface heating is usually not sufficient to facilitate the desired mixing.

It was also observed that there is no distinct date or week or even month when the seasons of the year begin or end. Therefore, the forecaster is advised to strictly observe the actual beginning or end of the seasons before changing from using one Index to another. In 1989, for example, the short rainy season extended deep into December. In fact more rainfall and rain days were reported in December than October. Consequently, the Indices recommended for use during the short rainy season peformed better than those for the warm dry season during December, 1989.

### 3.1.2.7 COMPARISON BETWEEN THE PERFORMANCES OF THE SELECTED INDICES AND THE OTHER FORECASTING GUIDES

The performances of the two Indices selected for use during each season were tested,on a monthly basis,using the Chi-square goodness of fit test and compared to those of the forecasting guides used in forecasting afternoon or early evening precipitation in the Nairobi and surrounding area as reported by the daily weather forecast bulletins (WFB) during the years 1988, 1989 and 1990. The comparisons involved the computation of the Chi-square ($\chi_c^2$) and Index Predictability (IP) values of the Indices and guides for each month. The one with the smaller $\chi_c^2$ (or larger IP) value was presumed the better. In addition, any, whose computed Chi-square ($\chi_c^2$) value during any month was larger than the critical Chi-square value for the 0.05 significance level ($\chi_o^2$ .95 = 3.84), was considered to have failed the goodness of fit test for that month and hence declared unsuitable for use during the period. Tables 43, 44 and 45 show the comparisons during each month in 1988, 1989 and 1990 respectively.

The results generally show a great improvement in the accuracy of the forecasts when the Indices are used. In all the 33 months of the period of study, the $\chi_c^2$ values,for both Indices used, were

TABLE 43: COMPARISON OF THE PREDICTIONS BASED ON THE SELECTED STABILITY INDICES AND THOSE OF THE DAILY WEATHER FORECAST BULLETINS (WFB) FOR THE NAIROBI AND SURROUNDING AREA DURING 1988.

| | INDEX | YY | NN | YN | NY | TOTAL | CORRECT | FS % | PTI % | PTII % | $\chi_c^2$ | IP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| JAN. | WFB | 4 | 12 | 14 | 1 | 31 | 16 | 52 | 8 | 78 | 10.97 | 9 |
| | $TTHI_2$ | 3 | 23 | 3 | 2 | 31 | 26 | 84 | 8 | 50 | 1.66 | 55 |
| | $SDI_2$ | 2 | 24 | 2 | 3 | 31 | 26 | 84 | 11 | 50 | 1.33 | 53.5 |
| FEB. | WFB | 1 | 18 | 10 | 0 | 29 | 19 | 66 | 0 | 91 | 9.09 | 20.5 |
| | $TTHI_2$ | 1 | 24 | 4 | 0 | 29 | 25 | 86 | 0 | 80 | 3.20 | 46 |
| | $SDI_2$ | 1 | 25 | 3 | 0 | 29 | 26 | 90 | 0 | 75 | 2.25 | 52.5 |
| MAR. | WFB | 12 | 2 | 16 | 1 | 31 | 14 | 45 | 33 | 57 | 9.48 | 0 |
| | $TTHI_2$ | 12 | 14 | 4 | 1 | 31 | 26 | 84 | 7 | 25 | 1.07 | 68 |
| | $KI_2$ | 13 | 14 | 4 | 0 | 31 | 27 | 87 | 0 | 24 | 0.94 | 75 |
| APR. | WFB | 16 | 0 | 14 | 0 | 30 | 16 | 53 | 0 | 47 | 6.53 | 29.5 |
| | $TTHI_2$ | 9 | 9 | 5 | 7 | 30 | 18 | 60 | 44 | 36 | 4.85 | 20 |
| | $KI_2$ | 9 | 10 | 4 | 7 | 30 | 19 | 63 | 41 | 31 | 4.11 | 27 |
| MAY | WFB | 10 | 3 | 17 | 1 | 31 | 13 | 42 | 25 | 63 | 10.95 | -2 |
| | $TTHI_2$ | 4 | 18 | 2 | 7 | 31 | 22 | 71 | 28 | 33 | 2.63 | 40.5 |
| | $KI_2$ | 6 | 14 | 6 | 5 | 31 | 20 | 65 | 26 | 50 | 4.32 | 27 |
| JUN. | WFB | 0 | 13 | 5 | 2 | 20 | 13 | 65 | 13 | 100 | 5.27 | 8.5 |
| | $LHI_1$ | 1 | 17 | 1 | 1 | 20 | 18 | 90 | 6 | 50 | 0.56 | 62 |
| | $KI_2$ | 1 | 18 | 0 | 1 | 20 | 19 | 95 | 5 | 0 | 0.05 | 92.5 |
| JUL. | WFB | 2 | 21 | 5 | 3 | 31 | 23 | 74 | 13 | 71 | 3.95 | 32 |
| | $LHI_1$ | 1 | 24 | 2 | 4 | 31 | 25 | 81 | 14 | 67 | 1.90 | 40.5 |
| | $KI_2$ | 1 | 26 | 0 | 4 | 31 | 27 | 87 | 13 | 0 | 0.53 | 80.5 |
| AUG. | WFB | 3 | 22 | 3 | 3 | 31 | 25 | 81 | 12 | 50 | 1.89 | 50 |
| | $LHI_1$ | 2 | 24 | 1 | 4 | 31 | 26 | 84 | 14 | 33 | 0.90 | 60.5 |
| | $KI_2$ | 1 | 24 | 1 | 5 | 31 | 25 | 81 | 17 | 50 | 1.36 | 47.5 |
| SEPT. | WFB | 2 | 16 | 7 | 4 | 29 | 18 | 62 | 20 | 78 | 6.24 | 13 |
| | $LHI_1$ | 2 | 16 | 6 | 5 | 29 | 18 | 62 | 24 | 75 | 5.69 | 12.5 |
| | $KI_2$ | 0 | 20 | 2 | 7 | 29 | 20 | 69 | 26 | 100 | 3.31 | 6 |
| OCT. | WFB | 9 | 3 | 13 | 2 | 27 | 12 | 44 | 40 | 59 | 8.48 | -5.5 |
| | $TTHI_1$ | 5 | 13 | 5 | 4 | 27 | 18 | 67 | 24 | 50 | 3.44 | 30 |
| | $LHI_1$ | 6 | 12 | 6 | 3 | 27 | 18 | 67 | 20 | 50 | 3.60 | 32 |
| NOV. | WFB | 8 | 3 | 19 | 0 | 30 | 11 | 37 | 0 | 70 | 13.37 | 2 |
| | $TTHI_1$ | 5 | 15 | 9 | 1 | 30 | 20 | 67 | 6 | 64 | 5.85 | 32 |
| | $LHI_1$ | 3 | 20 | 4 | 3 | 30 | 23 | 77 | 13 | 57 | 2.68 | 42 |
| DEC. | WFB | 9 | 8 | 12 | 2 | 31 | 17 | 55 | 20 | 57 | 7.26 | 16.5 |
| | $TTHI_2$ | 4 | 15 | 7 | 5 | 31 | 19 | 61 | 25 | 64 | 5.70 | 16.5 |
| | $SDI_2$ | 4 | 19 | 3 | 5 | 31 | 23 | 74 | 21 | 43 | 2.33 | 42 |

*TABLE 44: COMPARISON OF THE PREDICTIONS BASED ON THE SELECTED STABILITY INDICES AND THOSE OF THE DAILY WEATHER FORECAST BULLETINS (WFB) FOR THE NAIROBI AND SURROUNDING AREA DURING 1989.*

| | INDEX | YY | NN | YN | NY | TOTAL | CORRECT | FS % | PTI % | PTII % | $\chi_c^2$ | IP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| JAN. | WFB | 8 | 7 | 12 | 4 | 31 | 15 | 48 | 36 | 60 | 8.65 | 0 |
| | $TTHI_2$ | 10 | 12 | 7 | 2 | 31 | 22 | 71 | 14 | 41 | 3.17 | 43.5 |
| | $SDI_2$ | 11 | 10 | 9 | 1 | 31 | 21 | 68 | 9 | 45 | 4.14 | 41 |
| FEB. | WFB | 3 | 18 | 6 | 1 | 28 | 21 | 75 | 5 | 67 | 4.05 | 39 |
| | $TTHI_2$ | 3 | 21 | 3 | 1 | 28 | 24 | 86 | 5 | 50 | 1.55 | 58.5 |
| | $SDI_2$ | 3 | 21 | 3 | 1 | 28 | 24 | 86 | 5 | 50 | 1.55 | 58.5 |
| MAR. | WFB | | | | | | | | | | | |
| | $TTHI_2$ | N | O | | D | A | T | A | – | – | – | – |
| | $KI_2$ | | | | | | | | | | | |
| APR. | WFB | N | O | | D | A | T | A | – | – | – | – |
| | $TTHI_2$ | | | | | | | | | | | |
| | $KI_2$ | | | | | | | | | | | |
| MAY | WFB | | | | | | | | | | | |
| | $TTHI_2$ | | | | | | | | | | | |
| | $KI_2$ | N | O | | D | A | T | A | – | – | – | – |
| JUN. | WFB | 0 | 12 | 5 | 0 | 17 | 12 | 71 | 0 | 100 | 5.00 | 21 |
| | $LHI_1$ | 0 | 15 | 2 | 0 | 17 | 15 | 88 | 0 | 100 | 2.00 | 38 |
| | $KI_2$ | 0 | 16 | 1 | 0 | 17 | 16 | 94 | 0 | 100 | 1.00 | 44 |
| JUL. | WFB | 3 | 16 | 7 | 5 | 31 | 19 | 61 | 24 | 70 | 6.09 | 14 |
| | $LHI_1$ | 2 | 20 | 3 | 6 | 31 | 22 | 71 | 23 | 60 | 3.18 | 29.5 |
| | $KI_2$ | 1 | 22 | 1 | 7 | 31 | 23 | 74 | 24 | 50 | 2.19 | 37 |
| AUG. | WFB | 3 | 12 | 12 | 4 | 31 | 15 | 48 | 25 | 80 | 10.6 | -4.5 |
| | $LHI_1$ | 3 | 23 | 2 | 3 | 31 | 26 | 84 | 12 | 40 | 1.15 | 58 |
| | $KI_2$ | 0 | 24 | 1 | 6 | 31 | 24 | 77 | 20 | 100 | 2.20 | 17 |
| SEPT. | WFB | 7 | 12 | 8 | 3 | 30 | 19 | 63 | 20 | 53 | 4.87 | 26.7 |
| | $LHI_1$ | 5 | 18 | 2 | 5 | 30 | 23 | 77 | 22 | 29 | 1.66 | 51.5 |
| | $KI_2$ | 4 | 20 | 0 | 6 | 30 | 24 | 80 | 23 | 0 | 1.38 | 68.5 |
| OCT. | WFB | 12 | 0 | 18 | 1 | 31 | 12 | 39 | 100 | 60 | 11.80 | -41 |
| | $TTHI_1$ | 4 | 18 | 1 | 8 | 31 | 22 | 71 | 31 | 20 | 2.66 | 44.5 |
| | $LHI_1$ | 6 | 19 | 0 | 6 | 31 | 25 | 81 | 24 | 0 | 1.44 | 69 |
| NOV. | WFB | 9 | 0 | 21 | 0 | 30 | 9 | 30 | 0 | 70 | 14.70 | -5 |
| | $TTHI_1$ | 6 | 17 | 6 | 1 | 30 | 23 | 77 | 6 | 50 | 3.06 | 49 |
| | $LHI_1$ | 5 | 15 | 8 | 2 | 30 | 20 | 67 | 12 | 62 | 5.16 | 30 |
| DEC. | WFB | 12 | 3 | 15 | 1 | 31 | 15 | 48 | 25 | 56 | 8.58 | -7.5 |
| | $TTHI_2$ | 9 | 10 | 9 | 3 | 31 | 19 | 61 | 23 | 50 | 5.19 | 24.5 |
| | $SDI_2$ | 6 | 11 | 8 | 6 | 31 | 17 | 55 | 35 | 57 | 6.69 | 11 |

