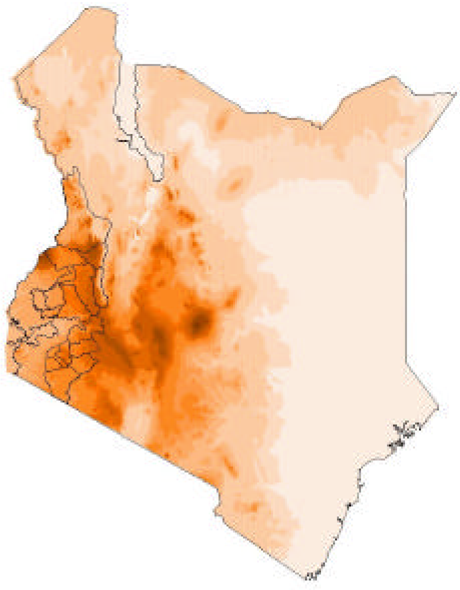
The inter-sectoral response to the 2002 malaria outbreak in the highlands of western Kenya



Report of an individual consultancy to the UNICEF, Kenya Country Office (KCO)

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Table of contents

1. Executive Summary

The Government of Kenya (GoK) declared the presence of a number of malaria epidemics in the western highland districts during the second quarter of 2002. The United Nations Children's Fund (UNICEF), on behalf of the Ministry of Health (MoH), commissioned a rapid situation assessment of some of the affected areas (Kisii Central, Gucha, Nandi and Kericho districts), a broader analysis of the justification for investment in epidemic preparedness in the western highlands and recommendations for more effective use of national data and resources in future emergencies.

Analyses of available case burden data support the position of near normal seasonal transmission in Kisii Central and a slightly enhanced seasonal resurgence in Gucha. Nandi and Kericho experienced severe epidemics. Application of simple forecasting techniques might have predicted some of these exceptional seasonal increases in disease risk.

A number of key point and recommendations were identified:

1. The Division of Malaria Control (DoMC) and the Disease Outbreak Management Unit (DOMU) had not institutionalised a system of accessing seasonal forecasting data from the international community or Kenyan Meteorological Department (KMD). The cost of rainfall data from the KMD was also prohibitive and was consequently not available to the public-health community during this emergency.
2. A review of the available seasonal forecasts suggests that their predictive accuracy is limited and may not assist the DoMC or DOMU in anticipating exceptional malaria case-burdens. Conversely, monitoring 10-days rainfall totals through the public-domain African Data Dissemination Service (ADDS) was more reliable and showed exceptional rainfall events to have occurred in most highland districts in late April and late May, long before the epidemic took hold.
3. The capacity of the DoMC to monitor rainfall patterns through the ADDS should therefore be strengthened.
4. Districts in the north-east of Kenya also received anomalously high rainfall in April and May, although no precautionary actions were taken. All epidemic prone districts, not just the highlands, should be monitored as a matter of routine.
5. In June 2002 the international community declared the start of El Niño conditions for the first time since 1998. This is not considered to be a significant problem for Kenya, however, because (i) the current El Niño is relatively weak and (ii) the relationship between the El Niño Southern Oscillation and Kenyan rainfall patterns over the longer-term is not strong. Public opinion and media awareness of this "problem" is so acute, however, that the GoK-DoMC should also monitor on-line El Niño reports to be in an informed position to respond to future enquiries.
6. Surveillance requirements were widely understood at the district level but their capacity to fulfil statutory obligations was poor. The reality is that a comprehensive picture of the 2002 malaria emergency in the western highland districts will not be known until well after the epidemics have finished. What remains unclear is why the system for Integrated Disease Surveillance and Response (IDSR), with a remit to detecting epidemics, was not fully functional during this period. Strengthening district-level Health Management Information Systems (HMIS) must remain a priority.
7. Surveillance of monthly out-patient (OP) data remains an insensitive detection tool for malaria epidemics. Routine introduction of weekly recording in May, June and July is suggested for western highland districts with acute seasonal transmission. Of the epidemic detection techniques tested the cumulative sum (C-SUM) method is preferred as it is least sensitive to shifts in seasonal transmission. District-level staff and DoMC should be trained in applications of the C-SUM methodology.
8. There should be a single and immediate effort to collate all the malaria OP admissions data (1996-2002) archived at the central HMIS. This should be used as a central reference database at DoMC to:

  a. Provide an evidence-based platform to check future case reporting by DOMU against historical disease burdens.
  b. Form part of a national burden of disease framework – the highlands were found to not constitute a single epidemiological block with some districts nationally important and others unimportant. More attention should be paid by the GoK and inter-sectoral partners to rationalise control expenditure equitably both within and outside of the highlands.

9. A number of issues related to the management of the epidemics should also be noted:
   a. The media played a prominent role in shaping public and political opinion during this emergency. To develop more credible, informed reporting depends critically upon an improved system of communication between the DoMC/MoH and the national media. The media provide the most powerful conduit to communities in the midst of emergencies. This requires a long-term commitment to build this partnership and a dedicated liaison officer. In the short-term the DoMC/MoH must respond more effectively to early reports such as "Epidemics test malaria policy" and "Malaria toll a grave mistake".
   b. Malaria in the highlands is a predictable annual event. The Government's National Malaria Strategy articulates a number of preventative and disease management strategies that would ameliorate the burden of malaria nationally. Enhancing access to early, prompt and effective treatment, ITNs and intermittent presumptive treatment (IPT) of malaria during pregnancy are likely to have, as great an effect in the highlands, as elsewhere in the country.
   c. The present review identified a number of critical weaknesses in access to essential interventions in the western highlands and consistent with the DoMC recent findings from their baseline Roll Back Malaria (RBM) surveys. The use of insecticide treated nets (ITNs) and IPT is very low. Accessing quality assured medications in the informal sector remains a major concern. Case-management in the highlands continues to require strengthening at all-levels of the system in concert with national guidelines and drug supplies must be guaranteed.

10. Areas of the country, such as the western highlands, that demonstrate low, intensity acute seasonal transmission might benefit from an extension to the broader approaches to malaria control and prevention.
    a. Understanding the seasonal patterns of disease burdens and some ability to forecast anomalies to this pattern might be useful in planning resource allocation. Protecting drug and commodity supplies for periods of maximal risk is simply good management.
    b. IRS may have a comparative advantage over ITNs programs where communities prefer IRS and the costs-per infection prevented are cheaper with IRS than ITNs.
    c. Routine suspension of cost sharing for malaria treatment in May-June-July may also encourage more prompt treatment of disease as a mid-way to mass drug administration (MDA).
    d. Finally, leave should be strictly managed for key medical and administrative staff at the relevant districts, provinces and central levels in the months of May, June and July.

The main conclusion was that exceptional rainfall conditions coupled with a lack of epidemic preparedness in the districts lead to resurgent outbreaks in Kisii and Gucha and epidemics in Nandi and Kericho in June and July 2002. All current indications (meteorological and epidemiological) were that these epidemics will naturally abate during August. The inter-sectoral preparedness could have been better and mechanisms to improve this in the future are suggested. Given such emergency conditions, however, the reaction of GoK, UNICEF and partners was largely justified but more proactive deployment in the future will increase the effectiveness of any measure taken.

2. Aim and scope of the report

2.1. Background to current "epidemic" from UNICEF

Following heavy rains in April and May, a serious malaria outbreak has occurred in the highlands of Kenya. The malaria outbreak has claimed 324 lives to date, with an estimated number of reported cases of infected people being 200,000 in 11 districts (Nandi, Kericho, Uasin Gishu, Buret, Bomet, West Pokot, Trans Mara, Trans Nzoia, Kisii, Gucha, Nyamira). It is reported that the number of cases is stabilising in Kisii but is increasing in other districts. At present, the estimated number of persons at risk is 5.7 million.

The United Nations Children's Fund (UNICEF) has provided supplies worth US$ 200,000 to the Government of Kenya (GoK), through the Ministry of Health (MoH). These include insecticide (Fendona for insecticide treated nets (ITNs), deltamethrin for insecticide residual spraying (IRS)); ITNs and drugs (quinine; Sulfadoxine Pyrimethamine (SP); sodium lactate). In addition, UNICEF are providing logistical support for distributing these supplies, assistance in social mobilisation and monitoring the situation on the ground.

Surveillance has been identified as an area of comparative weakness. There is an urgent requirement to analyse available data to estimate the scale of the emergency and the response necessary to control it. Collection and detailed analysis of this data will also be particularly important for documentation and lesson learning in this emergency.

2.2. Inter-sectoral response digest: chronology

30.4.02 – 08.05.02. Due to the heavy rains around Mount Kenya, there was landslide and breaking of the banks of the Kuja and Migori Rivers, leaving the Nyatike area completely covered by water and killing several people.

04.05.02 - 08.05.02. Expansion of flooding to other districts in around Lake Victoria in Nyanza and Western Provinces affecting Nandi, Rachuonyo and Kisumu, Busia, Muranga, Kakelo-Kakoth, Karapolo, East Kanyor, West Kanyor, West Kanyaruanda and Arieko districts. In total an estimated 200,000 people were affected by the floods in April and May.

02.05.02 – 10.05.02. Multi-sectoral District and National level Disaster Management Committees were reactivated, chaired by the District Commissioner and Office of the President respectively and with representatives from relevant agencies and partners at each level. In response to the disaster, assessments were made by various teams and supplies and relief items were donated. GOK donated supplies mainly food items, local well wishers provided food, blankets and cash. UNICEF Kenya Country Office (KCO) donated emergency kits including drugs, mosquito nets, cooking utensils and water purification tablets. Red Cross donated blankets, tents and some drugs.

03.05.02. UNICEF meets with Division of Malaria Control (DoMC) to discuss the possibility of malaria outbreak and appropriate forestalling measures.

05.05.02. The team in Nyanza identifies health as the weakest sector in the area. An urgent need for anti-malaria drugs, cholera and dysentery kits, chlorine tabs, mosquito nets, as well as firewood to cook the food distributed was requested. The risk of cholera is very high taking into account that wells and latrines are under water.

10.05.02. A UNDMT was convened to formulate a common United Nations (UN) response strategy and to support GoK efforts in the rescue operations. KRC informed that they launched an appeal for non-food items for 1,6M CHF for 125,000 beneficiaries. Oxfam-GB mobilises some US$20,000 to help on the health sector through African Medical and Research Foundation (AMREF), and Médecins Sans Frontières – France (MSF-F) will look for cholera kits among all the MSF sections in Kenya. World Food Programme (WFP) to provide cooking oil if needed.

19.05.02. UNICEF donates ITNs, antimalarials and insecticides to the government.

05.07.02. Newspaper reports of upsurge in malaria cases in Nyanza and Rift Valley Provinces. UNICEF contacted MoH to confirm the reports and alerted Red Cross to be prepared for coordinated response; WHO were already aware.

05.07 - 08.07.02. Assessment teams sent to the affected districts.

08.07.02. First coordinating meeting in response to the epidemic: MoH meets with partners to officially announce the outbreak and provide briefing on actions taken by the GoK so far. The gaps to be met were identified by all partners and roles apportioned to avoid duplication of efforts.

11.07.02. GoK through the MoH issues a statement of epidemic alert.

2.3. Terms of reference

The consultant will review the data on malaria case-burden, seasonal distribution, between year variations, early warning, detection and prediction in the highlands and put this into the context of the current "epidemic".

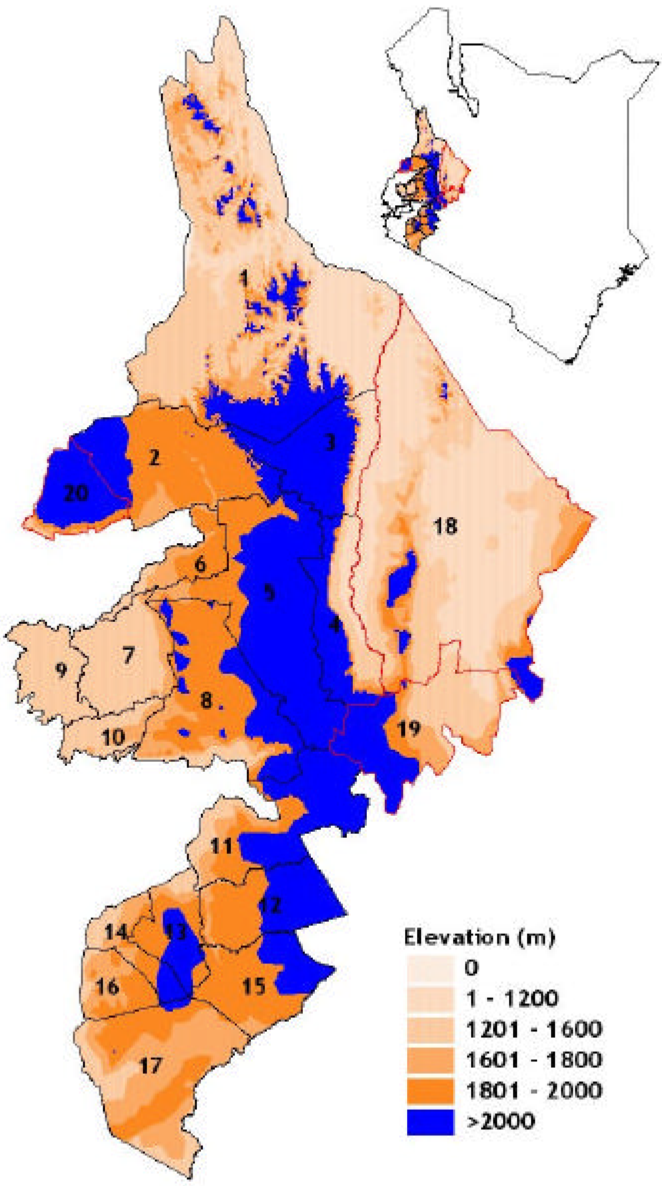
Document experiences and lessons learned from the current emergency, and recommendations for malaria emergency preparedness and response in the highlands of western Kenya. This includes a description of what constitutes an epidemic in the highlands, recommendations of what these data imply for future surveillance protocols (and how existing proposals around integrated disease surveillance should be enhanced) and how the data can be used by MoH as better communication tools to support emergency response interventions.