TABLE 45: COMPARISON OF THE PREDICTIONS BASED ON THE SELECTED STABILITY INDICES AND THOSE OF THE DAILY WEATHER FORECAST BULLETINS (WFB) FOR THE NAIROBI AND SURROUNDING AREA DURING 1990.

| | INDEX | YY | NN | YN | NY | TOTAL | CORRECT | FS % | PTI % | PTII % | $\chi^2_c$ | IP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| JAN. | WFB | 2 | 17 | 10 | 2 | 31 | 19 | 61 | 11 | 83 | 8.54 | 14 |
| | $TTHI_2$ | 2 | 25 | 2 | 2 | 31 | 27 | 87 | 7 | 50 | 1.15 | 58.5 |
| | $SDI_2$ | 2 | 25 | 2 | 2 | 31 | 27 | 87 | 7 | 50 | 1.15 | 58.5 |
| FEB. | WFB | 5 | 12 | 9 | 2 | 28 | 17 | 61 | 14 | 64 | 6.07 | 22 |
| | $TTHI_2$ | 6 | 17 | 2 | 3 | 28 | 23 | 82 | 15 | 25 | 0.95 | 62 |
| | $SDI_2$ | 5 | 16 | 3 | 4 | 28 | 21 | 75 | 20 | 38 | 1.93 | 46 |
| MAR. | WFB | 16 | 0 | 15 | 0 | 31 | 16 | 52 | 0 | 48 | 7.28 | 28 |
| | $TTHI_2$ | 10 | 10 | 5 | 6 | 31 | 20 | 65 | 38 | 33 | 3.92 | 29.5 |
| | $KI_2$ | 7 | 6 | 9 | 9 | 31 | 13 | 42 | 60 | 56 | 10.46 | -16 |
| APR. | WFB | 17 | 0 | 13 | 0 | 30 | 17 | 57 | 0 | 43 | 5.63 | 35.5 |
| | $TTHI_2$ | 16 | 8 | 5 | 1 | 30 | 24 | 80 | 11 | 24 | 1.30 | 62.5 |
| | $KI_2$ | 16 | 8 | 5 | 1 | 30 | 24 | 80 | 11 | 24 | 1.30 | 62.5 |
| MAY | WFB | 13 | 0 | 18 | 0 | 31 | 13 | 42 | 0 | 58 | 10.45 | 13 |
| | $TTHI_2$ | 6 | 12 | 6 | 7 | 31 | 18 | 58 | 37 | 50 | 5.58 | 14.5 |
| | $KI_2$ | 8 | 14 | 4 | 5 | 31 | 22 | 71 | 26 | 33 | 2.65 | 41.5 |
| JUN. | WFB | 0 | 22 | 5 | 3 | 30 | 22 | 73 | 12 | 100 | 5.36 | 17 |
| | $LHI_1$ | 1 | 25 | 2 | 2 | 30 | 26 | 87 | 7 | 67 | 1.48 | 50 |
| | $KI_2$ | 1 | 26 | 1 | 2 | 30 | 27 | 90 | 7 | 50 | 0.64 | 61.5 |
| JUL. | WFB | 1 | 19 | 9 | 2 | 31 | 20 | 65 | 10 | 90 | 8.29 | 15 |
| | $LHI_1$ | 0 | 28 | 0 | 3 | 31 | 28 | 90 | 10 | 0 | 0.29 | 85 |
| | $KI_2$ | 0 | 28 | 0 | 3 | 31 | 28 | 90 | 10 | 0 | 0.29 | 85 |
| AUG. | WFB | 1 | 18 | 7 | 5 | 31 | 19 | 61 | 22 | 88 | 7.21 | 6 |
| | $LHI_1$ | 0 | 23 | 2 | 6 | 31 | 23 | 74 | 21 | 100 | 3.24 | 13.5 |
| | $KI_2$ | 1 | 24 | 1 | 5 | 31 | 25 | 81 | 17 | 50 | 1.36 | 47.5 |
| SEPT. | WFB | 5 | 12 | 12 | 1 | 30 | 17 | 57 | 8 | 71 | 8.55 | 17.5 |
| | $LHI_1$ | 7 | 19 | 2 | 2 | 30 | 26 | 87 | 10 | 22 | 0.63 | 71 |
| | $KI_2$ | 2 | 21 | 0 | 7 | 30 | 23 | 77 | 25 | 0 | 1.75 | 64.5 |
| OCT. | WFB | 9 | 6 | 15 | 1 | 31 | 15 | 48 | 14 | 63 | 9.52 | 9.5 |
| | $TTHI_1$ | 6 | 17 | 4 | 4 | 31 | 23 | 74 | 19 | 40 | 2.36 | 44.5 |
| | $LHI_1$ | 8 | 19 | 2 | 2 | 31 | 27 | 87 | 10 | 20 | 0.50 | 72 |
| NOV. | WFB | 9 | 3 | 15 | 3 | 30 | 12 | 40 | 50 | 63 | 10.88 | -16.5 |
| | $TTHI_1$ | 8 | 15 | 4 | 3 | 30 | 23 | 77 | 17 | 33 | 1.83 | 52 |
| | $LHI_1$ | 5 | 12 | 7 | 6 | 30 | 17 | 57 | 33 | 58 | 6.08 | 11.5 |
| DEC. | WFB | 5 | 8 | 15 | 3 | 31 | 13 | 42 | 27 | 75 | 12.07 | -9 |
| | $TTHI_2$ | 4 | 17 | 6 | 4 | 31 | 21 | 68 | 19 | 60 | 4.36 | 28.5 |
| | $SDI_2$ | 2 | 19 | 4 | 6 | 31 | 21 | 68 | 24 | 67 | 4.11 | 22.5 |

smaller than those of the forecasting guides except in March, 1990 when, that of one Index was higher. It's unfortunately observed from the results that the forecasting guides failed the Chi-square goodness of fit in all the 33 months except in August, 1988. On the other hand, at least one of the two Indices passed the test during each month except in April 1988, December 1989, and March and December, 1990. This shows December as the month with the least reliable predictions. One of the main reasons for this may be that December being a transitional month between the short rainy and warm dry seasons, the Indices selected for either season may perform better than those for the other depending on when the change of seasons occurs. This view is supported by the observation that the $LHI_1$, ranked overall best during the short rainy season and 15th during the warm dry season, was ranked overall best during December. Considering the year 1989, for example, there were more rain days in December than October and the $X_c^2$ values, using the $LHI_1$, were 3.86 and 5.16 respectively. It is observed from the comparison tables that in 21 out of the 33 months, both Indices passed the Chi-square test. The months with the most reliable predictions were February, June, July, August and October when, both Indices used passed the test throughout the whole period of study. In addition, both Indices passed in January 1988 and 1990, September 1989 and 1990, March 1988 and in April, 1990. It is interesting to note that if the level of significance is changed to 0.01($\chi^2_{0.99}$ =6.35), both Indices pass the test in all the 33 months except December, 1989 and March, 1990 when, only one passes. In comparison, the forecasting guides then pass only in 12 months out of the 33. It should also be noted that, in general, a decrease in the $\chi^2_c$ value corresponded to an increase in the IP value implying that the latter is also a reasonable indicator of goodness of fit.

In general, the results clearly illustrate that the predictions based on the computed Indices values were much more accurate and reliable than those given by the current daily weather forecast bulletins (WFB) based on the forecasting guides for afternoon or early evening rainfall in the Nairobi and surrounding area. However, it was observed that the use of the Indices alone could be misleading and at times, the Indices may be practically unpresentative.

## 3.2.0 THUNDERSTORM FORECASTING USING STABILITY INDICES

The results have been arranged in two categories, A and B. In category A, the Indices most suitable for predicting the non-occurrence of thunderstorms were determined while in B, those giving the highest number of correct predictions (for both occurrence and non-occurrence) were determined. Threshold values for both categories are shown in Table 46. In category B, only the Indices incorporating moisture in their computation were considered as the others performed relatively very poorly.

3.2.1 CATEGORY A - PREDICTION OF NON-OCCURRENCE OF THUNDERSTORMS

3.2.1.1 THE WARM DRY SEASON

In general, most Indices performed quite well during this season as shown in Table 47. The most outstanding performances were those of the $TTDI_1$ and $KI_2$ with an IR of 71 and 63 respectively. Out of the 271 days in the season, the $TTDI_1$ predicted the non-occurrence of thunderstorms in 200 days and was wrong only in 4 cases while the $KI_2$ predicted 164 and was wrong only in 3. The two were therefore selected for the season.

3.2.1.2 THE LONG RAINY SEASON

This is the most important season as far as forecasting thunderstorms is concerned, since this is when at least 50% of the overall total occurred. As shown in Table 48, many Indices performed poorly with only 3 having an IR above 20. These are the $SHI_2$, $TTHI_1$ and $TTHI_2$. Since the $TTHI_1$ and $TTHI_2$ are basically the same and their performances were identical, any could have been selected. Therefore the $SHI_2$ and $TTHI_2$ were selected for this season. The $SHI_2$ predicted a total of 48 no thunderstorm days and was wrong in 5 while the $TTHI_2$ predicted 80 and was wrong in 11.

### 3.2.1.3 THE COOL AND DRY SEASON

The Indices, generally, performed quite well during this season with 7 having an IR greater than 70 as seen in Table 49. The most outstanding were the $TTDI_1$ and $KI_2$ with an IR of 77 and 74 respectively. The $TTDI_1$ predicted a total of 296 no thunderstorm days and was wrong in only 13 cases while the $KI_2$ predicted 285 and was wrong in 12. Therefore the two were selected for this season. It should be noted that the same Indices were selected for the warm dry season.

### 3.2.1.4 THE SHORT RAINY SEASON

The Indices performed reasonably well unlike during the long rainy season. As seen in Table 50, all but 3 had an IR above 30, of which, 6 were above 50. The leading three Indices were the $TTDI_1$, $TTDI_2$ and $TTI_1$ respectively. Since the first two are basically the same, either could have been selected. Therefore the $TTDI_1$ and $TTI_1$ were selected. The $TTDI_1$ predicted 128 no thunderstorm days and was wrong in 6 while the $TTI_1$ predicted 85 and were all correct.