3. Malaria epidemiology in the western highlands of Kenya

3.1. Kenyan biogeography

The highlands of Kenya are located in the south west of the country and bisected by the Rift Valley (Odingo 1971). Here we consider the malaria epidemiology of the politically and economically important western highlands including the Uasin Gishu plateau and the Trans-Nzoia uplands. See Figure 3.1.1. Synoptic meteorological aspects of the western highlands are considered in Section 5.

Figure 3.1.1. Location map of the western Kenyan highlands overlaid on a digital elevation model.



The MoH defined epidemic prone districts are bordered in black (Snow *et al.* 1999). Note districts partitioned in the recent census from "parent" districts classified as epidemic prone have also been included. Those bordered in red are included as they are of reported concern to the DoMC during the current outbreak. North is to the top of the page. 1 West Pokot, 2 Trans Nzoia, 3 Marakwet, 4 Keiyo, 5 Uasin Gishu, 6 Lugari, 7 Kakamega, 8 Nandi, 9 Butere, 10 Vihiga, 11 Kericho, 12 Buret, 13 Kisii North (Nyamira), 14 Kisii Central, 15 Bomet, 16 Gucha, 17 Trans Mara, 18 Mt Elgon, 19

Koibatek, 20 Baringo. The distance from the extreme north of West Pokot to the extreme south of Trans Mara is 520 km.

3.2. A brief history of highland "epidemics"

Before the First World War malaria was considered largely absent from areas of Kenya above 1500 m (Garnham 1948). Malaria first appeared in the western highlands of Kenya in the 1920s with the influx of gametocyte laden labourers and their creation of breeding sites during railway construction (Anderson 1929). Malaria epidemics were frequently reported in the 1930s and this continued until the advent of dichloro-diphenyl-trichloroethane (DDT) and widespread intervention efforts in the 1950s and 1960s (Roberts 1964a; Roberts 1964b; Roberts 1964c). The effective, widely and cheaply available antimalarial chloroquine (CQ) also helped to keep transmission low throughout the 1970s (Snow *et al.* 1999). The recrudescence of malaria since the 1980s is thought to be related to the widespread emergence of CQ resistance in Kenya (Shretta *et al.* 2000), coupled to a decrease in efficacy of clinical services (partly due to massive population increases) rather than frequently cited climate change (Hay *et al.* 2002; Hay *et al.* 2002; Hay *et al.* 2002; Shanks *et al.* 2002). The most comprehensive review of the of epidemiology, politics and control of malaria epidemics in Kenya for the 1900-1998 period can be found in (Snow *et al.* 1999).

3.3. What constitutes an epidemic?

The term endemicity is used to define the intensity of malaria transmission in a location. Endemicity can be measured in various ways but is conveniently defined on the basis of the parasite rate (PR) in sample of children often between 2 and 10 years of age. A conceptual transmission continuum exists from high-stable to low-unstable, frequently subdivided as holoendemic (PR >= 75%), hyperendemic (PR = 50-74.9%), mesoendemic (PR = 10-49.9%) and hypoendemic (PR < 10%) (Bruce-Chwatt 1991).

In holoendemic areas of high malaria challenge the average age of infection is low and adult population immunity consequently high, so that the susceptible population is determined largely by the birth rate. Seasonal and between year variation are is characteristically low, although not absent, and the disease is primarily a paediatric phenomenon. A clear example would be the lakeside populations of western Kenya. In contrast hypoendemic areas of low transmission have high average ages of infection with consequently low levels of population immunity. The population susceptible to infection is therefore large and when conditions become transiently suitable for higher levels of transmission, epidemics can be devastating in all age groups. These areas experience "true epidemics" (Nájera *et al.* 1998) and a unambiguous example would be the arid areas of north and north-eastern Kenya. The highlands of western Kenya lie between these extremes and are best defined as mesoendemic with significant seasonality in transmission (Hay *et al.* 2002) (see Section 6) and as such experience "resurgent outbreaks" (Nájera *et al.* 1998). These outbreaks may often be perceived as epidemics but this is related more to an ability to cope than local malaria epidemiology.

These considerations have important implications for malaria early warning systems (MEWS) and subsequent control options (Hay *et al.* 2001). If the extremes of the transmission continuum are again considered, MEWS are irrelevant in holoendemic areas because malaria transmission is uniformly high, but could have significance for epidemic preparedness in hypoendemic locations. The crux of this report is to consider where the highland epidemic prone districts of western Kenya fit between these extremes and the consequent implications for evidence-based control strategies.

3.4. What constitutes a malaria early warning system?

A MEWS is simply a rubric for improving preparedness and as such should not be conceptually or operationally separated from control (W.H.O. 2001). A MEWS framework develops on a good knowledge of the spatial variation in malaria risk in a region.

Mapping the variation in malaria risk simply puts our epidemiological understanding of malaria into a geographical context. Defining those areas which are endemic, those prone to resurgent outbreaks and those vulnerable to true epidemics facilitates the estimation of populations at risk and district based plans for mitigation and control. To a large extent this mapping component has been achieved (Omumbo *et al.* 1998; Snow *et al.* 1998; Snow *et al.* 1999) and research efforts locally and internationally are directed towards refining, spatially and temporally, our existing basic understanding of malaria endemicity across Kenya and Africa (Hay *et al.* 2000; Omumbo *et al.* 2002; Rogers *et al.* 2002).

The MEWS aspect is simply a series of approaches to refine this spatial epidemiological awareness in a dynamic environment (Myers *et al.* 2000). This is usually further classified as forecasting, early warning and early detection. Forecasting refers to very low specificity regional climate forecasts (see Section 4). It has been suggested their current accuracy allows them to alert very cautiously at national scales with lead times of 3-6 months (W.H.O. 2001) although this is still being evaluated (Thomson *et al.* 2000). Early warning refers to the monitoring of meteorological indicators such as rainfall and temperature (see Section 5). This is of increased specificity but with lead times of only 1-2 months. Early detection is surveillance (see Section 6). It has the highest specificity, when implemented correctly, but has the shortest of lead times. It is not necessary for all components of a MEWS to be employed; each part adds incrementally to an evidence base for rationalising control and intervention options.

3.5. Priorities for evaluation during the 2002 emergency

In this report we evaluate the existing information on the malaria epidemiology, historical and contemporary, to determine at what level MEWS may be appropriate for the western Kenyan highlands. The report is structured to comment on the current abilities to implement forecasting (Section 4), early warning (Section 5) and early detection (Section 6) during the 2002 malaria outbreak. The report then attempts to compare these recent conditions with past records to evaluate the extent and severity of the malaria resurgence. Section 7 reviews information on the burden of disease treatment across Kenya to try and assess the significance of the western highlands in the national context. Section 8 reviews ancillary information pertinent to the control of malaria in the western highlands, with an attempt to understand the factors that contributed to the current resurgence. Section 9 contains the conclusions and recommendations (operational and research issues are considered) and Section 10 is an executive summary. References (Section 11), acknowledgements (Section 12), some suggestions for the report distribution (Section 13) and a glossary (Section 14) are also included.

4. Forecasting

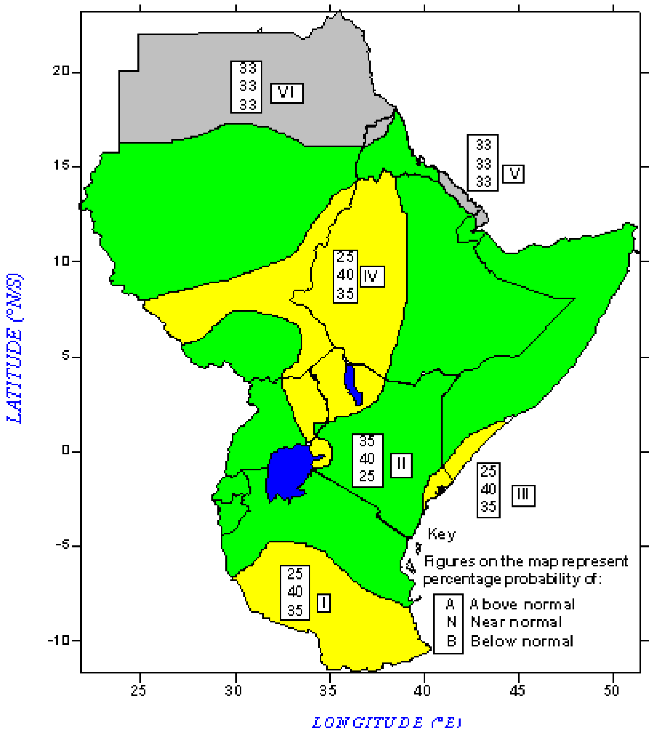
4.1. A background to seasonal climate forecasts

Since the 1980s there has been an increase in the capacity to model weather systems and every year brings refinements to the General Circulation Models (GCMs) (Carson 1998). The output from GCMs is not deterministic and typically presented as a range of probabilities (see below). Note a seasonal climate forecast usually refers to the next 3 months. Recent technical progress has increased considerably both the data available for seasonal climate forecasting and the number of forecasts available. Perceived forecasting success during the 1997/1998 El Niño (Stockdale *et al.* 1998) has brought the possibility of seasonal climate forecasting to the attention of the epidemiological and malaria control community (Thomson *et al.* 2000; W.H.O. 2001).

4.2. Climate forecasts: Greater Horn of Africa

The statement from the Greater Horn of Africa Climate Forum (GHARCOF) in February 2002 was "*There is increased likelihood of near-normal to above-normal rainfall over northern Tanzania, Rwanda, Burundi, much of Uganda and Kenya as well as Somalia, eastern half of Ethiopia, southern Djibouti, extreme southern and central Sudan and western Eritrea for the period March to May 2002*" (http://www.cpc.ncep.noaa.gov/products/african_desk/rain_guidance/ea_forum.html). This statement is clarified in Figure 4.2.1. which maps these findings for the Greater Horn of Africa region. The motivation for these forecasts is forewarning of potential areas of food supply insecurity in the region.

Fig 4.2.1. Greater Horn of Africa consensus climate outlook for the period March to May 2002



Interpreting the map is as follows. The numbers in the boxes for each zone indicate the probabilities (chances of occurrence) of rainfall in each of the three categories (terciles), above-, near-, and below normal. The top number indicates the probability of rainfall occurring in the above-normal category; the middle number is for the near normal and the bottom number for the below-normal category. Above-normal rainfall is defined as within the wettest third of recorded rainfall amounts in each zone; near-normal is defined as the third of the recorded rainfall amounts centred around the climatological median; below-normal rainfall as within the driest third of the rainfall amounts. For example, in case of western Kenyan highlands (zone II), there is 35%

probability of rainfall occurring in the above normal category; 40% probability of rainfall occurring in the near-normal category; and 35% probability of rainfall occurring in the below normal category.

This seasonal forecast was based on examining current and expected sea surface temperature (SST) anomalies over the Pacific Ocean as well as the Indian and Atlantic Oceans, together with other factors that affect the climate of the sub region. These factors were assessed using coupled ocean-atmosphere models, further statistical models and expert interpretation. The published caveat is that "*the current status of seasonal forecasting allows prediction of spatial and temporal averages and may not fully account for the physical and dynamical factors that influence regional and national climate variability*".

It is obviously difficult to interpret the accuracy of these probabilistic predictions over regional extents and we shall comment on this in more detail in Section 5 with reference to the observed rainfall patterns in March to May 2002. The outlook for the highlands was the highest likelihood (40% probability) of normal conditions, a good chance of higher than average rainfall (35% probability) with a low chance (25% probability) of drier conditions. From the end of February 2002, therefore, a forecast existed that indicated an approximately one in three chance of above average rainfall (but a higher chance of normal conditions) in the western highlands of Kenya between March and May 2002. This could (and probably will) be construed as an alert; although it is not a very strong or accurate one. It is more appropriate for UNICEF to decide if they would find this type of information useful. The predictions for the June to August period were not available on-line at the time of writing this report.

4.3. Climate forecasts: Kenya

The Kenya Meteorological Department (KMD) also publishes Kenya specific seasonal climate forecasts. We did not have time to approach the KMD directly during this work and information on KMD forecasts for 2002 were obtained indirectly from Eric C. Were of the DoMC. A KMD circular, dated 10 July 2002 and entitled "*Weather review during the October – December 2001 short rains and January – February 2002, and the forecast for March – May 2002 long rains season*" predicted 30%, 50%, 20% probability of above normal, near normal and below normal rainfall for western highland districts north of Kericho and 35%, 40%, 25% for Kericho and districts to the south. The forecasts are based on a similar methodology to GHARCOF (see Section 4.2). Again we have a forecast the highest likelihood of near normal conditions across the western Kenyan highlands.

A further circular dated 15 July 2002 entitled "*Review of the weather in June 2002 and the forecast for July – August 2002*" indicated the highlands to the west of the Rift Valley (Kakamega, Kitale, Kericho, Eldoret *etc*.) and the central Rift Valley (Nakuru, Narok *etc*.) were expected to receive near normal to below normal rainfall. The exact probabilities on spatially explicit maps were not given in this circular so it is even harder to judge this forecast.

It is not known if we have missed the original circular with the March-May forecast or it was only made available after the forecasting period on 10 July 2002. In either event, the DoMC is not routinely included on the distribution list for this circular and it should be. Furthermore, these forecasts should be published on the KMD website at on a fixed date each year to be of maximal benefit to the agricultural and epidemiological communities.

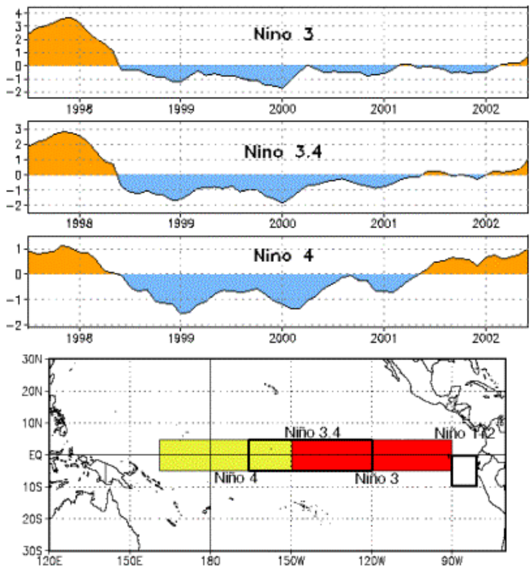
4.4. The portend of a 2002-2003 El Niño?

There is considerable international interest in the influence of the El Niño Southern Oscillation (ENSO) on public health (Kovats 2000). The ENSO is a periodic inter-annual biphasic variation in sea-level pressure across the Pacific Ocean that drives a complex global system of meteorological perturbations (Philander 1990; McPhaden 1999). The El-Niño period is characterised by high surface pressure over the western, and low surface pressure over the south-eastern Pacific; the complementary phase is termed La Niña. During the El-Niño, conditions are usually said to be wetter in Kenya (Ropelewski 1992; Epstein 1999) although recent evidence suggests that the coupling of the with El Niño Southern Oscillation (ENSO) and climate around the Indian Ocean region is less strong than previously suggested (Saji *et al.* 1999; Camberlin *et al.* 2001; Mason and Goddard 2001). In addition to the claimed links with malaria in India (Bouma and van der Kaay 1994) and South America (Bouma *et al.* 1997) the El Niño has also been argued to be predictive of Rift Valley Fever "epidemics" in Kenya (Linthicum *et al.* 1999). Recent analyses, however, have shown no influence of ENSO on temperature and rainfall patterns (1965-1998 inclusive) in the Kenyan western highlands (specifically Kericho), with the between year variation in malaria explained adequately by established theory on malaria population dynamics (Hay *et al.* 2000). In essence a seasonal upsurge is seen every year in June and July but it takes approximately three years for a reservoir of highly susceptible children to accumulate to facilitate major resurgences.

Based on the latest seasonally-averaged SST data, a Pacific basin warm episode (El Niño) has now developed (http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/enso_advisory.html). The three-month (April-May-June 2002) average SST anomaly for the Niño 3.4 region equalled the +0.5°C threshold value that the National Oceanic and Atmospheric Administration (NOAA) uses to define an El Niño. During June 2002 SST anomalies increased to greater than +1°C throughout the equatorial Pacific between 170°E and 105°W and subsurface temperature anomalies increased throughout the central and east-central Pacific. While positive SST anomalies in the vicinity of the international date line (180°W) have gradually increased since mid-2001, those in the east-central portion of the basin (between 140°W and 105°W) gradually increased beginning in early 2002 and then rapidly increased during late May and early June 2002. For the first time since the end of the 1997-98 El Niño episode the Niño 3, Niño 3.4 and Niño 4 indices in June 2002 were all greater than +0.5°C (see Figure 4.4.1).

The oceanic and atmospheric variables discussed above reflect the presence of El Niño conditions. Most coupled model and statistical model forecasts indicate that El Nño conditions are likely to continue through the end of 2002 and into early 2003. Although there is considerable uncertainty in the forecasts about the timing and intensity of the peak of this warm episode, all of the forecasts indicate that it will be much weaker than the 1997-98 El Niño. It is important to add that the global impacts of this warm episode should be correspondingly weaker than those observed during the very strong 1997 - 1998 El Niño.

Figure 4.4.1. Time-series of SST anomalies for the Nino 3, 3.4 an 4 regions (bottom panel). Anomalies are departures from the 1971-2000 average.



Given the poor coupling between ENSO and rainfall events in East Africa and the fact current predictions indicate only a weak El Niño event, the El Niño should not have a major impact on rainfall and consequent malaria patterns in the Kenyan western highlands in the latter part of 2002. It would perhaps, however, be sensible to monitor the El Niño forecast because the perceived importance of this phenomenon in the wider public and media consciousness (see section 8.7). This is simply a matter of checking the following Universal Resource Locator (URL) periodically: http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/enso_advisory.html. If current predictions of the scale of the current El Niño were to be revised upwards substantially, it would be prudent to re-evaluate and have a position on its implication for malaria in Kenya in 2003, in response to the inevitable national and international media circus. In fact the first soothsayers have been at work speculating about the impact of the current 2002 El Niño in the Daily Nation (Otieno 2002b). In the longer-term a study of the correlation between ENSO and rainfall across Kenya should be completed to assess its influence comprehensively.

5. Early warning: rainfall trends from Jan-Jul 2002

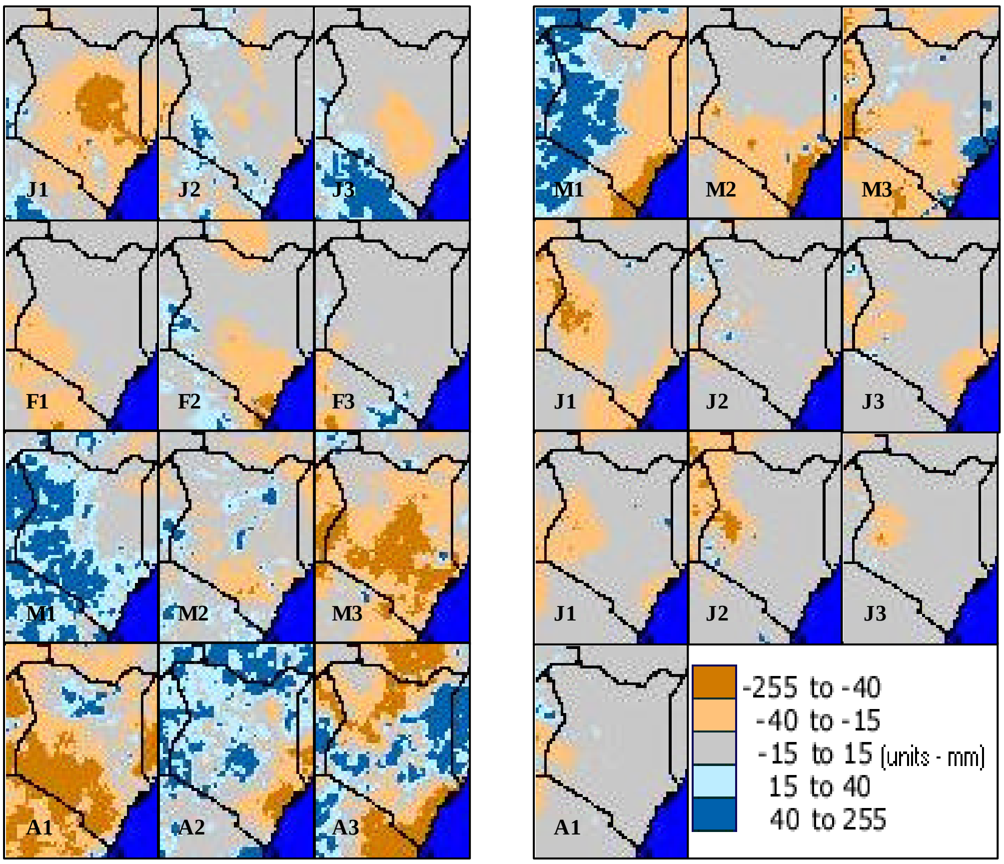
5.1. Data access and retrieval

Rainfall estimate (RFE) data for Africa are routinely available in near real-time from the USAID African Data Dissemination Service (ADDS) (http://edcsnw4.cr.usgs.gov/adds/adds.html). Satellite and meteorological station data are combined (Xie and Arkin 1997) to provide a continent wide digital coverage of RFEs at an 8 x 8 km spatial resolution. The data are presented as rainfall totals (mm) per dekad. The first dekad for a month is the total of rainfall in days 1-10, the second in days 11-20 and the third in days 21-28, 29, 30 or 31, depending on the length of the month. Each new dekad is available on-line about one day after it has past. A historical archive is available from the second dekad of July 1995 to-date against which current conditions can be compared. A limited proficiency with a Geographic Information System (GIS) is required to maximise the potential of this information source. All data preparation and extraction for this report was performed with WinDisp 4.0, a GIS available in the public domain (http://www.fao.org/WAICENT/faoinfo/economic/giews/english/windisp/windisp.htm).

5.2. Rainfall anomalies across Kenya in 2002

A short term mean was derived from RFE data for the period 1995-1999. The maps in Figure 5.2.1. show the current rainfall pattern minus the short term mean for each available dekad of 2002 from January to August inclusive. J1 = January dekad 1, F2 = February dekad 2 *etc*. Such graphics are useful to provide a visual overview. It is immediately obvious for example, that in early March, mid to late April and early May, the western Kenyan highlands experienced heavier than normal rainfall. Since this time, however, rainfall has been less than normal in this region.

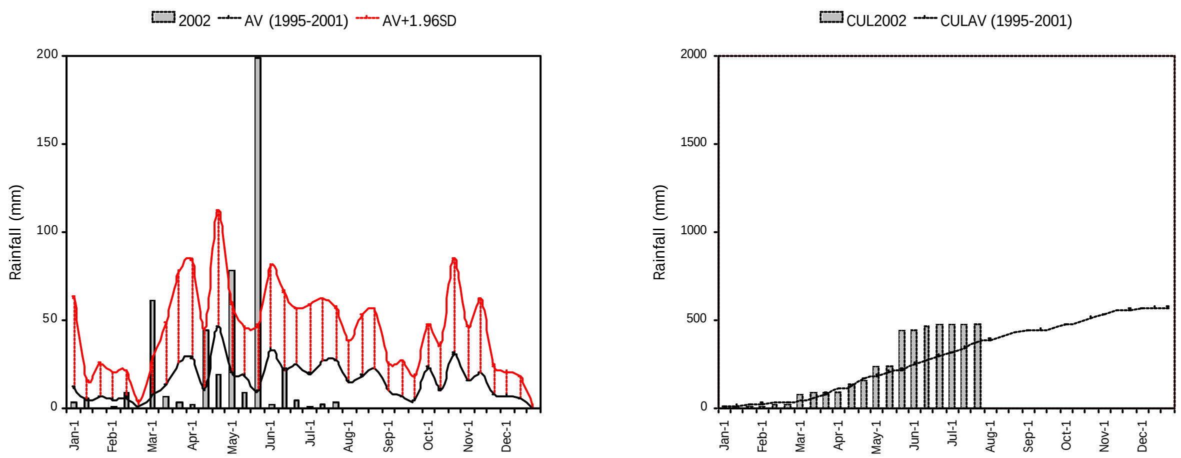
Figure 5.2.1. Rainfall anomalies for Kenya from January to August 2002 inclusive.



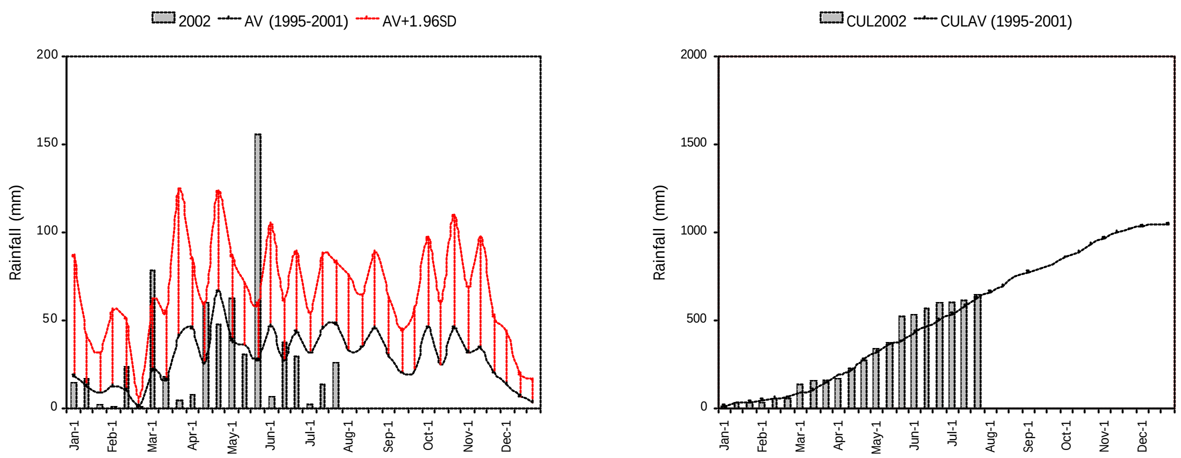
5.3. Rainfall distribution in the western highland districts in 2002

The RFE are in a digital format so it is also possible to extract average monthly RFEs for each of the districts with which we are concerned (see Figure 3.1.1. for a full list) for the duration of the RFE data archive. The following graphs display such data and allow us to quantify the visual impression gained from Figure 5.2.1. The data for each district are presented in two graphs and arranged in order of decreasing latitude of the northerly extent of each district. The first graph presents dekadal 2002 rainfall as grey bars. The lower black line shows the district average for each dekad for the 1995-2001 period and the upper red line is this average plus 1.96 times the standard deviation. We should expect, therefore, the upper red line to be exceeded in only five of a hundred observations (in this dataset years!). A rainfall total above the lower black line is therefore wetter than normal and above the upper red line very exceptional. There are some statistical simplifications in this approach and a more detailed treatment of the statistical complexities of rainfall data can be found in (Wilks 1995). The second graph simply plots the cumulative total for 2002 against the cumulative total rainfall for the average year. We use the deviations from the cumulative mean to rank the "unusualness" of 2002 rainfall between the western highland districts.