TABLE 46: THRESHOLD VALUES FOR THE NON-OCCURRENCE AND AND LIKELIHOOD OF THUNDERSTORMS OVER THE NAIROBI AND SURROUNDING AREA.

| INDEX | CATEGORY A (Non-occurrence | CATEGORY B (Likelihood) |
|---|---|---|
| AI | ≥ 0.35 | - |
| AHI | ≥ - 40 | - |
| ADI | ≥ 1 | 0.5 ≤ |
| $LH_1$ | ≥ 0 | - |
| $LHI_1$ | ≥ - 3 | -5 ≤ |
| $LDI_1$ | ≥ 3 | 1 ≤ |
| $LI_2$ | ≥ 0 | - |
| $LHI_2$ | ≥ - 3 | - 5 ≤ |
| $LDI_2$ | ≥ 3 | 1 ≤ |
| $SI_1$ | ≥ 2 | - |
| $SHI_1$ | ≥ - 1 | - 3 ≤ |
| $SDI_1$ | ≥ 4 | 2 ≤ |
| $SI_2$ | ≥ 2 | - |
| $SHI_2$ | ≥ - 1 | - 3 ≤ |
| $SHI_2$ | ≥ 4 | 2 ≤ |
| $KI_1$ | 22 ≤ | ≥ 25 |
| $KI_2$ | 27 ≤ | ≥ 30 |
| $TTI_1$ | 32 ≤ | - |
| $TTHI_1$ | 65 ≤ | ≥ 72 |
| $TTDI_1$ | 30 ≤ | ≥ 32 |
| $TTI_2$ | 42 ≤ | - |
| $TTHI_2$ | 75 ≤ | ≥ 82 |
| $TTDI_2$ | 37 ≤ | 40 |

TABLE 47: COMPARISON OF THE PERFORMANCES OF THE STABILITY INDICES DURING THE WARM DRY SEASONS OF 1988, 1989 AND 1990.

| INDEX | YY | NN | YN | NY | TOTAL | CORRECT | FS % | PTI % | PTII % | IR | RANK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AI | 18 | 134 | 109 | 10 | 271 | 152 | 56 | 7 | 86 | 35 | 21 |
| AHI | 18 | 139 | 104 | 10 | 271 | 157 | 58 | 7 | 85 | 37 | 17 |
| ADI | 18 | 135 | 108 | 4 | 271 | 159 | 59 | 3 | 86 | 50 | 10 |
| $LI_1$ | 24 | 87 | 156 | 4 | 271 | 111 | 41 | 4 | 87 | 29 | 23 |
| $LHI_1$ | 26 | 108 | 135 | 2 | 271 | 134 | 49 | 2 | 84 | 43 | 14 |
| $LDI_1$ | 27 | 117 | 126 | 1 | 271 | 144 | 53 | 1 | 82 | 50 | 11 |
| $LI_2$ | 23 | 108 | 135 | 5 | 271 | 131 | 48 | 4 | 85 | 36 | 20 |
| $LHI_2$ | 23 | 124 | 119 | 5 | 271 | 147 | 54 | 4 | 84 | 42 | 15 |
| $LDI_2$ | 26 | 132 | 111 | 2 | 271 | 158 | 58 | 1 | 81 | 55 | 8 |
| $SI_1$ | 24 | 90 | 153 | 4 | 271 | 114 | 42 | 4 | 86 | 30 | 22 |
| $SHI_1$ | 26 | 107 | 137 | 1 | 271 | 133 | 49 | 1 | 84 | 46 | 12 |
| $SDI_1$ | 25 | 137 | 106 | 3 | 271 | 162 | 60 | 2 | 81 | 54 | 9 |
| $SI_2$ | 23 | 111 | 132 | 5 | 271 | 134 | 49 | 4 | 85 | 37 | 18 |
| $SHI_2$ | 25 | 117 | 126 | 3 | 271 | 142 | 52 | 3 | 83 | 43 | 13 |
| $SDI_2$ | 24 | 158 | 85 | 4 | 271 | 182 | 67 | 2 | 78 | 61 | 4 |
| $KI_1$ | 25 | 157 | 86 | 3 | 271 | 182 | 67 | 2 | 77 | 61 | 3 |
| $KI_2$ | 25 | 161 | 82 | 3 | 271 | 186 | 69 | 2 | 77 | 63 | 2 |
| $TTI_1$ | 25 | 101 | 142 | 3 | 271 | 126 | 46 | 3 | 85 | 37 | 19 |
| $TTHI_1$ | 25 | 145 | 98 | 3 | 271 | 170 | 63 | 2 | 80 | 57 | 6 |
| $TTDI_1$ | 23 | 186 | 58 | 4 | 271 | 209 | 77 | 2 | 72 | 71 | 1 |
| $TTI_2$ | 21 | 130 | 113 | 7 | 271 | 151 | 56 | 5 | 84 | 41 | 16 |
| $TTHI_2$ | 24 | 157 | 86 | 4 | 271 | 181 | 67 | 2 | 78 | 61 | 4 |
| $TTDI_2$ | 25 | 146 | 97 | 3 | 271 | 171 | 63 | 2 | 80 | 57 | 6 |

TABLE 48: COMPARISON OF THE PERFORMANCES OF THE STABILITY INDICES DURING THE LONG RAINY SEASONS OF 1988 AND 1990.

| INDEX | YY | NN | YN | NY | TOTAL | CORRECT | FS % | PTI % | PTII % | IR | RANK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AI | 40 | 41 | 85 | 18 | 184 | 81 | 44 | 31 | 68 | - 49 | 22 |
| AHI | 38 | 34 | 92 | 20 | 184 | 72 | 39 | 37 | 71 | - 72 | 23 |
| ADI | 41 | 50 | 76 | 17 | 184 | 91 | 49 | 25 | 65 | - 26 | 20 |
| $LI_1$ | 51 | 50 | 76 | 7 | 184 | 101 | 55 | 12 | 60 | 19 | 5 |
| $LHI_1$ | 47 | 51 | 75 | 11 | 184 | 98 | 53 | 18 | 61 | - 1 | 16 |
| $LDI_1$ | 46 | 63 | 63 | 12 | 184 | 109 | 59 | 16 | 58 | 11 | 8 |
| $LI_2$ | 50 | 46 | 80 | 8 | 184 | 96 | 52 | 15 | 62 | 7 | 13 |
| $LHI_2$ | 48 | 53 | 73 | 10 | 184 | 101 | 55 | 16 | 60 | 7 | 12 |
| $LDI_2$ | 48 | 59 | 67 | 10 | 184 | 107 | 58 | 14 | 58 | 16 | 6 |
| $SI_1$ | 50 | 26 | 100 | 8 | 184 | 76 | 41 | 24 | 67 | - 31 | 21 |
| $SHI_1$ | 51 | 43 | 83 | 7 | 184 | 94 | 51 | 14 | 62 | 9 | 10 |
| $SDI_1$ | 45 | 63 | 63 | 13 | 184 | 108 | 59 | 17 | 58 | 8 | 11 |
| $SI_2$ | 48 | 38 | 88 | 10 | 184 | 86 | 47 | 21 | 65 | - 16 | 19 |
| $SHI_2$ | 53 | 43 | 83 | 5 | 184 | 96 | 52 | 10 | 61 | 22 | 1 |
| $SDI_2$ | 44 | 64 | 62 | 14 | 184 | 108 | 59 | 18 | 58 | 5 | 15 |
| $KI_1$ | 45 | 66 | 60 | 13 | 184 | 111 | 60 | 16 | 57 | 12 | 7 |
| $KI_2$ | 44 | 67 | 59 | 14 | 184 | 111 | 60 | 17 | 57 | 9 | 9 |
| $TTI_1$ | 47 | 50 | 76 | 11 | 184 | 97 | 53 | 18 | 62 | - 1 | 17 |
| $TTHI_1$ | 47 | 68 | 58 | 11 | 184 | 115 | 63 | 14 | 55 | 21 | 2 |
| $TTDI_1$ | 33 | 92 | 34 | 25 | 184 | 125 | 68 | 21 | 51 | 5 | 14 |
| $TTI_2$ | 45 | 53 | 73 | 13 | 184 | 98 | 53 | 20 | 62 | - 7 | 18 |
| $TTHI_2$ | 47 | 69 | 57 | 11 | 184 | 116 | 63 | 14 | 55 | 21 | 2 |
| $TTDI_2$ | 45 | 92 | 54 | 13 | 184 | 117 | 64 | 15 | 55 | 19 | 4 |

TABLE 49: COMPARISON OF THE PERFORMANCES OF THE STABILITY INDICES DURING THE COOL AND DRY SEASONS OF 1988, 1989 AND 1990.

| INDEX | YY | NN | YN | NY | TOTAL | CORRECT | FS % | PTI % | PTII % | IR | RANK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AI | 4 | 177 | 128 | 16 | 325 | 181 | 56 | 8 | 97 | 32 | 23 |
| AHI | 3 | 204 | 101 | 17 | 325 | 207 | 64 | 8 | 97 | 40 | 21 |
| ADI | 5 | 190 | 115 | 15 | 325 | 195 | 60 | 7 | 96 | 39 | 22 |
| $LI_1$ | 15 | 216 | 89 | 5 | 325 | 231 | 71 | 2 | 86 | 65 | 16 |
| $LHI_1$ | 14 | 228 | 77 | 6 | 325 | 242 | 74 | 3 | 85 | 65 | 15 |
| $LDI_1$ | 14 | 231 | 74 | 6 | 325 | 245 | 75 | 3 | 84 | 66 | 13 |
| $LI_2$ | 10 | 222 | 83 | 10 | 325 | 232 | 71 | 4 | 89 | 59 | 20 |
| $LHI_2$ | 12 | 242 | 63 | 8 | 325 | 254 | 78 | 3 | 84 | 69 | 8 |
| $LDI_2$ | 12 | 232 | 73 | 8 | 325 | 244 | 75 | 3 | 86 | 66 | 14 |
| $SI_1$ | 12 | 238 | 67 | 8 | 325 | 250 | 77 | 3 | 85 | 68 | 9 |
| $SHI_1$ | 12 | 237 | 68 | 8 | 325 | 249 | 77 | 3 | 85 | 68 | 9 |
| $SDI_1$ | 9 | 260 | 45 | 11 | 325 | 269 | 83 | 4 | 83 | 71 | 5 |
| $SI_2$ | 9 | 254 | 49 | 13 | 325 | 263 | 81 | 5 | 84 | 66 | 12 |
| $SHI_2$ | 9 | 262 | 43 | 11 | 325 | 271 | 83 | 4 | 83 | 71 | 5 |
| $SDI_2$ | 8 | 271 | 34 | 12 | 325 | 279 | 86 | 4 | 81 | 74 | 3 |
| $KI_1$ | 8 | 269 | 36 | 12 | 325 | 277 | 85 | 4 | 82 | 73 | 4 |
| $KI_2$ | 8 | 273 | 32 | 12 | 325 | 281 | 86 | 4 | 80 | 74 | 2 |
| $TTI_1$ | 10 | 237 | 68 | 10 | 325 | 247 | 76 | 4 | 87 | 64 | 17 |
| $TTHI_1$ | 11 | 229 | 76 | 9 | 325 | 240 | 74 | 4 | 87 | 62 | 19 |
| $TTDI_1$ | 6 | 283 | 23 | 13 | 325 | 289 | 89 | 4 | 79 | 77 | 1 |
| $TTI_2$ | 7 | 258 | 47 | 13 | 325 | 265 | 82 | 5 | 87 | 67 | 11 |
| $TTHI_2$ | 9 | 235 | 70 | 11 | 325 | 244 | 75 | 4 | 89 | 63 | 18 |
| $TTDI_2$ | 9 | 261 | 44 | 11 | 325 | 270 | 83 | 4 | 83 | 71 | 5 |

TABLE 50: <u>COMPARISON OF THE PERFORMANCES OF THE STABILITY *INDICES DURING THE* SHORT RAINY *SEASONS OF 1988, 1989 AND 1990*</u>.