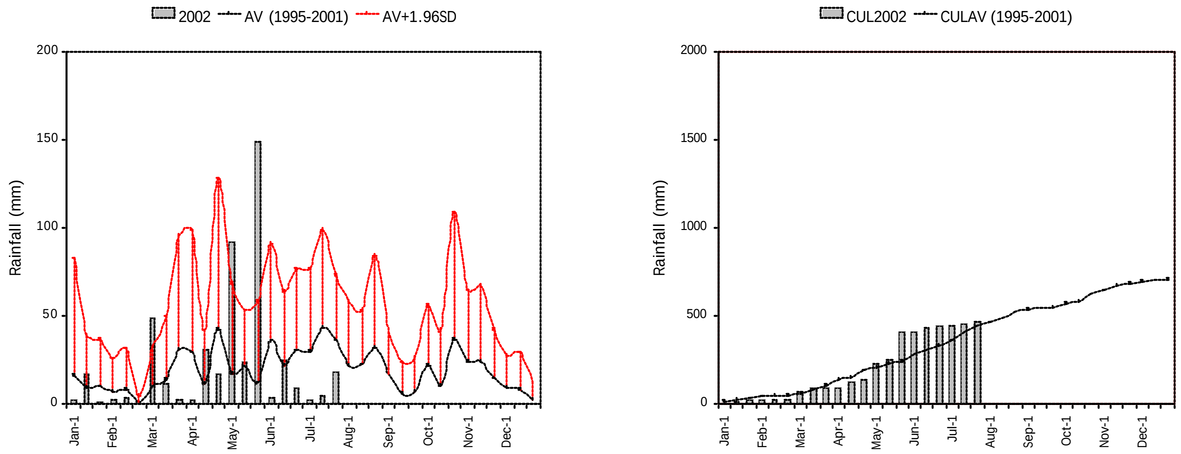
5.3.1. West Pokot (a) normal time-series and (b) cumulative time-series.



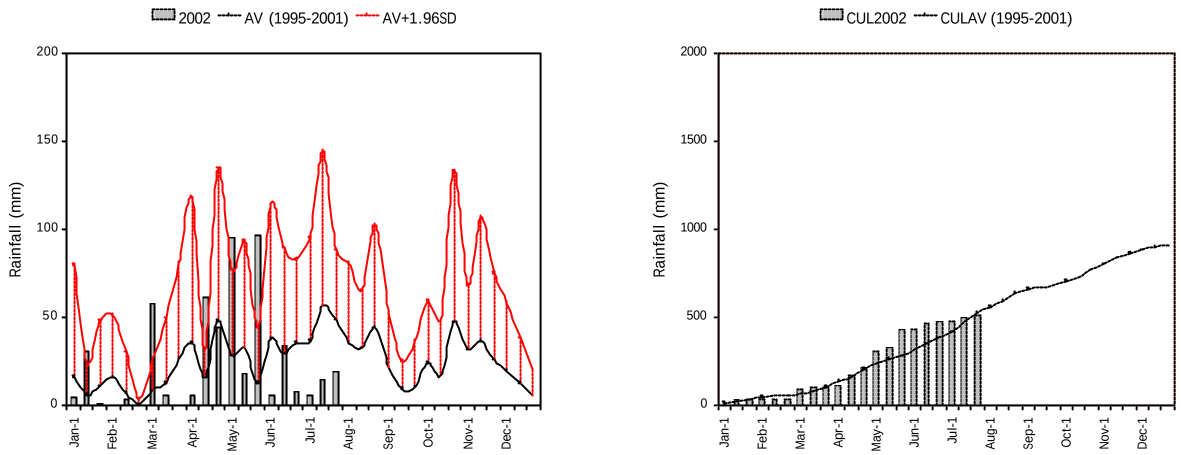
5.3.2. Trans Nzoia (a) normal time-series and (b) cumulative time-series.



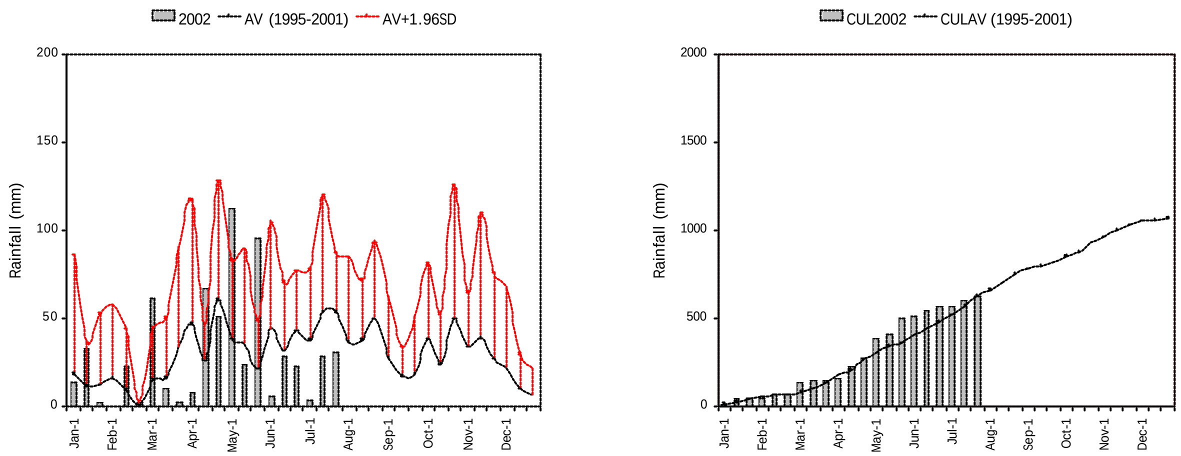
5.3.3. Marakwet (a) normal time-series and (b) cumulative time-series.



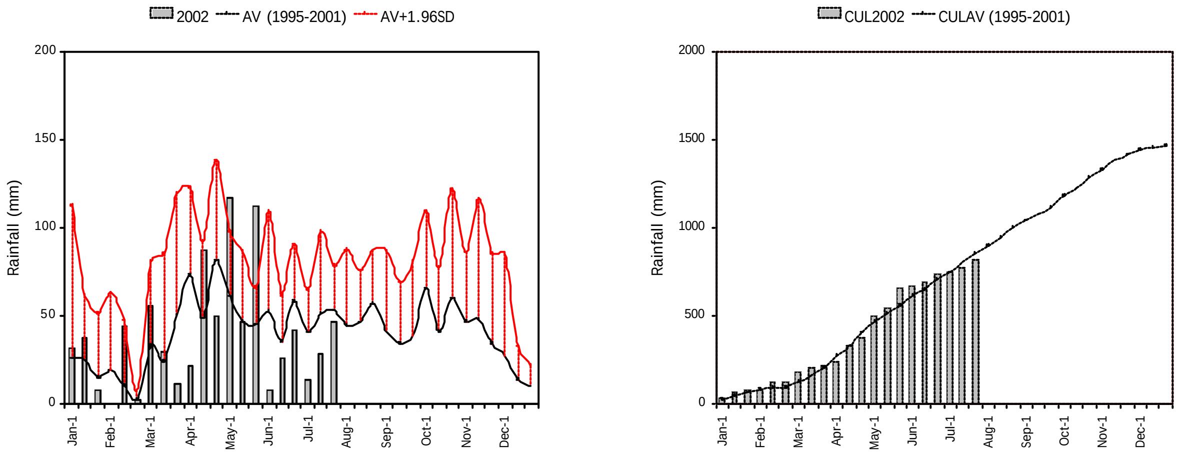
5.3.4. Keiyo (a) normal time-series and (b) cumulative time-series.



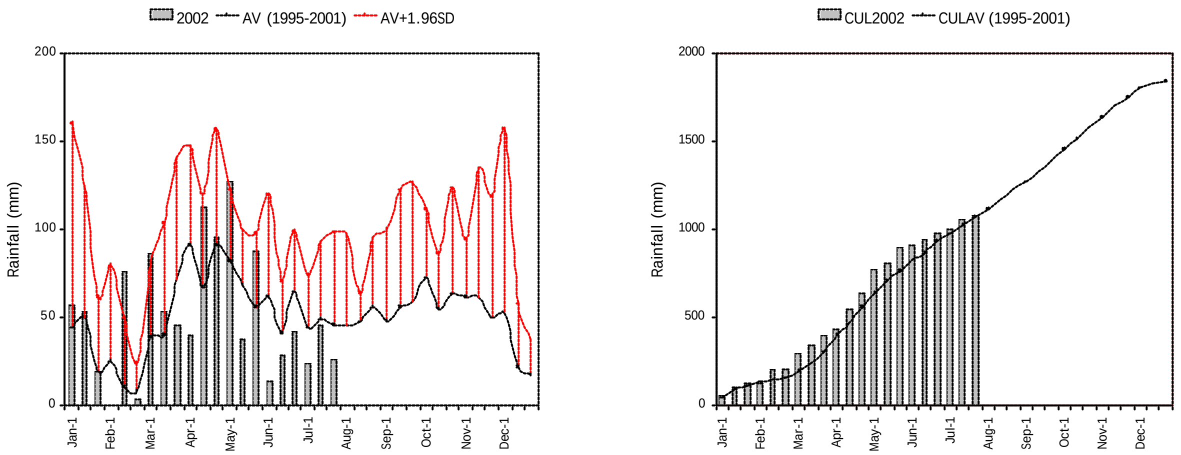
5.3.5. Uasin Gishu (a) normal time-series and (b) cumulative time-series.



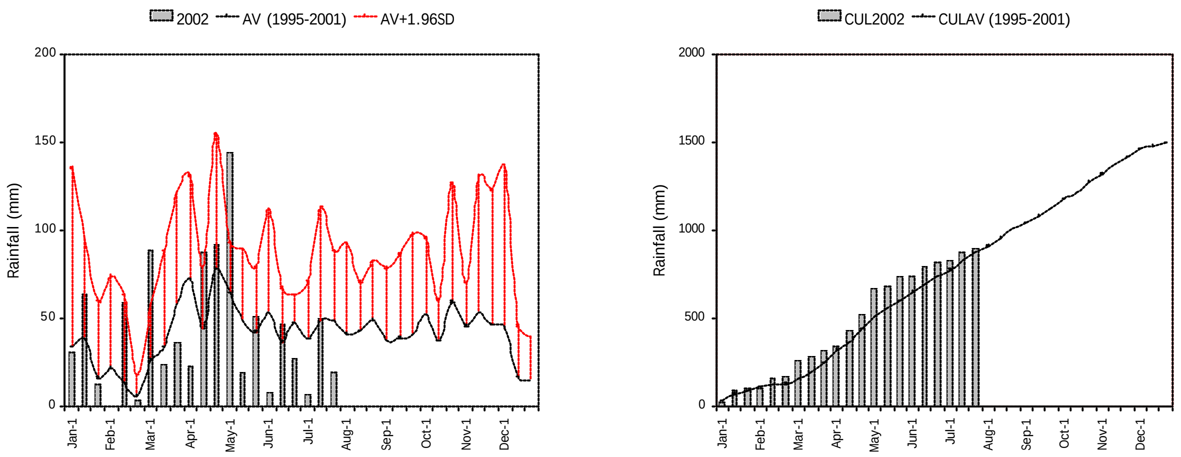
5.3.6. Lugari (a) normal time-series and (b) cumulative time-series.



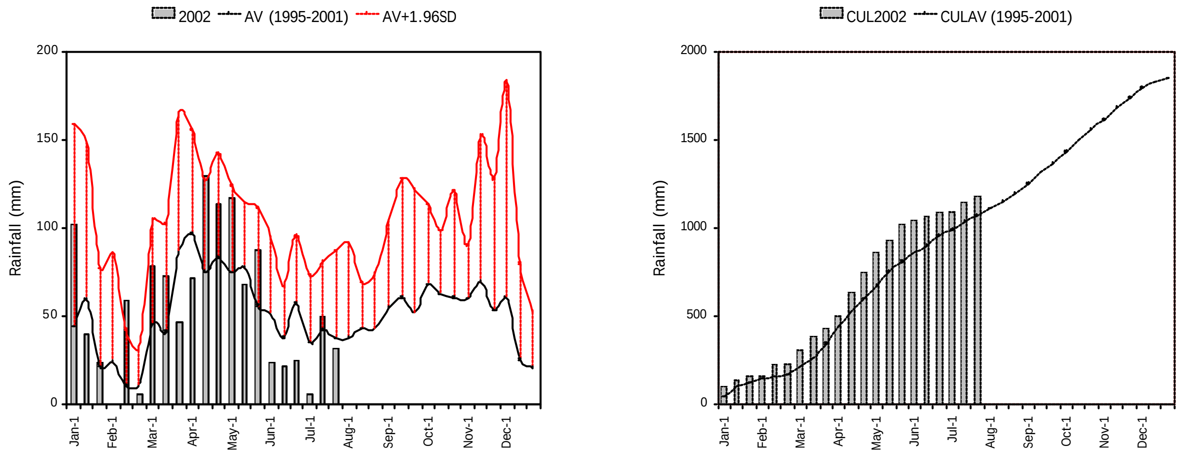
5.3.7. Kakamega (a) normal time-series and (b) cumulative time-series.



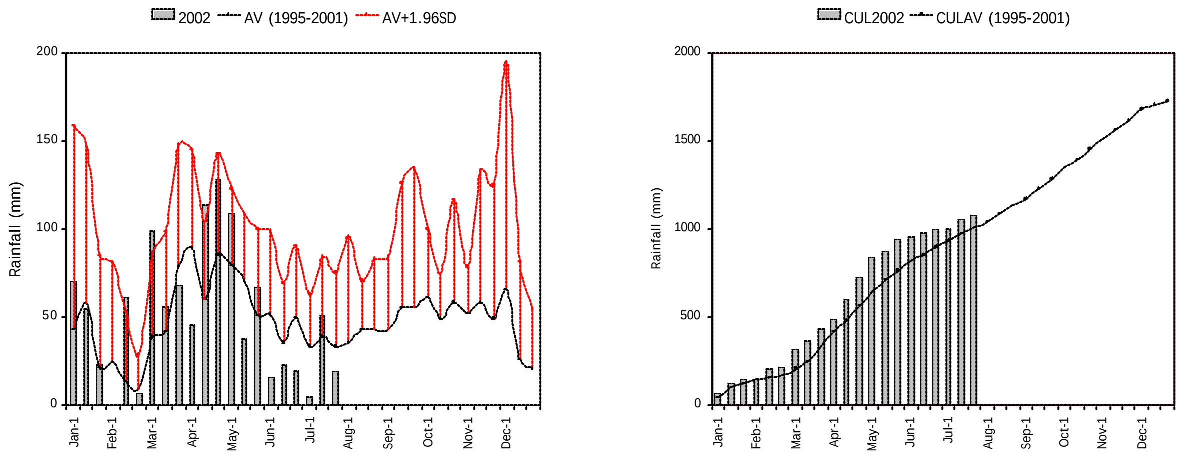
5.3.8. Nandi (a) normal time-series and (b) cumulative time-series.



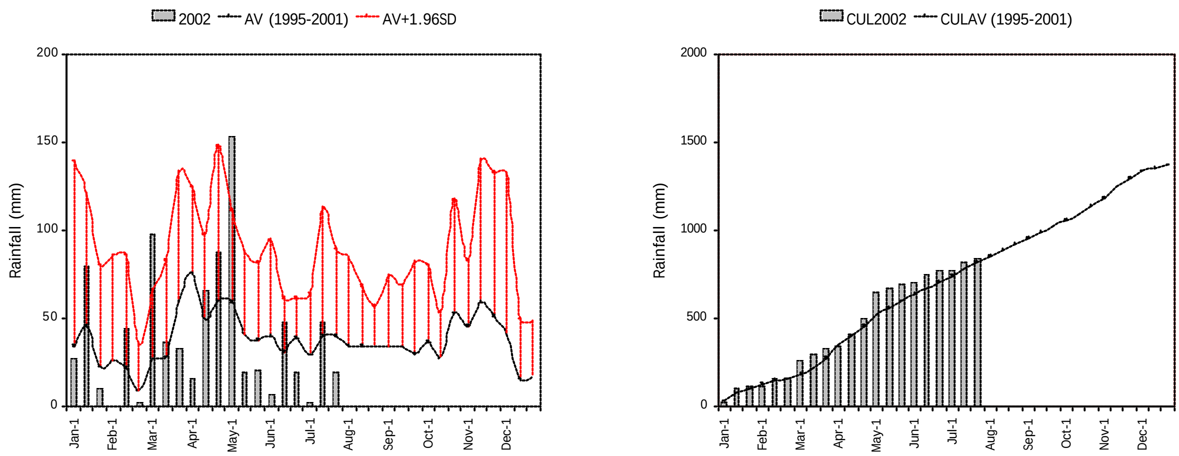
5.3.9. Butere (a) normal time-series and (b) cumulative time-series.



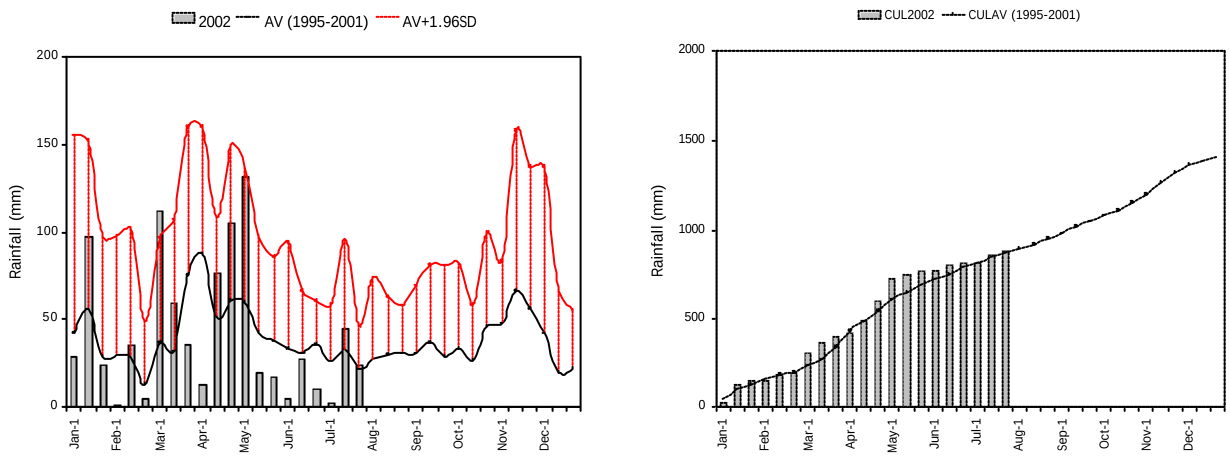
5.3.10. Vihiga (a) normal time-series and (b) cumulative time-series.



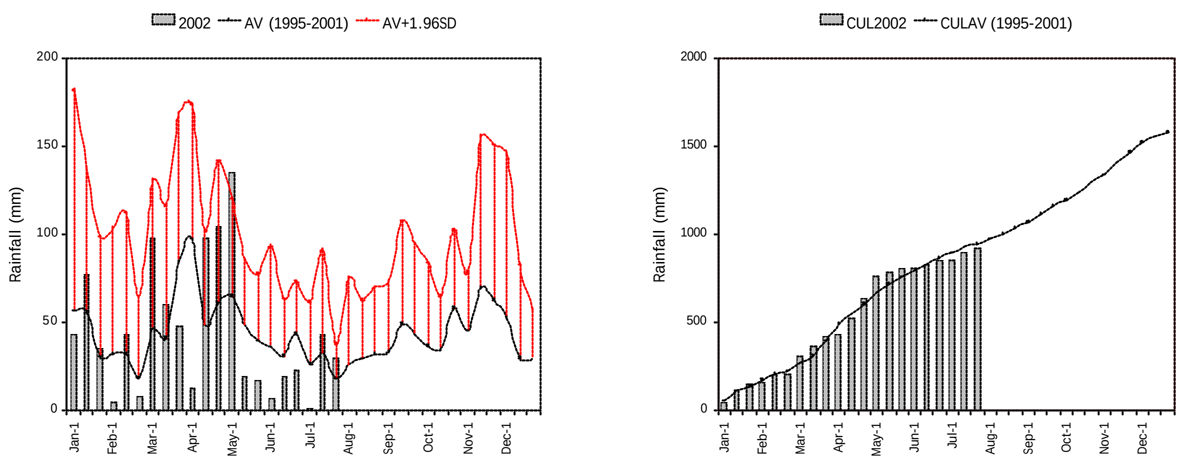
5.3.11. Kericho (a) normal time-series and (b) cumulative time-series.



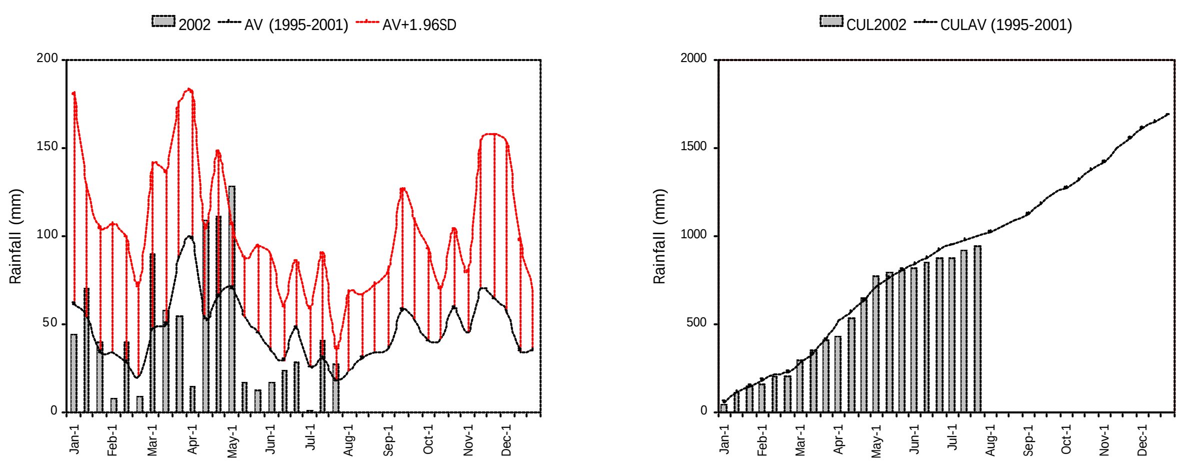
5.3.12. Buret (a) normal time-series and (b) cumulative time-series.



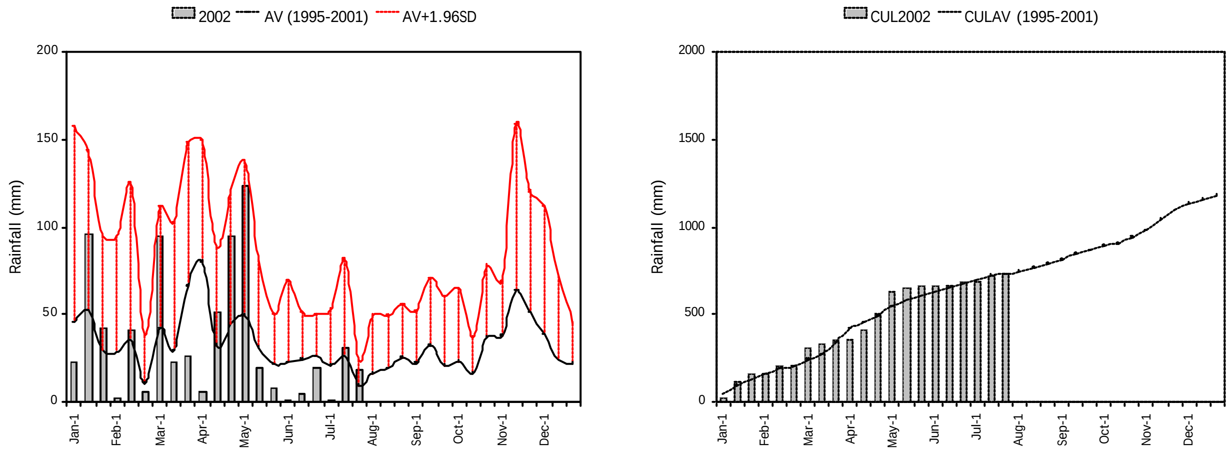
5.3.13. Kisii North (Nyamira) (a) normal time-series and (b) cumulative time-series.



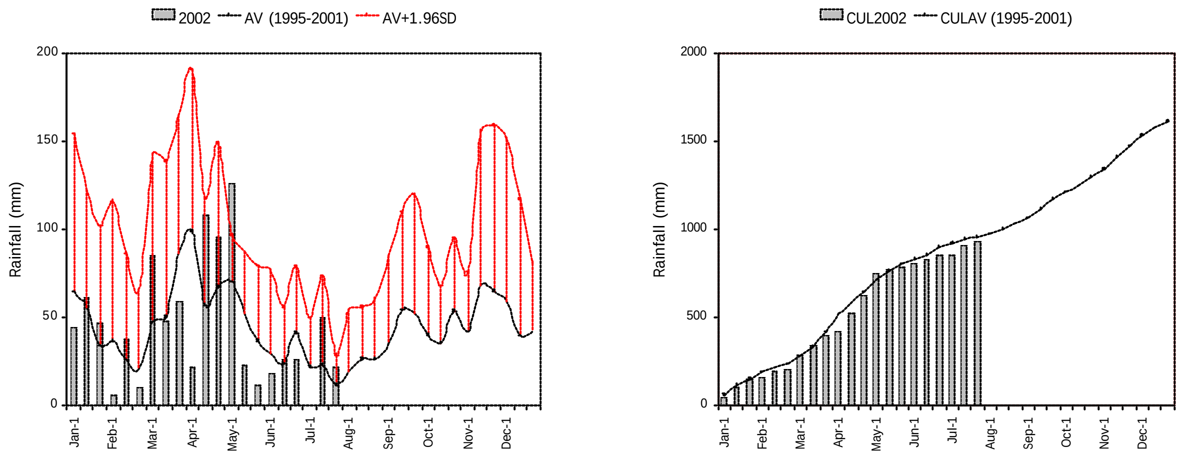
5.3.14. Kisii Central (a) normal time-series and (b) cumulative time-series.