| INDEX | YY | NN | YN | NY | TOTAL | CORRECT | FS % | PTI % | PTII % | IR | RANK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AI | 8 | 62 | 104 | 5 | 179 | 70 | 39 | 7 | 93 | 18 | 22 |
| AHI | 6 | 70 | 96 | 7 | 179 | 76 | 42 | 9 | 94 | 15 | 23 |
| ADI | 9 | 66 | 100 | 4 | 179 | 75 | 42 | 6 | 92 | 24 | 21 |
| $LI_1$ | 12 | 82 | 84 | 1 | 179 | 94 | 53 | 1 | 88 | 50 | 7 |
| $LHI_1$ | 12 | 88 | 78 | 1 | 179 | 100 | 56 | 1 | 87 | 53 | 5 |
| $LDI_1$ | 10 | 75 | 91 | 3 | 179 | 85 | 47 | 4 | 90 | 35 | 20 |
| $LI_2$ | 9 | 99 | 67 | 4 | 179 | 108 | 60 | 4 | 88 | 48 | 9 |
| $LHI_2$ | 9 | 95 | 71 | 4 | 179 | 104 | 58 | 4 | 89 | 46 | 14 |
| $LDI_2$ | 8 | 90 | 76 | 5 | 179 | 98 | 55 | 5 | 90 | 40 | 18 |
| $SI_1$ | 13 | 73 | 93 | 0 | 179 | 86 | 48 | 0 | 88 | 48 | 11 |
| $SHI_1$ | 12 | 72 | 94 | 1 | 179 | 84 | 47 | 1 | 89 | 44 | 16 |
| $SDI_1$ | 9 | 94 | 72 | 4 | 179 | 103 | 58 | 4 | 89 | 46 | 14 |
| $SI_2$ | 8 | 87 | 79 | 5 | 179 | 95 | 53 | 5 | 91 | 38 | 19 |
| $SHI_2$ | 8 | 96 | 70 | 5 | 179 | 104 | 58 | 5 | 90 | 43 | 17 |
| $SDI_2$ | 7 | 112 | 54 | 6 | 179 | 119 | 66 | 5 | 89 | 51 | 6 |
| $KI_1$ | 9 | 99 | 67 | 4 | 179 | 108 | 60 | 4 | 88 | 48 | 9 |
| $KI_2$ | 8 | 109 | 57 | 5 | 179 | 117 | 65 | 4 | 88 | 53 | 4 |
| $TTI_1$ | 13 | 85 | 81 | 0 | 179 | 98 | 55 | 0 | 86 | 55 | 3 |
| $TTHI_1$ | 9 | 96 | 70 | 4 | 179 | 105 | 59 | 4 | 89 | 47 | 12 |
| $TTDI_1$ | 7 | 122 | 44 | 6 | 179 | 129 | 72 | 5 | 86 | 57 | 1 |
| $TTI_2$ | 6 | 114 | 52 | 7 | 179 | 120 | 67 | 6 | 90 | 49 | 8 |
| $TTHI_2$ | 8 | 102 | 64 | 5 | 179 | 110 | 61 | 5 | 89 | 46 | 13 |
| $TTDI_2$ | 8 | 112 | 54 | 5 | 179 | 120 | 67 | 4 | 87 | 55 | 2 |

### 3.2.1.5 OVERALL PERFORMANCE OF THE INDICES

The overall results are shown in Table 51 and clearly show the $TTDI_1$, $KI_2$,$KI_1$ and $TTDI_2$ as the leading 4. Since the $TTDI_1$ and $TTD_2$ are essentially the same just as the $KI_1$ and $KI_2$ are, either could have been selected. However, by considering conistency during the whole period of study, the $TTDI_1$ and $KI_2$ were selected. The $TTDI_1$ and $KI_2$ were ranked $1^{st}$, $14^{th}$, $1^{st}$ and $1^{st}$, and $2^{nd}$, 9th, $2^{nd}$ and $4^{th}$ in the warm dry, long rainy, cool and dry, and short rainy seasons respectively and subsequently, $1^{st}$ and $2^{nd}$ in the overall results. Therefore the conclusion made was that the $TTDI_1$ and $KI_2$ be used throughout the year except during the long rainy season when,the $SHI_2$ and $TTHI_2$,should be used.

### 3.2.2 CATEGORY B - PREDICTION OF THE LIKELIHOOD OF THUNDERSTORM OCCURRENCE

As already stated,the objective here was to determine the Indices which give the greatest number of correct predictions (i.e, highest forecasting skills) with the least possible errors. Threshold values for the various Indices are given in Table 46.

### 3.2.2.1 THE WARM DRY SEASON

As observed in Table 52, the leading 3 Indices were the $KI_2$, $KI_1$ and $TTDI_2$ with a thunderstorm forecasting potential (TFP) and FS of 52,48,47 and

TABLE 51: COMPARISON OF THE OVERALL PERFORMANCES OF THE STABILITY INDICES DURING 1988, 1989 AND 1990.

| INDEX | YY | NN | YN | NY | TOTAL | CORRECT | FS % | PTI % | PTII % | IR | RANK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AI | 69 | 414 | 427 | 49 | 959 | 483 | 50 | 11 | 86 | 17 | 23 |
| AHI | 62 | 447 | 396 | 54 | 959 | 509 | 53 | 11 | 86 | 20 | 22 |
| ADI | 78 | 441 | 400 | 40 | 959 | 519 | 54 | 8 | 84 | 30 | 21 |
| $LI_1$ | 102 | 436 | 405 | 16 | 959 | 538 | 56 | 4 | 80 | 44 | 18 |
| $LHI_1$ | 98 | 475 | 366 | 20 | 959 | 573 | 60 | 4 | 79 | 48 | 13 |
| $LDI_1$ | 96 | 486 | 355 | 22 | 959 | 582 | 61 | 4 | 79 | 49 | 10 |
| $LI_2$ | 91 | 475 | 366 | 27 | 959 | 566 | 59 | 5 | 80 | 44 | 16 |
| $LHI_2$ | 91 | 514 | 327 | 27 | 959 | 605 | 63 | 5 | 78 | 48 | 11 |
| $LDI_2$ | 93 | 515 | 328 | 25 | 959 | 606 | 63 | 5 | 78 | 48 | 11 |
| $SI_1$ | 99 | 428 | 413 | 19 | 959 | 527 | 55 | 4 | 81 | 43 | 19 |
| $SHI_1$ | 100 | 459 | 383 | 17 | 959 | 559 | 58 | 4 | 79 | 46 | 14 |
| $SDI_1$ | 81 | 554 | 287 | 31 | 959 | 641 | 67 | 5 | 78 | 52 | 7 |
| $SI_2$ | 88 | 491 | 348 | 32 | 959 | 579 | 60 | 6 | 80 | 42 | 20 |
| $SHI_2$ | 94 | 518 | 323 | 24 | 959 | 612 | 64 | 4 | 77 | 52 | 8 |
| $SDI_2$ | 82 | 605 | 236 | 36 | 959 | 687 | 72 | 6 | 74 | 54 | 5 |
| $KI_1$ | 86 | 594 | 250 | 29 | 959 | 680 | 71 | 5 | 74 | 56 | 3 |
| $KI_2$ | 84 | 610 | 231 | 34 | 959 | 694 | 72 | 5 | 73 | 57 | 2 |
| $TTI_1$ | 94 | 473 | 368 | 24 | 959 | 567 | 59 | 5 | 80 | 44 | 16 |
| $TTHI_1$ | 91 | 538 | 303 | 27 | 959 | 629 | 66 | 5 | 77 | 51 | 9 |
| $TTDI_1$ | 68 | 683 | 160 | 48 | 959 | 751 | 78 | 7 | 70 | 57 | 1 |
| $TTI_2$ | 78 | 555 | 286 | 40 | 959 | 633 | 66 | 7 | 79 | 45 | 15 |
| $TTHI_2$ | 87 | 563 | 278 | 31 | 959 | 650 | 68 | 5 | 76 | 53 | 6 |
| $TTDI_2$ | 86 | 591 | 252 | 30 | 959 | 677 | 71 | 5 | 75 | 56 | 4 |

85%, 83%,82% respectively. The $KI_2$ and $TTDI_2$ were selected. The $KI_2$ predicted a total of 219 no thunderstorm days and was wrong in 8, indicating an accuracy of 96% while it predicted 52 thunderstorm days and was wrong in 32 indicating an accuracy of 38%. Of course the prediction of thunderstorm occurrence is not good enough but this is expected since only 28 thunderstorms occurred during the whole season of 271 days. As already stated, at least 50% of all the thunderstorms occurred during the long rainy season and therefore, that is when a reasonable degree of accuracy in their forecasting is expected.

3.2.2.2 THE LONG RAINY SEASON

The peformance was generally good unlike in category A. As seen in Table 53, the 5 top ranked Indices performed nearly equally well with a TFP ranging from 40 to 43.5 and an FS of either 72% or 73%. It was therefore difficult to select the best two. However, by taking consistency into account and considering that $TTHI_2$ and $TTHI_1$ are basically the same just as the $KI_2$ and $KI_1$ are, the $TTHI_2$ and $KI_2$ were selected. The $TTHI_2$ predicted a total of 111 no thunderstorm days and was wrong in 17, indicating an accuracy of 85% while it predicted a total of 73 thunderstorm days and was wrong in 32, indicating an accuracy of

56%. The $KI_2$ predicted 131 no thunderstorm days and was wrong in 28, indicating an accuracy of 79% while it predicted a total of 53 thunderstorm days and was wrong in 23, indicating an accuracy of 57%. It should be mentioned that the thunderstorms that occurred during March, April and May, 1989 were not included as there was no data to evaluate the Indices.

### 3.2.2.3 THE COOL AND DRY SEASON

All Indices performed well during this season but, as observed from Table 54, the $SDI_2$ and $KI_2$ were evidently the overall best. It should be be noted that they were followed by the $SDI_1$ and $KI_1$ which respectively, are basically the same. The $SDI_2$ and $KI_2$ had a TFP of 64 and 61.5 respectively and an FS of 94% each. The $SDI_2$ predicted a total of 333 no thunderstorm days and was wrong in 16, indicating an accuracy of 95% while it predicted 9 thunderstorm days and was wrong in 5, indicating an accuracy 45%. The $KI_2$ predicted 337 no thunderstorm days and was wrong in 18, indicating an accuracy of 95% while it predicted 5 thunderstorm days and was wrong in 3, indicating an accuracy of 40%. It should be noted that it was much harder to predict correctly the occurrence than the non-occurrence of thunderstorms considering that only 20 occurred during the whole season of 342 days. Therefore, the performance of the two Indices was fairly good.

3.2.2.4 THE SHORT RAINY SEASON

The Indices performed reasonably well with 10 having a TFP above 30 and all, but one, an FS above 70% as shown in Table 55. The $LHI_1$ evidently had the best performance with a TFP of 40.5 and FS of 82%. The $TTDI_1$ was ranked overall 2$^{nd}$ closely followed by the $TTHI_1$ and $TTHI_2$. The $TTDI_1$ had a TFP and FS of 39.5 and 84% respectively. Therefore, the $LHI_1$ and $TTDI_1$ were selected for this season.

3.2.2.4 OVERALL PERFORMANCE OF THE INDICES

The overall results are shown in Table 56 and show a close contest between the 6 top ranked Indices with all having a TFP ranging from 46 to 50.5 and FS of either 84 or 85. The selection was therefore based on consistency as shown in Table 57. Since the $KI_2$ and $KI_1$ are basically the same, it is clear, from the table, that the $KI_2$ and $TTHI_2$ performed most consistently. The general conclusion arrived at was that if only two Indices are required for use throughout the year, then the $KI_2$ and $TTHI_2$ should be selected. In any case at least one of them is among the two already selected for use during each season. In case one Index is required for use throughout the year, then $KI_2$ is the most suitable.

TABLE 52: COMPARISON OF THE PERFORMANCES OF THE STABILITY INDICES DURING THE WARM DRY SEASONS OF 1988, 1989 AND 1990.

| INDEX | YY | NN | YN | NY | TOTAL | CORRECT | FS % | PTI % | PTII % | TFP | RANK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AI | - | - | - | - | - | - | - | - | - | - | - |
| AHI | - | - | - | - | - | - | - | - | - | - | - |
| ADI | 14 | 201 | 42 | 14 | 271 | 215 | 79 | 7 | 75 | 38 | 10 |
| $LI_1$ | - | - | - | - | - | - | - | - | - | - | - |
| $LHI_1$ | 14 | 192 | 51 | 14 | 271 | 206 | 76 | 7 | 78 | 33.5 | 13 |
| $LDI_1$ | 19 | 176 | 67 | 9 | 271 | 195 | 72 | 5 | 78 | 30.5 | 15 |
| $LI_2$ | - | - | - | - | - | - | - | - | - | - | - |
| $LHI_2$ | 15 | 210 | 33 | 13 | 271 | 225 | 83 | 6 | 69 | 44.5 | 5 |
| $LDI_2$ | 20 | 195 | 48 | 8 | 271 | 215 | 79 | 4 | 71 | 41.5 | 7 |
| $SI_1$ | - | - | - | - | - | - | - | - | - | - | - |
| $SHI_1$ | 17 | 184 | 59 | 11 | 271 | 201 | 74 | 6 | 78 | 32 | 14 |
| $SDI_1$ | 17 | 198 | 45 | 11 | 271 | 215 | 79 | 5 | 73 | 40 | 8 |
| $SI_2$ | - | - | - | - | - | - | - | - | - | - | - |
| $SHI_2$ | 15 | 195 | 48 | 13 | 271 | 210 | 77 | 6 | 76 | 36 | 12 |
| $SDI_2$ | 16 | 207 | 36 | 12 | 271 | 223 | 82 | 5 | 69 | 45 | 4 |
| $KI_1$ | 20 | 204 | 39 | 8 | 271 | 224 | 83 | 4 | 66 | 48 | 2 |
| $KI_2$ | 20 | 211 | 32 | 8 | 271 | 231 | 85 | 4 | 62 | 52 | 1 |
| $TTI_1$ | - | - | - | - | - | - | - | - | - | - | - |
| $TTHI_1$ | 16 | 195 | 48 | 12 | 271 | 211 | 78 | 6 | 75 | 37.5 | 11 |
| $TTDI_1$ | 12 | 213 | 30 | 16 | 271 | 225 | 83 | 7 | 71 | 44 | 6 |
| $TTI_2$ | - | - | - | - | - | - | - | - | - | - | - |
| $TTHI_2$ | 15 | 199 | 44 | 13 | 271 | 214 | 79 | 6 | 75 | 38.5 | 9 |
| $TTDI_2$ | 21 | 201 | 42 | 7 | 271 | 222 | 82 | 3 | 67 | 47 | 3 |

TABLE 53: COMPARISON OF THE PERFORMANCES OF THE STABILITY INDICES DURING THE LONG RAINY SEASONS OF 1988 AND 1990.

| INDEX | YY | NN | YN | NY | TOTAL | CORRECT | FS % | PTI % | PTII % | TFP | RANK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AI | - | - | - | - | - | - | - | - | - | - | - |
| AHI | - | - | - | - | - | - | - | - | - | - | - |
| ADI | 26 | 97 | 29 | 32 | 184 | 123 | 67 | 25 | 53 | 28 | 15 |
| $LI_1$ | - | - | - | - | - | - | - | - | - | - | - |
| $LHI_1$ | 33 | 97 | 29 | 25 | 184 | 130 | 71 | 20 | 47 | 37.5 | 6 |
| $LDI_1$ | 36 | 92 | 34 | 22 | 184 | 128 | 70 | 19 | 49 | 36 | 8 |
| $LI_2$ | - | - | - | - | - | - | - | - | - | - | - |
| $LHI_2$ | 33 | 101 | 25 | 25 | 184 | 134 | 73 | 20 | 43 | 41.5 | 3 |
| $LDI_2$ | 36 | 92 | 34 | 22 | 184 | 128 | 70 | 19 | 49 | 36 | 8 |
| $SI_1$ | - | - | - | - | - | - | - | - | - | - | - |
| $SHI_1$ | 42 | 76 | 50 | 16 | 184 | 118 | 64 | 17 | 54 | 28.5 | 14 |
| $SDI_1$ | 34 | 93 | 33 | 24 | 184 | 127 | 69 | 21 | 49 | 34 | 10 |
| $SI_2$ | - | - | - | - | - | - | - | - | - | - | - |
| $SHI_2$ | 38 | 85 | 41 | 20 | 184 | 123 | 67 | 19 | 52 | 31.5 | 12 |
| $SDI_2$ | 31 | 95 | 31 | 27 | 184 | 126 | 68 | 22 | 50 | 32 | 11 |
| $KI_1$ | 33 | 101 | 25 | 25 | 184 | 134 | 73 | 20 | 43 | 41.5 | 3 |
| $KI_2$ | 30 | 103 | 23 | 28 | 184 | 133 | 72 | 21 | 43 | 40 | 5 |
| $TTI_1$ | - | - | - | - | - | - | - | - | - | - | - |
| $TTHI_1$ | 41 | 93 | 33 | 17 | 184 | 134 | 73 | 15 | 45 | 43 | 2 |
| $TTDI_1$ | 19 | 107 | 19 | 39 | 184 | 126 | 68 | 27 | 50 | 29.5 | 13 |
| $TTI_2$ | - | - | - | - | - | - | - | - | - | - | - |
| $TTHI_2$ | 41 | 94 | 32 | 17 | 184 | 135 | 73 | 15 | 44 | 43.5 | 1 |
| $TTDI_2$ | 30 | 100 | 26 | 28 | 184 | 130 | 71 | 22 | 46 | 37 | 7 |

TABLE 54: COMPARISON OF THE PERFORMANCES OF THE STABILITY INDICES DURING THE COOL AND DRY SEASONS OF 1988, 1989 AND 1990.

| INDEX | YY | NN | YN | NY | TOTAL | CORRECT | FS % | PTI % | PTII % | TFP | RANK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AI | - | - | - | - | - | - | - | - | - | - | - |
| AHI | - | - | - | - | - | - | - | - | - | - | - |
| ADI | 3 | 297 | 25 | 17 | 342 | 300 | 88 | 5 | 89 | 41 | 15 |
| $LI_1$ | - | - | - | - | - | - | - | - | - | - | - |
| $LHI_1$ | 4 | 302 | 20 | 16 | 342 | 306 | 89 | 5 | 83 | 45 | 12 |
| $LDI_1$ | 7 | 301 | 21 | 13 | 342 | 308 | 90 | 4 | 75 | 50.5 | 9 |
| $LI_2$ | - | - | - | - | - | - | - | - | - | - | - |
| $LHI_2$ | 3 | 304 | 18 | 17 | 342 | 307 | 90 | 5 | 86 | 44.5 | 13 |
| $LDI_2$ | 6 | 304 | 19 | 13 | 342 | 310 | 91 | 4 | 76 | 51 | 7 |
| $SI_1$ | - | - | - | - | - | - | - | - | - | - | - |
| $SHI_1$ | 5 | 306 | 16 | 15 | 342 | 311 | 91 | 5 | 76 | 50.5 | 8 |
| $SDI_1$ | 4 | 312 | 10 | 16 | 342 | 316 | 92 | 5 | 71 | 54 | 3 |
| $SI_2$ | - | - | - | - | - | - | - | - | - | - | - |
| $SHI_2$ | 3 | 310 | 12 | 17 | 342 | 313 | 92 | 5 | 80 | 49.5 | 10 |
| $SDI_2$ | 4 | 317 | 5 | 16 | 342 | 321 | 94 | 5 | 55 | 64 | 1 |
| $KI_1$ | 2 | 316 | 6 | 18 | 342 | 318 | 93 | 5 | 75 | 53 | 4 |
| $KI_2$ | 2 | 319 | 3 | 18 | 342 | 321 | 94 | 5 | 60 | 61.5 | 2 |
| $TTI_1$ | - | - | - | - | - | - | - | - | - | - | - |
| $TTHI_1$ | 5 | 294 | 30 | 13 | 342 | 299 | 87 | 4 | 86 | 42 | 14 |
| $TTDI_1$ | 4 | 311 | 11 | 16 | 342 | 315 | 92 | 5 | 73 | 53 | 5 |
| $TTI_2$ | - | - | - | - | - | - | - | - | - | - | - |
| $TTHI_2$ | 6 | 304 | 18 | 14 | 342 | 310 | 91 | 4 | 75 | 51.5 | 6 |
| $TTDI_2$ | 5 | 303 | 19 | 15 | 342 | 308 | 90 | 7 | 79 | 47 | 11 |

TABLE 55: COMPARISON OF THE PERFORMANCES OF THE STABILITY INDICES DURING THE SHORT RAINY SEASONS OF 1988, 1989 AND 1990.

| INDEX | YY | NN | YN | NY | TOTAL | CORRECT | FS % | PTI % | PTII % | TFP | RANK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AI | - | - | - | - | - | - | - | - | - | - | - |
| AHI | - | - | - | - | - | - | - | - | - | - | - |
| ADI | 2 | 121 | 45 | 11 | 179 | 123 | 69 | 8 | 96 | 17 | 15 |
| $LI_1$ | - | - | - | - | - | - | - | - | - | - | - |
| $LHI_1$ | 7 | 140 | 26 | 6 | 179 | 147 | 82 | 4 | 79 | 40.5 | 1 |
| $LDI_1$ | 5 | 128 | 38 | 8 | 179 | 133 | 74 | 6 | 88 | 27 | 14 |
| $LI_2$ | - | - | - | - | - | - | - | - | - | - | - |
| $LHI_2$ | 2 | 147 | 19 | 11 | 179 | 149 | 83 | 7 | 90 | 34.5 | 5 |
| $LDI_2$ | 4 | 134 | 32 | 9 | 179 | 138 | 77 | 6 | 89 | 29.5 | 11 |
| $SI_1$ | - | - | - | - | - | - | - | - | - | - | - |
| $SHI_1$ | 7 | 129 | 37 | 6 | 179 | 136 | 76 | 4 | 84 | 32 | 7 |
| $SDI_1$ | 4 | 132 | 34 | 9 | 179 | 136 | 76 | 6 | 89 | 28.5 | 13 |
| $SI_2$ | - | - | - | - | - | - | - | - | - | - | - |
| $SHI_2$ | 5 | 134 | 32 | 8 | 179 | 139 | 78 | 6 | 86 | 32 | 6 |
| $SDI_2$ | 3 | 137 | 29 | 10 | 179 | 140 | 78 | 7 | 91 | 29 | 12 |
| $KI_1$ | 3 | 138 | 28 | 10 | 179 | 141 | 79 | 7 | 90 | 30.5 | 9 |
| $KI_2$ | 3 | 139 | 27 | 10 | 179 | 142 | 79 | 7 | 90 | 30.5 | 9 |
| $TTI_1$ | - | - | - | - | - | - | - | - | - | - | - |
| $TTHI_1$ | 7 | 135 | 31 | 6 | 179 | 142 | 79 | 4 | 82 | 36 | 3 |
| $TTDI_1$ | 4 | 146 | 20 | 9 | 179 | 150 | 84 | 6 | 83 | 39.5 | 2 |
| $TTI_2$ | - | - | - | - | - | - | - | - | - | | - |
| $TTHI_2$ | 7 | 135 | 31 | 6 | 179 | 142 | 79 | 4 | 82 | 36 | 3 |
| $TTDI_2$ | 4 | 136 | 30 | 9 | 179 | 140 | 78 | 6 | 88 | 31 | 8 |