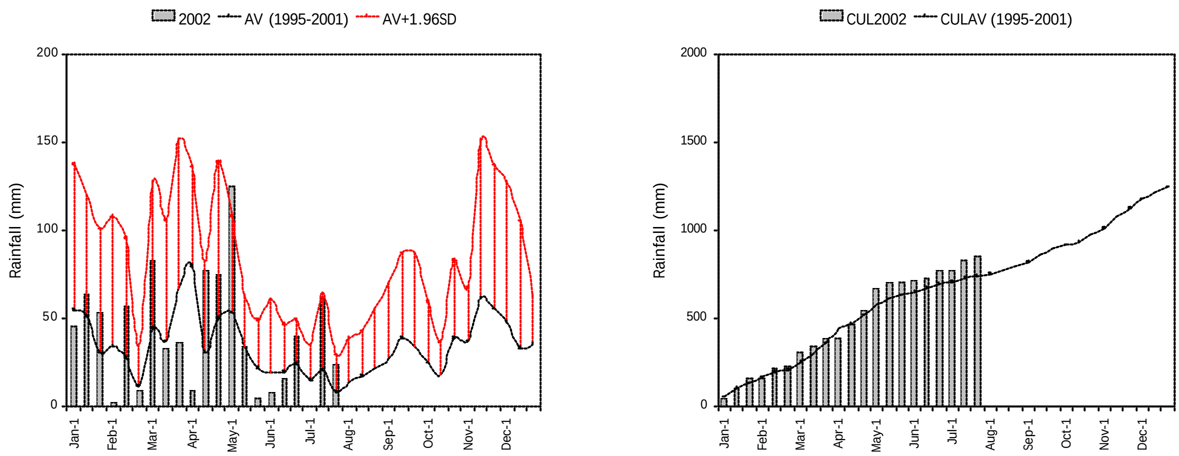
5.3.15. Bomet (a) normal time-series and (b) cumulative time-series.



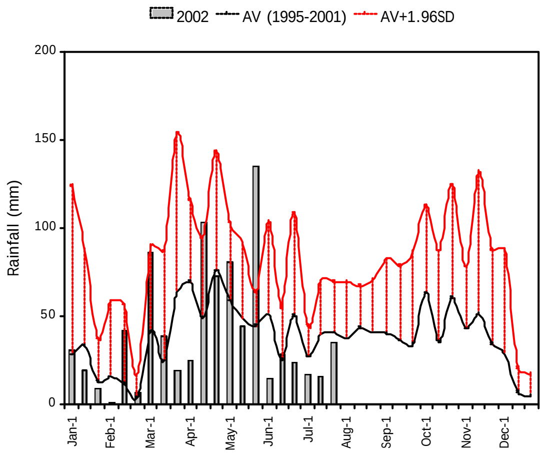
5.3.16. Gucha (a) normal time-series and (b) cumulative time-series.

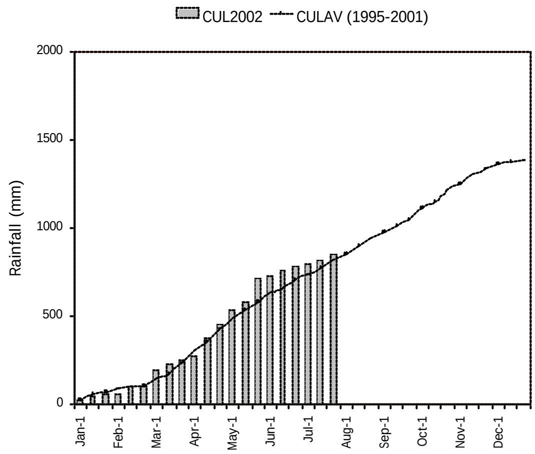


5.3.17. Trans Mara (a) normal time-series and (b) cumulative time-series.

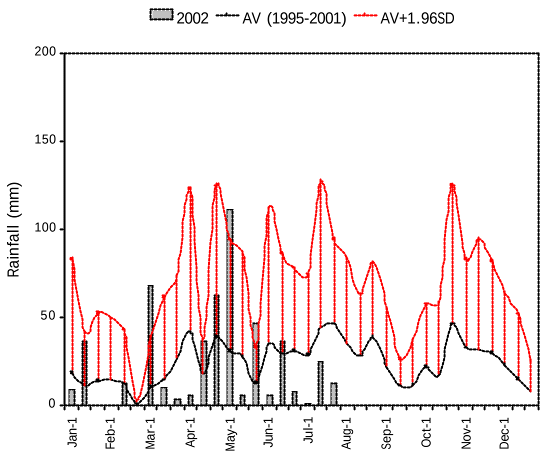


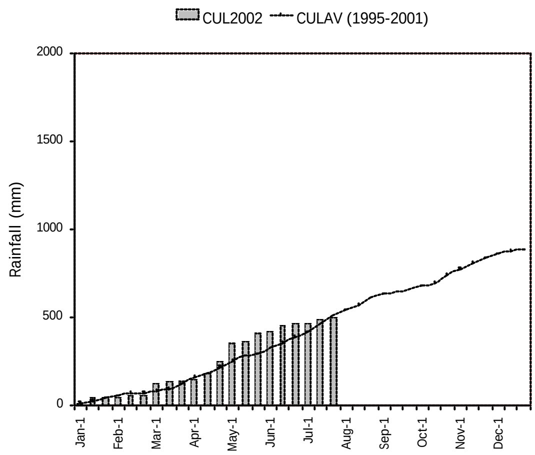
5.3.18. Mount Elgon (a) normal time-series and (b) cumulative time-series.



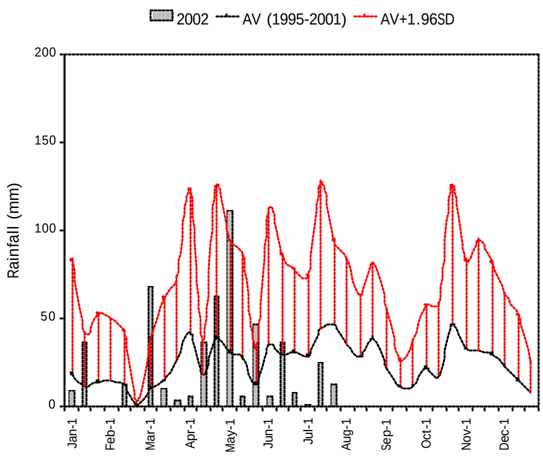


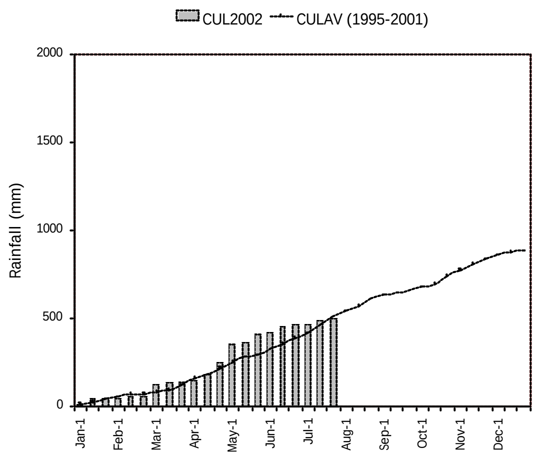
5.3.19. Koibatek (a) normal time-series and (b) cumulative time-series.





5.3.20. Baringo (a) normal time-series and (b) cumulative time-series.





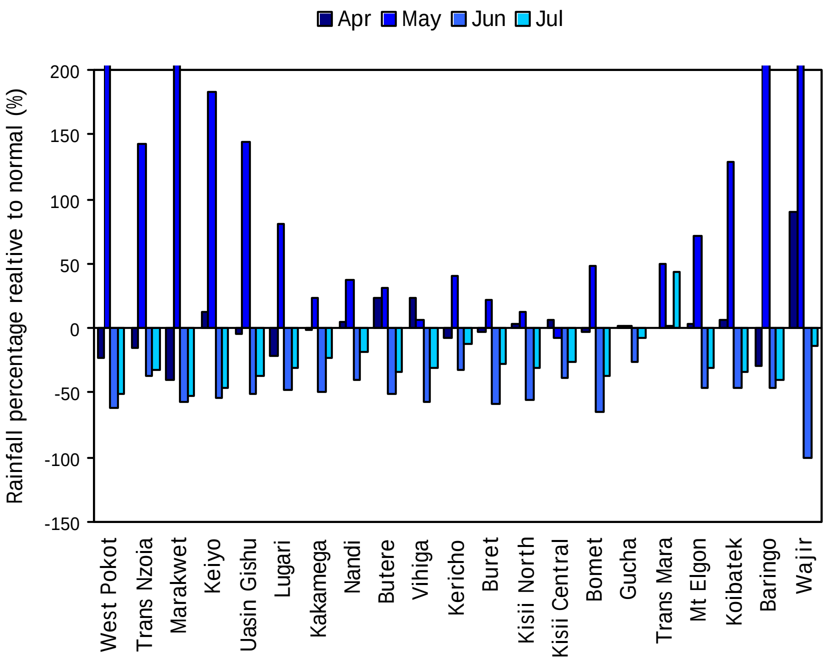
It can be seen (Figures 5.3.1 – 5.3.20) that during the 1995-2001 period the average rainfall patterns are consistent with the notion of a bimodal rainfall pattern in the western highlands with long rains from March to May and short rains from October to December (Cox *et al.* 1999; Hay *et al.* 2002). This pattern become clearer when dekadal totals were summed for each month but are not shown as it simply re-iterates what has been long known.

All districts had rainfall totals significantly in excess of normal in May and this was particularly evident in the more northern districts (See Figure 5.4.1). In the months of June and July, however, rainfall was significantly less so at the time of writing this report most districts were close to the average cumulative for July (Figures 5.3.1 – 5.3.20). The exception is Trans Mara where above average rainfalls were experienced in July.

5.4. The possible duration of the malaria resurgence in 2002

If malaria transmission was dependent only on rainfall we would expect malaria to be in excess of the normal seasonal upsurge in June and July (see Section 6) and for this effect to be more exaggerated in northern districts (See Figure 5.4.1). West Pokot, Trans Nzoia, Marakwet, Keiyo, Uasin Gishu, Koibatek and Baringo all received more than double their usual rainfall in May.

Figure 5.4.1. Rainfall for April to July expressed as the percentage total relative to the normal for the 1995 - 2001 period.



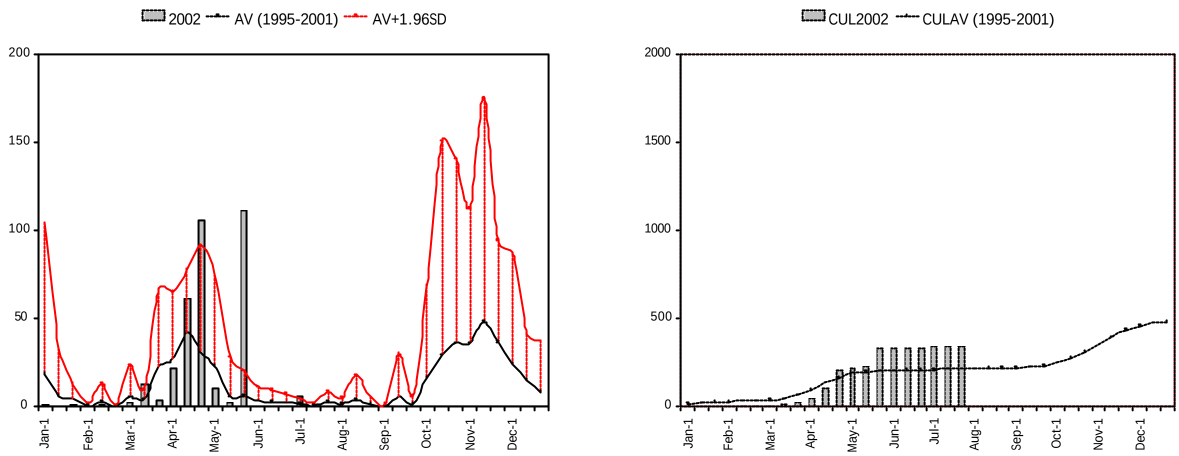
Note the West Pokot, Trans Nzoia, Marakwet and Baringo are off the scale with values of 482, 413 and 298% respectively. Rainfall information for August were not complete at the time of writing but were normal during the first 10 days (see Figure 5.2.1).

We should also expect the current resurgences to wane along with the normal seasonal pattern of disease in the region (Hay *et al.* 2002) (also see Section 6) but this opinion would change if significant rainfall was experienced in the region in August. Heavy rains in August would be less significant than rainfall excesses in the early parts of the year, however, as the synoptic trend for decreasing temperatures from July to December would act to restrict the development of the malaria parasite in the anophelene vectors (Hay *et al.* 2002). The exception would be a large excess rainfall in August in Trans Mara. This is because Trans Mara was the only district to have excess rainfall in July and is one of the most southerly, low lying and hence warmest of the highland districts. The malaria situation in this district should be monitored.

5.5. The hold of the highlands

It is also evident from the Figure 5.2.1. that the north east of Kenya experienced significantly higher rainfall than average in mid to late April and late May and as an example Wajir district was also included in Figure 5.4.2. The same rainfall plots as before are shown in Figure 5.5.1 for Wajir. Rainfall totals were 90% above normal in April and 250% above normal in May. This semi-arid district is very sensitive to excess rainfall events, as was demonstrated during the massive epidemic in 1998 (Allan *et al.* 1998; Brown *et al.* 1998; Snow *et al.* 1999), when a three month lag was observed between the peak in rainfall and the peak in malaria cases (Hay *et al.* 2001). In contrast to the highlands, however, the north east of Kenya is not generally on the local or international media radar. Such information, however, could be used as a prompt for the DoMC/MoH and relevant partners to check on the situation before it hits the Daily Nation. In addition, informal enquiries suggest that the malaria situation in this region may be deteriorating (*pers. comm.* Abdisalan M. Noor).