TABLE 56: COMPARISON OF THE OVERALL PERFORMANCES OF THE STABILITY INDICES DURING 1988, 1989 AND 1990.

| INDEX | YY | NN | YN | NY | TOTAL | CORRECT | FS % | PTI % | PTII % | TFP | RANK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AI | - | - | - | - | - | - | - | - | - | - | - |
| AHI | - | - | - | - | - | - | - | - | - | - | - |
| ADI | 45 | 716 | 141 | 74 | 976 | 761 | 78 | 9 | 76 | 35.5 | 15 |
| $LI_1$ | - | - | - | - | - | - | - | - | - | - | - |
| $LHI_1$ | 58 | 731 | 126 | 61 | 976 | 789 | 81 | 8 | 68 | 43 | 11 |
| $LDI_1$ | 67 | 697 | 160 | 52 | 976 | 764 | 78 | 7 | 70 | 39.5 | 14 |
| $LI_2$ | - | - | - | - | - | - | - | - | - | - | - |
| $LHI_2$ | 53 | 762 | 95 | 66 | 976 | 815 | 84 | 8 | 64 | 48 | 3 |
| $LDI_2$ | 66 | 725 | 133 | 52 | 976 | 791 | 81 | 7 | 67 | 44 | 9 |
| $SI_1$ | - | - | - | - | - | - | - | - | - | - | - |
| $SHI_1$ | 71 | 695 | 162 | 48 | 976 | 766 | 78 | 6 | 70 | 40 | 13 |
| $SDI_1$ | 59 | 735 | 122 | 60 | 976 | 794 | 81 | 8 | 67 | 43.5 | 10 |
| $SI_2$ | - | - | - | - | - | - | - | - | - | - | - |
| $SHI_2$ | 61 | 724 | 133 | 58 | 976 | 785 | 80 | 7 | 69 | 42 | 12 |
| $SDI_2$ | 54 | 756 | 101 | 65 | 976 | 810 | 83 | 8 | 65 | 46.5 | 5 |
| $KI_1$ | 58 | 759 | 98 | 61 | 976 | 817 | 84 | 7 | 63 | 49 | 2 |
| $KI_2$ | 55 | 772 | 85 | 64 | 976 | 827 | 85 | 8 | 61 | 50.5 | 1 |
| $TTI_1$ | - | - | - | - | - | - | - | - | - | - | - |
| $TTHI_1$ | 69 | 717 | 142 | 48 | 976 | 786 | 81 | 6 | 67 | 44.5 | 8 |
| $TTDI_1$ | 39 | 777 | 80 | 80 | 976 | 816 | 84 | 9 | 67 | 46 | 6 |
| $TTI_2$ | - | - | - | - | - | - | - | - | - | - | - |
| $TTHI_2$ | 69 | 732 | 125 | 50 | 976 | 801 | 82 | 6 | 64 | 47 | 4 |
| $TTDI_2$ | 60 | 740 | 117 | 59 | 976 | 800 | 82 | 7 | 66 | 45.5 | 7 |

TABLE 57: <u>COMPARISON OF THE CONSISTENCY OF THE PERFORMANCES OF THE 6 (SIX) TOP RANKED STABILITY INDICES DURING 1988, 1989 AND 1990.</u>

| | INDEX AND RANK | | | | | |
|---|---|---|---|---|---|---|
| SEASON | $KI_2$ | $KI_1$ | $LHI_2$ | $TTHI_2$ | $SDI_2$ | $TTDI_1$ |
| WARM DRY | 1 | 2 | 5 | 9 | 4 | 6 |
| LONG RAINY | 5 | 3 | 3 | 1 | 11 | 13 |
| COOL AND DRY | 2 | 4 | 13 | 6 | 1 | 5 |
| SHORT RAINY | 9 | 9 | 5 | 3 | 12 | 2 |
| RANK SUM | 17 | 18 | 26 | 19 | 28 | 26 |

### 3.2.2.6 COMPARISON BETWEEN THE PERFORMANCES OF THE INDICES AND THE OTHER FORECASTING GUIDES

Tables 58, 59 and 60 show the comparisons, on a monthly basis, between the Indices' predictions and those of the forecasting guides currently being used in forecasting afternoon or early evening thunderstorms in the Nairobi and sorrounding area during 1988, 1989 and 1990 respectively. The results show that at least one of the Indices passed the Chi-square goodness of fit test at the 0.05 significance level in 27 out of the 33 months while both passed in 23 of the months. In comparison, the forecasting guides passed in 22 of the months. These results may not reflect the true picture of the difference in the accuracy and reliability of the Indices' predictions and those of the forecasting guides. The main reason is that the Chi-square goodness of fit test is,more often than not,unsatifactory when the expected frequencies and degrees of freedom are each less than 5. However, it is usually satisfactorily used even when the degrees of freedom are less than 5, provided the expected frequencies are greater than 5. This observation is based on experience and theoretical investigations (Hoel, 1984). This is clearly illustrated by considering that out of the 33 months, the WFB predictions indicated no thunderstorms at all in 11 of the months but, despite being correct only in 4 of the cases, they passed the Chi-square test in all the 11 months. This is because the frequency of the thunderstorms was 3 or less in each of the 7 months they occurred. Nevertheless, the results generally indicate a reasonable improvement in the forecasts when the Indices are used. It is important to note that during long rainy seasons when at least 50% of the total annual thunderstorms occurred, the WFB predictions did not pass the Chi-square test even a single month while both Indices used passed in all the months except April, 1988 when both failed and May, 1990 when one failed. Furthermore, using the 0.01 significance level, both Indices passed the test in all the 33 months except January and November, 1989 when one and both respectively, failed. In comparison, the forecasting guides then passed in 25 months.

TABLE 58: COMPARISON OF THE PREDICTIONS BASED ON THE SELECTED STABILITY INDICES AND THOSE OF THE DAILY WEATHER BULLETINS (WFB) FOR THE NAIROBI AND SURROUNDING AREA DURING 1988.

| MONTH | INDEX | YY | NN | YN | NY | TOTAL | CORRECT | FS % | PTI % | PTII % | $\chi_c^2$ | TFP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| JAN. | WFB | 0 | 28 | 0 | 3 | 31 | 28 | 90 | 10 | 0 | 0.29 | 85 |
| | $KI_2$ | 2 | 27 | 1 | 1 | 31 | 29 | 94 | 4 | 33 | 0.37 | 75.5 |
| | $TTDI_2$ | 2 | 27 | 1 | 1 | 31 | 29 | 94 | 4 | 33 | 0.37 | 75.5 |
| FEB. | WFB | 0 | 28 | 0 | 1 | 29 | 28 | 97 | 4 | 0 | 0.03 | 95 |
| | $KI_2$ | 1 | 27 | 1 | 0 | 29 | 28 | 97 | 0 | 50 | 0.50 | 72 |
| | $TTDI_2$ | 1 | 26 | 2 | 0 | 29 | 27 | 93 | 0 | 67 | 0.67 | 56.5 |
| MAR. | WFB | 9 | 11 | 9 | 2 | 31 | 20 | 65 | 15 | 50 | 9.31 | 32.5 |
| | $KI_2$ | 7 | 16 | 4 | 4 | 31 | 23 | 74 | 20 | 36 | 2.25 | 46 |
| | $TTHI_2$ | 11 | 15 | 5 | 0 | 31 | 26 | 84 | 0 | 31 | 1.56 | 68.5 |
| APR. | WFB | 13 | 0 | 16 | 1 | 30 | 13 | 43 | 100 | 55 | 9.83 | - 34.5 |
| | $KI_2$ | 4 | 13 | 3 | 10 | 30 | 17 | 57 | 43 | 43 | 5.63 | 14 |
| | $TTHI_2$ | 7 | 11 | 5 | 7 | 30 | 18 | 60 | 39 | 42 | 4.81 | 19.5 |
| MAY | WFB | 4 | 19 | 7 | 1 | 31 | 23 | 74 | 5 | 64 | 4.50 | 39.5 |
| | $KI_2$ | 2 | 22 | 4 | 3 | 31 | 24 | 77 | 12 | 67 | 3.03 | 37.5 |
| | $TTHI_2$ | 2 | 23 | 3 | 3 | 31 | 25 | 81 | 12 | 60 | 2.15 | 45 |
| JUN. | WFB | 0 | 20 | 0 | 0 | 20 | 20 | 100 | 0 | 0 | 0.00 | 100 |
| | $KI_2$ | 0 | 20 | 0 | 0 | 20 | 20 | 100 | 0 | 0 | 0.00 | 100 |
| | $SDI_2$ | 0 | 20 | 0 | 0 | 20 | 20 | 100 | 0 | 0 | 0.00 | 100 |
| JUL. | WFB | 0 | 30 | 0 | 1 | 31 | 30 | 97 | 3 | 0 | 0.03 | 95.5 |
| | $KI_2$ | 0 | 30 | 0 | 1 | 31 | 30 | 97 | 3 | 0 | 0.03 | 95.5 |
| | $SDI_2$ | 0 | 30 | 0 | 1 | 31 | 30 | 97 | 3 | 0 | 0.03 | 95.5 |
| AUG. | WFB | 0 | 30 | 1 | 0 | 31 | 30 | 97 | 0 | 100 | 1.00 | 47 |
| | $KI_2$ | 0 | 31 | 0 | 0 | 31 | 31 | 100 | 0 | 0 | 0.00 | 100 |
| | $SDI_2$ | 0 | 30 | 1 | 0 | 31 | 30 | 97 | 0 | 100 | 1.00 | 47 |
| SEPT. | WFB | 0 | 25 | 1 | 3 | 29 | 25 | 86 | 11 | 100 | 1.32 | 30.5 |
| | $KI_2$ | 0 | 25 | 1 | 3 | 29 | 25 | 86 | 11 | 100 | 1.32 | 30.5 |
| | $SDI_2$ | 0 | 25 | 1 | 3 | 29 | 25 | 86 | 11 | 100 | 1.32 | 30.5 |
| OCT. | WFB | 4 | 18 | 4 | 1 | 27 | 22 | 81 | 5 | 50 | 2.o5 | 53.5 |
| | $LHI_1$ | 2 | 16 | 6 | 3 | 27 | 18 | 67 | 16 | 75 | 4.97 | 21.5 |
| | $TTDI_1$ | 1 | 18 | 4 | 4 | 27 | 19 | 70 | 18 | 80 | 3.93 | 21 |
| NOV. | WFB | 0 | 14 | 15 | 1 | 30 | 14 | 47 | 7 | 100 | 15.07 | - 6.5 |
| | $LHI_1$ | 0 | 24 | 5 | 1 | 30 | 24 | 80 | 4 | 100 | 5.04 | 28 |
| | $TTDI_1$ | 1 | 23 | 6 | 0 | 30 | 24 | 80 | 0 | 86 | 5.14 | 37 |
| DEC. | WFB | 0 | 28 | 0 | 3 | 31 | 28 | 90 | 10 | 0 | 0.29 | 85 |
| | $KI_2$ | 1 | 23 | 5 | 2 | 31 | 24 | 77 | 8 | 83 | 4.33 | 31.5 |
| | $TTDI_2$ | 1 | 22 | 6 | 2 | 31 | 23 | 74 | 8 | 86 | 5.31 | 27 |

TABLE 59: COMPARISON OF THE PREDICTIONS BASED ON THE SELECTED STABILITY INDICES AND THOSE OF THE DAILY WEATHER FORECAST BUELLETINS (WFB) FOR THE NAIROBI AND SURROUNDING AREA DURING 1989

| MONTH | INDEX | YY | NN | YN | NY | TOTAL | CORRECT | FS % | PTI % | PTII % | $\chi^2_c$ | TFP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| JAN. | WFB | 1 | 20 | 4 | 6 | 31 | 21 | 68 | 23 | 80 | 4.58 | 16.5 |
| | $KI_2$ | 6 | 17 | 7 | 1 | 31 | 23 | 74 | 6 | 54 | 3.82 | 44 |
| | $TTDI_2$ | 6 | 13 | 11 | 1 | 31 | 19 | 61 | 7 | 65 | 7.19 | 2 |
| FEB. | WFB | 1 | 22 | 3 | 2 | 28 | 23 | 82 | 8 | 75 | 2.42 | 40.5 |
| | $KI_2$ | 2 | 23 | 2 | 1 | 28 | 25 | 89 | 4 | 50 | 1.07 | 62 |
| | $TTDI_2$ | 2 | 21 | 4 | 1 | 28 | 23 | 82 | 5 | 67 | 2.71 | 46 |
| MAR. | N | O | | D | A | T | A | - | - | - | - | - |
| APR. | N | O | | D | A | T | A | - | - | - | - | - |
| MAY | N | O | | D | A | T | A | - | - | - | - | - |
| JUN. | WFB | 0 | 17 | 0 | 0 | 17 | 17 | 100 | 0 | 0 | 0.00 | 100 |
| | $KI_2$ | 0 | 17 | 0 | 0 | 17 | 17 | 100 | 0 | 0 | 0.00 | 100 |
| | $SDI_2$ | 0 | 17 | 0 | 0 | 17 | 17 | 100 | 0 | 0 | 0.00 | 100 |
| JUL. | WFB | 0 | 31 | 0 | 0 | 31 | 31 | 100 | 0 | 0 | 0.00 | 100 |
| | $KI_2$ | 0 | 31 | 1 | 0 | 31 | 30 | 97 | 0 | 100 | 1.00 | 47 |
| | $SDI_2$ | 0 | 29 | 2 | 0 | 31 | 29 | 94 | 0 | 100 | 2.00 | 44 |
| AUG. | WFB | 0 | 29 | 0 | 2 | 31 | 29 | 94 | 6 | 0 | 0.13 | 91 |
| | $KI_2$ | 1 | 29 | 0 | 2 | 31 | 29 | 94 | 6 | 0 | 0.13 | 91 |
| | $SDI_2$ | 1 | 29 | 0 | 2 | 31 | 29 | 94 | 6 | 0 | 0.13 | 91 |
| SEPT. | WFB | 1 | 25 | 1 | 3 | 30 | 26 | 87 | 11 | 50 | 0.82 | 56.5 |
| | $KI_2$ | 0 | 26 | 0 | 4 | 30 | 26 | 87 | 13 | 0 | 0.53 | 80.5 |
| | $SDI_2$ | 2 | 26 | 0 | 2 | 30 | 28 | 93 | 7 | 0 | 0.14 | 89.5 |
| OCT. | WFB | 1 | 27 | 2 | 1 | 31 | 28 | 90 | 4 | 67 | 1.37 | 54.5 |
| | $LHI_1$ | 1 | 28 | 1 | 1 | 31 | 29 | 94 | 3 | 50 | 0.53 | 67.5 |
| | $TTDI_1$ | 1 | 29 | 0 | 1 | 31 | 30 | 97 | 3 | 0 | 0.03 | 95.5 |
| NOV. | WFB | 0 | 29 | 0 | 1 | 30 | 29 | 97 | 3 | 0 | 0.03 | 95.5 |
| | $LHI_1$ | 0 | 23 | 7 | 0 | 30 | 23 | 77 | 0 | 100 | 7.00 | 27 |
| | $TTDI_1$ | 0 | 23 | 7 | 0 | 30 | 23 | 77 | 0 | 100 | 7.00 | 27 |
| DEC. | WFB | 1 | 25 | 1 | 4 | 31 | 26 | 84 | 14 | 50 | 0.55 | 52 |
| | $KI_2$ | 3 | 20 | 6 | 2 | 31 | 23 | 74 | 9 | 67 | 4.18 | 36 |
| | $TTDI_2$ | 4 | 20 | 6 | 1 | 31 | 24 | 77 | 5 | 60 | 3.65 | 44.5 |

TABLE 60: COMPARISON OF THE PREDICTIONS BASED ON THE SELECTED STABILITY INDICES AND THOSE OF THE DAILY WEATHER FORECAST BULLETINS (WFB) FOR THE NAIROBI AND SURROUNDING AREA DURING 1990.

| MONTH | INDEX | YY | NN | YN | NY | TOTAL | CORRECT | FS % | PTI % | PTII % | $\chi^2_c$ | TFP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| JAN. | WFB | 0 | 30 | 0 | 1 | 31 | 30 | 97 | 3 | 0 | 1.00 | 95.5 |
| | $KI_2$ | 1 | 26 | 4 | 0 | 31 | 27 | 87 | 0 | 80 | 3.20 | 47 |
| | $TTDI_2$ | 1 | 26 | 4 | 0 | 31 | 27 | 87 | 0 | 80 | 3.20 | 47 |
| FEB. | WFB | 1 | 22 | 1 | 4 | 28 | 23 | 82 | 15 | 50 | 1.12 | 49.5 |
| | $KI_2$ | 4 | 22 | 1 | 1 | 28 | 26 | 93 | 4 | 20 | 0.24 | 81 |
| | $TTDI_2$ | 4 | 21 | 2 | 1 | 28 | 25 | 89 | 5 | 33 | 0.71 | 70 |
| MAR. | WFB | 8 | 10 | 10 | 3 | 31 | 18 | 58 | 23 | 56 | 6.25 | 18.5 |
| | $KI_2$ | 5 | 17 | 3 | 6 | 31 | 22 | 71 | 26 | 38 | 2.69 | 39 |
| | $TTHI_2$ | 6 | 15 | 5 | 5 | 31 | 21 | 68 | 25 | 45 | 3.52 | 33 |
| APR. | WFB | 11 | 1 | 17 | 1 | 30 | 12 | 40 | 50 | 61 | 10.82 | - 15.5 |
| | $KI_2$ | 9 | 12 | 6 | 3 | 30 | 21 | 70 | 20 | 40 | 3.00 | 40 |
| | $TTHI_2$ | 12 | 11 | 7 | 0 | 30 | 23 | 77 | 0 | 37 | 2.58 | 58.5 |
| MAY | WFB | 5 | 12 | 12 | 2 | 31 | 17 | 55 | 14 | 71 | 8.76 | 12.5 |
| | $KI_2$ | 3 | 23 | 3 | 2 | 31 | 26 | 84 | 8 | 50 | 1.66 | 55 |
| | $TTHI_2$ | 3 | 19 | 7 | 2 | 31 | 22 | 71 | 10 | 70 | 5.09 | 31 |
| JUN. | WFB | 0 | 27 | 1 | 2 | 30 | 27 | 90 | 7 | 100 | 1.14 | 36.5 |
| | $KI_2$ | 0 | 28 | 0 | 2 | 30 | 28 | 93 | 7 | 0 | 0.13 | 89.5 |
| | $SDI_2$ | 0 | 28 | 0 | 2 | 30 | 28 | 93 | 7 | 0 | 0.13 | 89.5 |
| JUL. | WFB | 0 | 31 | 0 | 0 | 31 | 31 | 100 | 0 | 0 | 0.00 | 100 |
| | $KI_2$ | 0 | 31 | 0 | 0 | 31 | 31 | 100 | 0 | 0 | 0.00 | 100 |
| | $SDI_2$ | 0 | 31 | 0 | 0 | 31 | 31 | 100 | 0 | 0 | 0.00 | 100 |
| AUG. | WFB | 0 | 28 | 1 | 2 | 31 | 28 | 90 | 7 | 100 | 1.13 | 36.5 |
| | $KI_2$ | 1 | 29 | 0 | 1 | 31 | 30 | 97 | 3 | 0 | 0.03 | 95.5 |
| | $SDI_2$ | 1 | 28 | 1 | 1 | 31 | 29 | 94 | 3 | 50 | 0.53 | 67.5 |
| SEPT. | WFB | 3 | 19 | 5 | 3 | 30 | 22 | 73 | 14 | 63 | 3.53 | 34.5 |
| | $KI_2$ | 1 | 23 | 1 | 5 | 30 | 24 | 80 | 18 | 50 | 1.39 | 46 |
| | $SDI_2$ | 1 | 24 | 0 | 5 | 30 | 25 | 83 | 17 | 0 | 0.86 | 74.5 |
| OCT. | WFB | 4 | 11 | 15 | 1 | 31 | 15 | 48 | 8 | 79 | 11.93 | 4.5 |
| | $LHI_1$ | 4 | 24 | 2 | 1 | 31 | 28 | 90 | 4 | 33 | 0.71 | 71.5 |
| | $TTDI_1$ | 1 | 25 | 1 | 4 | 31 | 26 | 84 | 8 | 57 | 1.05 | 51.5 |
| NOV. | WFB | 0 | 19 | 11 | 0 | 30 | 19 | 63 | 0 | 100 | 11.00 | 13 |
| | $LHI_1$ | 0 | 25 | 5 | 0 | 30 | 25 | 83 | 0 | 100 | 5.00 | 33 |
| | $TTDI_1$ | 0 | 28 | 2 | 0 | 30 | 28 | 93 | 0 | 100 | 2.00 | 43 |
| DEC. | WFB | 0 | 24 | 7 | 0 | 31 | 24 | 77 | 0 | 100 | 7.00 | 27 |
| | $KI_2$ | 0 | 26 | 5 | 0 | 31 | 26 | 84 | 0 | 100 | 5.00 | 34 |
| | $TTDI_2$ | 0 | 25 | 6 | 0 | 31 | 25 | 81 | 0 | 100 | 6.00 | 31 |

# CHAPTER 4

## 4.0 CONCLUSION AND RECOMMENDATIONS

In this study, a number of Stability Indices which could be useful in forecasting convective weather activities (in particular, rain or showers and thunderstorms) in the Nairobi and surrounding area have been investigated using upper air data extracted from the 2300z (2.00 A.M.local time) radiosonde soundings for the Nairobi station during 1988, 1989 and 1990. A relationship was established between the computed Indices' values and the probability of occurrence or non-occurrence of convective weather activities in the area on the successive days that followed the soundings. Optimum threshold values, above or below which convective weather activities should or should not be expected, were determined for each Index. Two categories of thresholds, A and B, were set. In category A, the values which rule out the possibility of the occurrence of convective weather activities were sought while in B, those giving the highest number of correct predictions of the occurrence or non-occurrence of the activities with the least possible errors were sought.

The performances of the various Indices were compared on a monthly, seasonal and annual basis. The comparisons were based on the Reliability and

Predictability as well as consistency of the individual Indices during a given period. The Indices incorporating the vertical extent of moisture in their evaluation performed better than those based purely on atmospheric stability. However, during the rainy seasons, these Indices may be unrepresentative at times due to the relatively large diurnal variation in the moisture content of the atmosphere. The Indices evaluated using the 450mb level, on the whole, performed better than their counterparts using the 500mb level except during the short rainy season. However, the difference in the performances was generally small and sometimes insignificant. The "K" and "Total Totals" Indices have the advantage that their evalution does not require a plotted sounding and therefore relatively cheaper, easier and quicker as well as being more accurate since the probability of making computational errors is greatly reduced. Hence, the two were the most successful throughout the whole period of study.