Figure 5.5.1. Wajir (a) normal time-series and (b) cumulative time-series.



5.6. The need for meteorological data for the western highlands

It was not considered necessary to purchase rainfall data for the western highland districts at considerable expense from the KMD since these RFE products of superior spatial coverage than point meteorological station records are available in the public domain (Hay and Lennon 1999). The influence of temperature has been largely ignored in this discussion, however, due to time-constraints. Temperature retrievals from satellite observations are very problematic (Hay 2000) and a it may be prudent to purchase monthly temperature data (monthly maximums, means and minimums) for 2002 to check the assumption that temperature will follow its usual seasonal decline and disrupt transmission. Historical temperature data for the 1997-2001 period would also allow the importance of the frosts in 2000 and the perceived warmer weather in 2002 to be evaluated. These factors were independently mentioned by several of the District Health Officers as responsible for low malaria in 2000 and 2001 (due to decimating the vector populations) and the significance of the epidemics in 2002 respectively (see Section 6).

5.7. The utility of forecasting and early warning during the 2002 malaria resurgence

The western highlands of Kenya experienced very exceptional rainfall events from March-May 2002. No seasonal climate forecast predicted this with the balance of probability in every case weighted on near-normal rainfall conditions. The present accuracy of such forecasts, therefore, severely compromises their utility for epidemiological applications and MEWS.

Public domain RFE information, however, provide regular and reliable indications of rainfall for the entire African continent that can be useful in early warning. Routine visual monitoring and plotting of current rainfall patterns against recent history will go a long way to improving preparedness in "true epidemic" areas as well as those prone to seasonal "resurgent outbreaks". Training to support this capacity in the DoMC and research to better define the seasonal complexity of transmission across Kenya (Hay *et al.* 1998; Hay *et al.* 1998) advocated.

Many will no doubt suggest that more sophisticated biological models are appropriate to parameterise explicitly the seasonal variation in malaria transmission potential in the western Kenyan highlands using a range of climate variables. I have no doubt such work would prove of great academic interest but am not clear on how such models could be run routinely for all at risk areas and that any warnings that they might generate would cause any different control actions to be taken over alerts based on rainfall anomalies only. As this added complexity would probably not lead to any different course of action it development is largely irrelevant for control purposes.

6. Surveillance: malaria trends from January to July 2002

6.1. Data access and retrieval

The Health Management Information System (HMIS) of Kenya, located in Afya House, receives reports on causes of out-patient (OP) morbidity through the "*District Out-Patient Morbidity Summary (MOH 719)*" from 4294 health facilities through the 69 districts of the country. A recent report has collated this information as annual summaries for the 1996-1999 period (HMIS 2001) and on-going efforts are entering the OP data for 2000 and 2001. These annual summaries of district reported malaria OP burdens are evaluated in more detail in Section 7. To derive malaria seasonality profiles for the 17 MoH defined "epidemic" prone districts we approached the HMIS to abstract for us the monthly data for these districts that were used to compile the report. The HMIS were enthusiastic and diligent in providing this information which was facilitated by its head Dr Arthur-Ogallo. The HMIS were also able to provide data for the 1996-2001 period for the 17 MoH defined "epidemic" prone districts for which we are exceedingly grateful.

We also visited health facilities in Kisii, Gucha, Nandi and Kericho to update data for the current resurgence to compliment in the most part data already archived by Eric C. Were, Health Record and Information Officer, DoMC-MoH. The facilities for which the data were collected are detailed in Table 6.1.1. It was generally possible to get only an overview of OP data as IP information and laboratory data usually remain uncollated during the malaria outbreak. In the rare number of facilities where these data could be collected, the results are also presented.

Table 6.1.1. Details of district and facility malariometric data collected.

Health facility	District	Code	OP	IP
Kisii all facilities	Kisii Central	KISII-OP	✓	
Kisii District Hospital	Kisii Central	KIS. DH-OP	✓	
Keumbu Health Centre	Kisii Central	KHD-OP	✓	
Iyabe Dispensary	Kisii Central	ID-OP	✓	
Itierio Mission Hospital	Kisii Central	IMH-OP/IP	✓	✓$_{bsc}$
Gucha all facilities	Gucha	GUCHA-OP	✓	
Nduro Health Centre	Gucha	NDU. HC-OP	✓	
Nyansakia Dispensary	Gucha	NYA. D-OP	✓	
Nymanche Health Centre	Gucha	NYM. HC-OP	✓	
Tabaka Mission Hospital	Gucha	TAB. MH-OP	✓	
Nandi all facilities	Nandi	NANDI-OP	✓	
Kapsabet District Hospital	Nandi	KAP. DH-OP/IP	✓	✓$_{bsc}$
St Joseph's Chepterit Mission Health Centre	Nandi	STJCMHC-OP	✓	
Kericho all facilities	Kericho	KERICHO-OP	✓	
Kericho District Hospital	Kericho	KER. DH-OP	✓	
Londiani District Hospital	Kericho	LON. DH-OP	✓	
Brooke Bond Tea Estate Hospital	Kericho	BBTE H-IP		✓$_{bsc}$

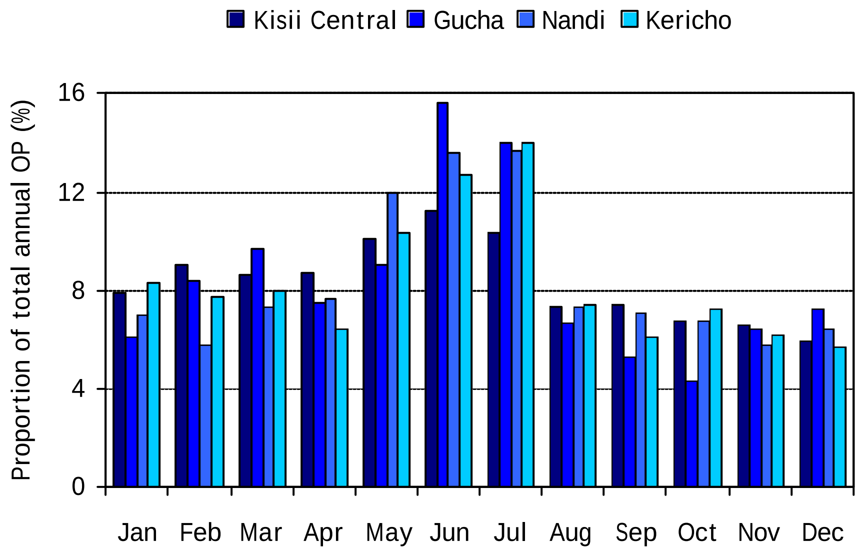
bsc = blood slide confirmed.

6.2. Malaria distribution in a normal seasonal: historical profiles

We must acknowledge the severe limitations in the reporting rate of the facilities per district within the HMIS data with an average of 39% of all expected reports submitted in 1996 and 34%, 36% and 40% in 1997, 1998 and 1999 respectively. These rates vary considerably between months and so were corrected to 100% reporting rate. Preliminary investigation of the monthly data has shown that the large facilities have the best reporting rates so our adjustment to 100% reporting rate ((OP malaria cases reported / reporting rate) x 100) will inflate the OP burden per district. Significant rates of unreported malaria and self-treatment (see Section 8) will tend to mitigate this effect, though to what extent is unknown. Given these caveats, however, we can establish a first approximation of the seasonal profiles per district (this Section) and with some further corrections compare treatment burdens between districts with some additional refinements (see Section 7).

Graphs of the proportion of annual treatment burden of malaria experienced in each month of an average year (1996-2001) are presented in Figure 6.2.1. We present information for Kisii Central, Gucha, Nandi and Kericho only, as they were the districts visited and the other districts showed a very similar seasonal pattern.

Figure 6.2.1. Proportion of annual malaria treatment burden experienced in each month in an average year (1996-2001) for Kisii Central, Gucha, Nandi and Kericho.



The seasonal resurgence in June and July is marked and is largely determined by the extent long-rains during March and May (see Section 5). On average these four districts experience one quarter (26%) of their annual malaria treatment burden in June and July. The seasonality in transmission of the Kenyan western highlands has long been realised (Hay *et al.* 1998; Hay *et al.* 1998; Hay *et al.* 2002; Hay *et al.* 2002). Control and intervention strategies and health-care budget allocations still largely ignore this seasonality, however. It does not take investment in a MEWS to conclude that better time-management of existing resources would be appropriate and this point is elaborated in Sections 9 and 10.

6.3. Evaluating the scale of the malaria resurgence in 2002

It is important to gauge the severity of current outbreak events against the past experience of the disease. Several “epidemic detection” methods have been suggested to quantify this and their performance in the acutely seasonal malaria transmission environments of the western highlands of Kenya has undergone a provisional evaluation (Hay *et al.* 2002). Most epidemic surveillance techniques aim to identify those points in a disease time-series that occur outside the 95% confidence intervals of a normal distribution determined from the history of cases at that location (in much the same way we determined if rainfall events were unusual in Section 5). Implicit in this approach is therefore is the detection of exceptional events in a normally distributed series of data. The importance of these statistical assumptions and about the surveillance data, and the fact that they are rarely met, is outlined in (Hay *et al.* 2002). It should be sufficient to state here, however, that malaria patterns rarely approximate a normal distribution, exhibit upward trends in the western highlands of Kenya, and resurge on an annual basis.

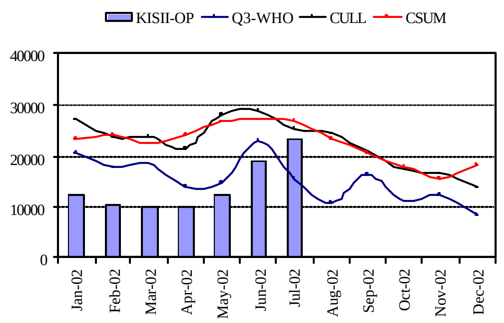
The W.H.O. have advocated the use a method that triggers an alert when current cases exceed the upper 3rd quartile or the “upper normal limit”, determined from five years of retrospective monthly case data (Nájera *et al.* 1998; W.H.O. 2001). For five years of observations, quartile 0 is the minimum, quartile 1 the second lowest, quartile 2 the median, quartile 3 the second highest and quartile 4 the maximum value of the series for any given month. If the current month’s cases exceeds quartile 3 an alarm is triggered. It is as simple as that. This method has been implemented for the detection of highland malaria epidemics in Ethiopia (Abose *et al.* 1999) and Uganda (Cox *et al.* 1999).

A method proposed by Cullen (Cullen *et al.* 1984) uses the previous five years of data (in which epidemic years are excluded; although it is not explained how) to construct an admissions profile for an average year. When applied here (see below) the epidemic years are not excluded. The alert threshold for each month is then determined as the mean plus two times the standard deviation (strictly the arithmetic mean plus 1.96 times the standard deviation should capture 95% of cases in normally distributed data (Kirkwood 1988)). This technique is reported to have been successfully applied to cases of *Plasmodium vivax* malaria in northern Thailand during the 1980s (Cullen *et al.* 1984). It has also been used for the surveillance of *P. falciparum* malaria in the Madagascan highlands (Albonico *et al.* 1999).

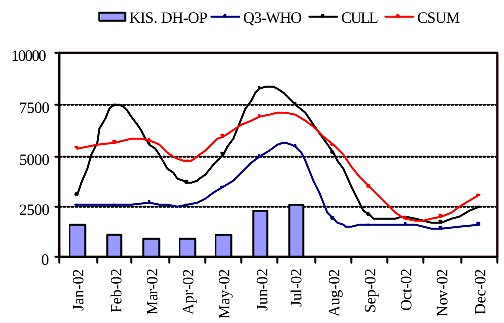
The Centres for Disease Control (CDC) has developed a further cumulative sum (C-SUM) method for epidemic detection. It is based on the construction of an average or base year by calculating the expected number of cases using the average for that month (and the previous and following month) during the past five years (C.D.C. 1986; Stroup *et al.* 1989; Kafadar and Stroup 1992). For example the expected number of cases for March 2002 would be derived from the average of February, March and April admissions from 1997-2001 inclusive (n = 15). A ratio of present:past cases is then usually presented as a current/past history graph (C.D.C. 1989) with values significantly greater than one representing disease increases or alerts. We have modified the C-SUM technique here to provide 95% confidence intervals for the expected cases so that it could be evaluated alongside the other techniques.

The W.H.O., Cullen and C-SUM methods are presented for each of the districts and health facilities for which data was collected in Figures 6.3.1 – 6.3.19. In each figure the blue bars are 2002 cases. If a bar exceeds the thin blue line it is a WHO defined epidemic, the black line a Cullen defined epidemic and the red line a C-SUM defined epidemic. The C-SUM technique is favoured due to its relatively high sensitivity and specificity coupled to an insensitivity to variation in the timing of the seasonal resurgence between years in a recent limited evaluation (Hay *et al.* 2002).