Though no particular Index was found to peform better than the others throughout the year, particular Indices were identified as most suitable for use during specific seasons of the year. The two Indices with the best performances were selected for each season. The Indices selected as first and second respectively for each season, have been listed. For forecasting precipitation, the following were selected: the $TTHI_2$ and $SHI_2$ in category A and the $TTHI_2$ and $SDI_2$ in category B during the warm dry season; the $LHI_2$ and $TTI_2$ in category A and the $TTHI_2$ and $KI_2$ in category B during the long rainy season; the $LDI_2$ and $TTI_2$ in category A and the $KI_2$ and $LHI_1$ in category B during the cool and dry season; and the $LHI_1$ and $SHI_1$ in category A and the $TTHI_1$ and $LHI_1$ in category B during the short rainy season. For forecasting thunderstorms, the following were selected: the $TTDI_1$ and $KI_2$ in category A and the $KI_2$ and $TTDI_2$ in category B during the warm dry season; the $SHI_2$ and $TTHI_2$ in category A and the $TTHI_2$ and $KI_2$ in category B during the long rainy season; the $TTDI_1$ and $KI_2$ in category A and the $SDI_2$ and $KI_2$ in category B during the cool and dry season; and the $TTDI_1$ and $TTI_1$ in category A and the $LHI_1$ and $TTDI_1$ in category B during the short rainy season.

The predictions based on the selected Indices in category B were compared to those of the forecasting guides being used in the area of study which are issued by the daily weather forecast bulletins. This was accomplished by subjecting the two to the Chi-square goodness of fit test on a monthly basis for the whole period of study. The results indicated a significant improvement in the forecasts when the Indices are used.

Following the results of the study, a number of recommendations have been made. It is recommended that the selected Indices be tested further using data for several years so that the most suitable, if any, for use in the area be established. Meanwhile, those selected should be incorporated in the routine weather forecasting procedures used for Nairobi area. The Indices selected in category A should be of great use to the forecaster particularly, in indicating the days when he or she should not devote much time and effort to further analysis and other considerations. The Indices selected in category B should be useful in serving as comparisons or complements to the forecasting guides currently being used in the area. They could also be used as independent forecasting tools when the other forecasting guides are absent or unreliable. The Index selected as the first during each season should be used. However, when all or some of the data required for its evaluation is missing or when an anomalous value is obtained, the second may then be used. The observation that the difference between the performances of the Indices evaluated using the 500mb level and their counterparts using the 450mb level is small and sometimes insignificant may be useful in the event of data missing at one level or obtaining an anomalous value. In such a situation, the Index using the alternative level may be used. Anomalous values occasionally do occur e.g, when a pronounced temperature inversion is present at or near the reference level being used. The use of Stability Indices alone can be quite misleading, and at times, an Index may be practically unrepresentative. Therefore it is recommended that they should be combined, either objectively or subjectively, with other data and synoptic considerations. The forecaster is also advised to strictly observed the actual beginning or end of the seasons before changing from using one Index to another since there is no distinct date or week or even month of the year when seasons change. The Lifted Index ($LI_1$), the only one currently being used in the area of study, was found unsuitable for use in its present form. However, its modified form, the Lifted-Humidity Index ($LHI_1$), is recommended for use during the short rainy, and cool and dry seasons. The performance of the Area Index could be greatly improved if a correction to accommodate the diurnal variation of moisture distribution in the lower 100mbs layer is found. It is therefore recommended that an attempt be made to determine this correction for each season. This may be achieved by using the climatological data of the area. The possibility of developing Stability Indices for the other areas with radiosonde data should also explored.

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REFERENCES

Asnani, G.C. and Kinuthia, J.H., (1979): Diurnal variation of precipitation in East Africa. Kenya Met. Dept., Research report NO. 8/79, 58pp.

Austin, J.M., (1948): A note on cumulus growth in a non-saturated environment. J. Meteor., vol.5, pp. 103-107.

Bailey, R.E., (1955): Local Thunderstorm Forecasting. Eastern Air Lines Sci. Rept. No. 1 (December, 1955), to Air Force Geophysics Research Directorate.

Barret, E.W. and Riehl, H., (1948): Exprimental verification of Entrainment of air into cumulus. J. Meteor., vol. 5, pp. 304-307.

Baum, W.A., (1951): Note on the theory of super-autoconvective lapse rates near the ground. J. Meteor., vol. 8, pp. 196-198.

Betts, A.K., (1973): A relationship between stratification, cloud depth and permitted cloud radii. J. App. Meteor., vol. 12, pp. 890-893.

______, (1974): Thermodynamic classification of tropical convective soundings. Mon. Wea. Rev., vol. 102, No.11, pp. 760-764.

Bjerkens, J., (1938): Saturated adiabatic ascent of air through dry-adiabatically descending environment.
Quart. J. Roy Meteor. Soc., vol. 64 pp.325-330.

Byers, H.R. and Braham, R.R., Jr., (1948): Thunderstorm structure and circulation.
J. Meteor., vol.5, pp. 71-86.

Byers, H.R. and Hull, E.C. (1949): Inflow patterns of thunderstorms as shown by winds aloft.
Bull. Am. Meteor. Soc., vol. 30, pp. 90-96.

Byers, H.R. and Hall, R.K., (1955): A census of cumulus-cloud height versus precipitation in the vicinity of Peurto Rico during the winter and spring of 1953-1954.
J. Meteor., vol. 12, No.2, pp. 176-178.

Byers, H.R., (1959): General Meteorology.
McGraw-Hill book company Inc., pp. 96-104.

Chalker, W.R., (1949): Vertical stability in regions of airmass showers.
Bull. Am. Meteor. Soc., vol. 30, pp. 145-147.

Chen, C.H. and Orville, H.D., (1980): Effects of mesoscale on cloud convection.
J. App. Meteor., vol. 19, pp. 256-274.

Cressman, G.P., (1946): The influence of the field of horizontal divergence on convection cloudiness.
J. Meteor., vol.3, pp. 85-99.

Donner, L.J., (1988): An Initialization for cumulus convection in Numerical weather prediction models.
Mon. Wea. Rev., Vol. 116, pp. 377-384.

George, J.J., (1960): Weather Forecasting for Aeronautics.
Academic Press, New York and London, pp. 407-415.

Godske, C.L., Bergeroy, T., Bjerkens, J. and Bundgaard, R.C., (1957): Dynamic Meteorology and Weather forecasting. Am. Meteor. Soc. Boston, Mass., pp. 621-623.

Haltiner, G.J. and Martin, F.L., (1957): Dynamical and Physical Meteorology.
McGraw-Hill Book Company, Inc. pp. 8-73.

Hess, S.L., (1959): Introduction to theoretical Meteorology.
Holt, Rinehart and Winston, New York. pp.147-149.

Hoel, P.G., (1984): Introduction to Mathematical Statistics.
John Wiley and Sons, Inc., pp. 252-257.

Holton, J.R., (1972): An introduction to dynamic meteorology. Academic Press, New York and London. pp. 261-278.

Houghton, H.G., (1951): On the Physics of clouds and precipitation.
Compendium of Meteorology.
Boston, Mass. Am. Meteor. Soc. pp. 165-181.

Johnson, D.H. (1962): Rain East Africa.
Quart. J. Roy. Meteor. Soc. Vol. 88, pp. 1-18.

______, and Morth, H.T., (1961): Forecasting research in East Africa.
Memoirs, E.A. Met. Dept. 3, No. 9, pp. 22-57.

Krishnamurti, T.N. and Bedi, H.S., (1988): Cumulus parameterization and Rainfall rates.
Mon. Wea. Rev., Vol. 116, pp. 583-599.

Kuo, H.L., (1965): On formation and intensification of tropical cyclones through latent heat release by cumulus convection.
J. Atmos. Sci. 22, pp. 40-63.

______, (1974): Further studies of the parameterization of the effect of cumulus convection on large-scale flow.
J. Atmos. Sci. 31, pp. 1232-1240.

Ludlam, F.H., (1966): Cumulus and cumulonimbus convection.
Tellus, Vol. 18, pp. 687-698.

Majugu, A.W., (1983): Mean and seasonal variation of precipitation in East Africa.
M.Sc. thesis. pp. 140-143 and 195-200.

Mather, J.S., (1949): An investigation of the dimensions of precipitation echos by Radar.
Bull. Am. Meteor. Soc., Vol. 30, pp. 271-277.

Namias, J., (1938): Thunderstorm forecasting with the aid of isentropic charts. Bull. Am. Meteor. Soc., Vol. 19, pp. 1-14.

Normand, C.W.B., (1946): Energy in the atmosphere. Quart. J. Roy. Meteor. Soc., Vol. 72, pp. 145-167.

Perkey, J.D. and Maddox, R.A., (1985): A numerical Investigation of a Mesoscale convective system. Mon. Wea. Rev., vol. 113, pp. 553-566.

Petterssen, S., (1940): Weather Analysis and Forecasting. McGraw-Hill Book Company Inc., New York and London pp. 75-110.

______, Knighting, E., James, R.W. and Herlofson, N., (1945): Convection in theory and practice. Geofys. Publ., Vol. 16, No. 10, 44 pp.

Riehl, H., (1954): Tropical Meteorology. McGraw-Hill Book Company, Inc., New York, Toronto, London. pp. 119-144.

Sanders, F. and Paine, J.R., (1975): The structure and thermodynamics of an intense mesoscale convective storm in Oklahoma. J. Atmos. Sci., Vol. 32, pp. 1563-1579.

Sansom, H.W., (1963a): A moisture/Stability Index as an aid to local forecasting in East Africa. Tech. Memo., E.A. Met. Dept., No.9, pp. 1-8.

Sansom, H.W., (1963b): The structure and behaviour of the inter-tropical convergence zone. Proc. of the WMO/FAO seminar on Met. and the Desert locust. Tehran-25 Nov. to 11 Dec. 1963, pp. 91-101.

Sawyer, J.S., (1970): Large scale disturbance of the equatorial atmosphere. Met. Mag., 99, NO. 1170.

Showalter, A.K. (1953): A stability Index for thunderstorm forecasting. Bull. Am. Meteor. Soc., Vol. 34, No.6, pp. 250-252.

Stommel, J.M., (1947): Entrainment of air into a cumulus cloud. J. Meteor., Vol. 4, pp. 91-94.

Thompson, B.W., (1957): Diurnal variation of precipitation in British East Africa. E.A. Met. Dept. Tech. Memo. No. 8, pp. 1-13.

Watson, A.I., Meitin, J.G. and Cunning, J.B., (1988): Evolution of the kinetic structure and precipitation characteristics of mesoscale convective system on 20 May, 1979.

Willams, N.R., (1948): Development of dust whirls and similar small-scale vortices. Bull. Am. Meteor. Soc., Vol. 29, pp. 106-117.

Wilson, J.W. and Schreiber, W.E., (1986): Initiation of convective storms by radar-observed boundary layer convergent lines. Mon. Wea. Rev., 114, pp. 2516-2536.

WMO and NOAA, (1989): Proc. of World Meteorological Organization (WMO) and National Oceanic Atmospheric Administration (NOAA) course No.1 on Aviation Meteorology with an emphasis on Satellite Interpretation. Tallahassee, Florida, (U.S.A.), October, 27, 1989.