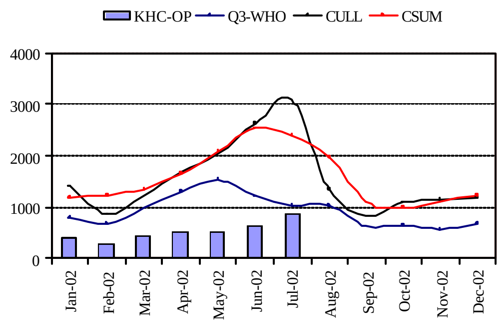
6.3.1. Kisii District OP



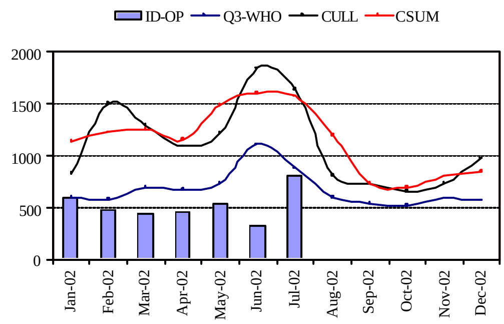
6.3.2. Kisii District Hospital OP



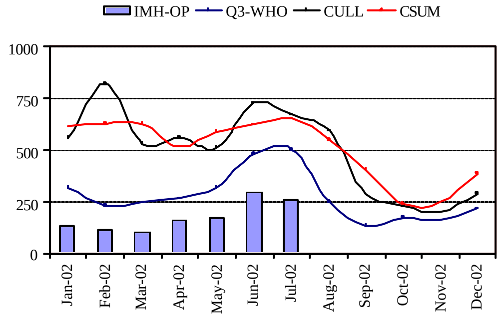
6.3.3. Keumbu Health Centre OP



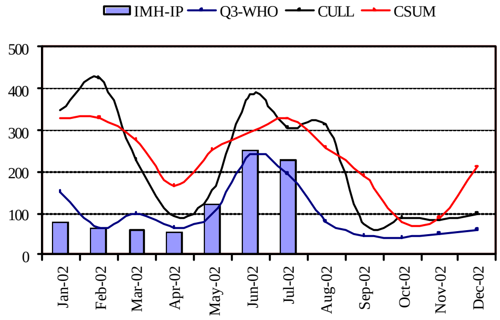
6.3.4. Iyabe Dispensary OP



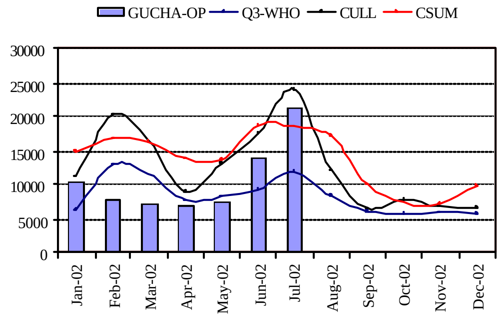
6.3.5. Itierio Mission Hospital OP



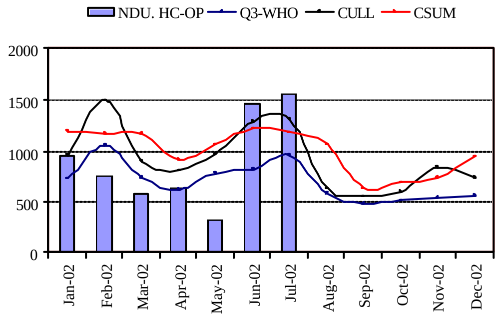
6.3.6. Itierio Mission Hospital IP



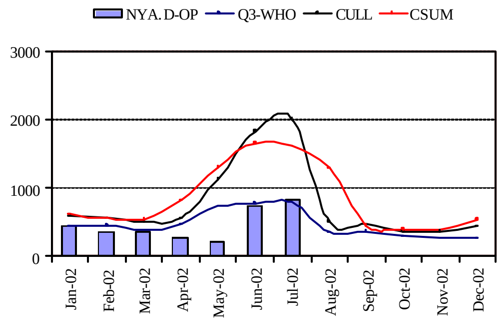
6.3.7. Gucha District OP



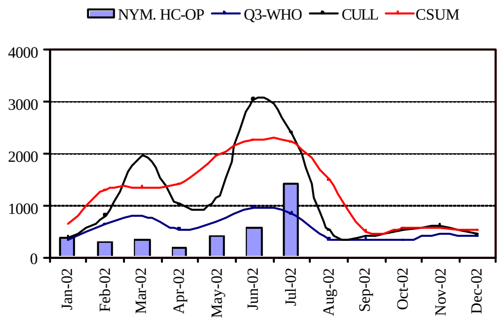
6.3.8. Nduro Health Centre OP



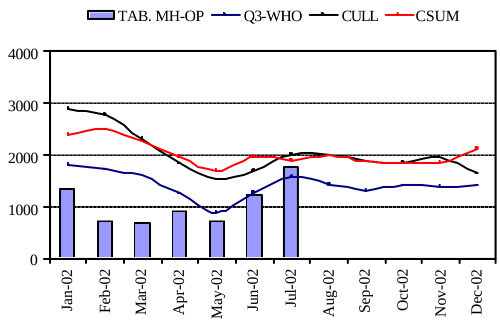
6.3.9. Nyansakia Dispensary OP



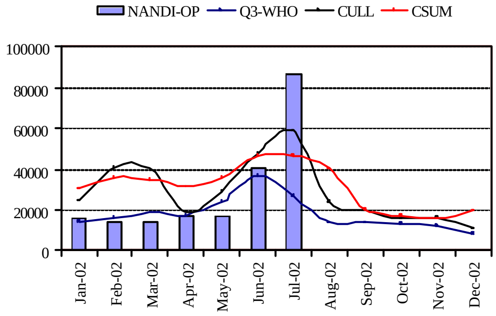
6.3.10. Nymanche Health Centre OP



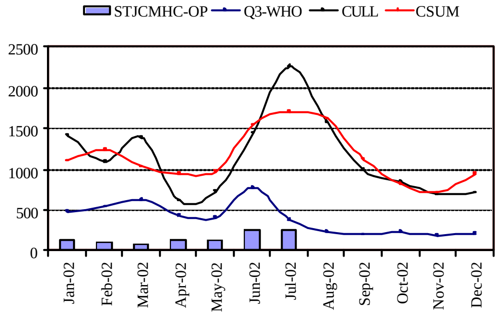
6.3.11. Tabaka Mission Hospital OP



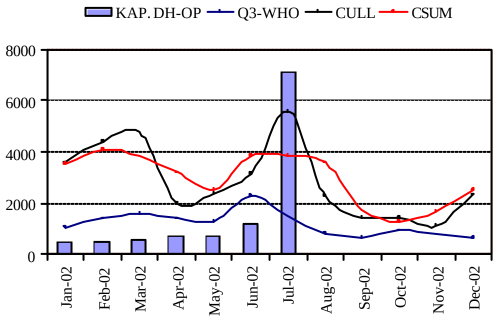
6.3.12. Nandi all facilities OP



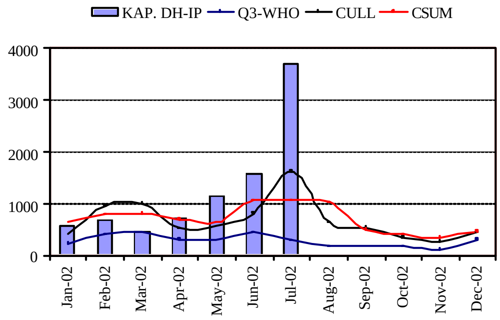
6.3.13. Chepterit Mission Health Centre OP



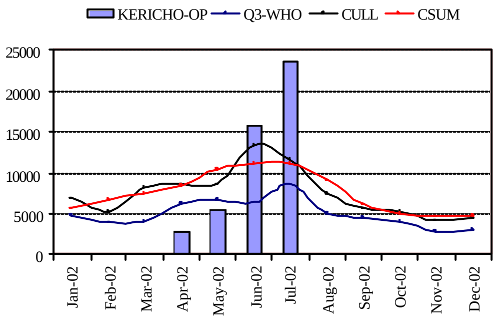
6.3.14. Kapsabet District Hospital OP



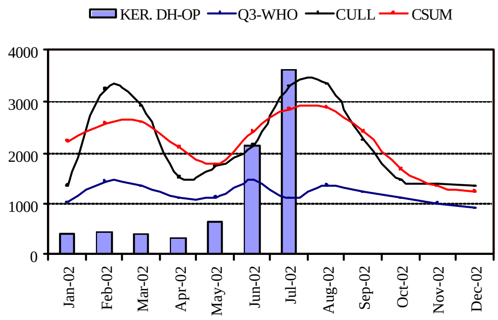
6.3.15. Kapsabet District Hospital IP



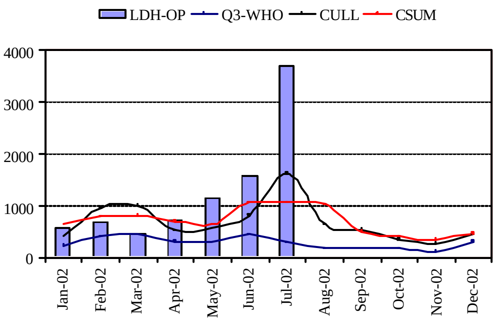
6.3.16. Kericho all facilities OP



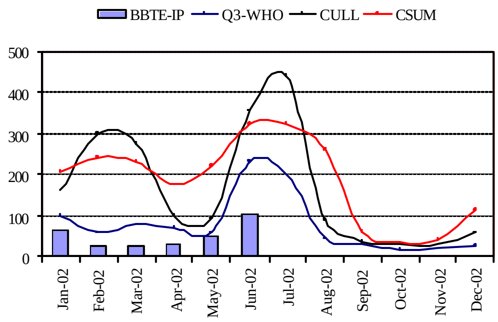
6.3.17. Kericho District Hospital OP



6.3.18. Londiani District Hospital OP



6.3.19. Brooke Bond Tea Estate Hospital IP



Kisii district is experiencing above average malaria in 2002 but only recorded epidemic conditions in July and only when using the WHO criteria (see Figure 6.3.1). In addition, OP records from four additional facilities in the district (see Figures 6.3.2. – 6.3.6) do not record epidemic conditions despite cost-sharing (part-payment for treatment) being suspended from the beginning of July which is assumed will have boosted OP attendances in July. Kisii had the least serious problem of the four districts we visited.

Gucha district has a more serious problem with epidemic conditions detected in June (WHO method only) and July (WHO and C-SUM methods) (see Figure 6.3.7). Moreover, OP records in a further four facilities detect epidemic in July although usually only with the WHO method (see Figures 6.3.8. – 6.3.11). Conditions worse than normal with epidemic alerts just exceeded in July.

Nandi district had epidemic conditions in June (WHO method only) and in July exceeded epidemic alert thresholds significantly (all methods) (see Figure 6.3.12). It is interesting to note an equivalent massive increase in OP evident in the GoK facility for which data were available (see Figure 6.3.14.) but not the private mission facility (see Figure 6.3.15.) where the suspension of cost-sharing would not have applied. Nandi was in the midst of a serious epidemic by July.

Kericho district had epidemic conditions in June (all methods) and July exceeded epidemic alert thresholds dramatically (all methods) (see Figure 6.3.16). It is again interesting to note an equivalent massive increase in OP evident in the GoK facilities for which data were available (see Figures 6.3.17. and 6.3.18.) but not the private Brooke Bond tea Estate facility (see Figure 6.3.19.) where the suspension of cost-sharing would not have had an influence since health-care is free to estate workers and their dependents. Kericho was in the midst of a serious epidemic by July and had probably the most serious problem among the districts visited. The contrast of no epidemic conditions in the privately cared for tea estate population (approximately 100,000 workers and dependents) is striking.

6.4. Prospects for early detection

None of these “early detection” techniques gave adequate prior warning of resurgences when using monthly OP data they simply document what has happened. There is some evidence that IP data (as we might expect) was more sensitive to developing epidemic conditions (see Figures 6.3.6. and 6.3.15.) though we do not have enough facilities to establish this conclusively. The level of district reporting at present, is such that we will only truly know the spatial and temporal extent of this epidemic when it is over. Future improvements would be to start routine weekly reporting in these districts from May to July. After three (ideally five) years of these efforts surveillance could be conducted on a weekly basis in these districts during the resurgent months as has been advocated elsewhere (Nájera *et al.* 1998). It would also be possible to establish a few sentinel facilities at the district level where IP records could be archived as ancillary data to central MoH requirements to increase the evidence base for action locally. Many district personnel were familiar with the WHO epidemic detection technique but few implemented it routinely. A round of preparedness advocacy in the early months of each year should also include motivating these essential medical records staff.

6.5. Existing surveillance and the rôle of the Disease Outbreak Management Unit

The statement from the Disease Outbreak Management Unit (DOMU) on the current outbreak is “*Following the long rains that have been received in most parts of the country, an upsurge of malaria cases have been noted in many parts of the Rift Valley and Nyanza provinces. Districts worst hit are; Kisii, Nyamira, Gucha, Kericho, Nandi, Buret, Bomet, Uasin Gishu, Trans Nzoia, Keiyo, Trans Mara and West Pokot. From the affected districts there are 205,993 reported outpatient malaria cases, 22,923 inpatients, 697 deaths and 16,447 positive laboratory confirmed cases.*”.

This is provided with a table with a breakdown of these numbers weekly for June and July 2002 by district. Though interesting there are very little ancillary information provided to allow as to assess the quality of these data (reporting rates, districts checked *etc.*). Importantly there is no attempt to compare these cases with historical burdens which is surprising as DOMU is administratively part of and physically adjacent to the HMIS in Afya house. As they stand these DOMU outputs serve only to document post-hoc the severity of the problem. They need to be integrated with HMIS archives to assess the severity of the problem in real time.

It is not known to what extent the activities of DOMU are complemented by the Integrated Disease Surveillance and Response (IDSR) unit of the Division of Vector Borne Diseases. Further review of the achievements versus responsibilities of these groups during the current epidemic would be prudent to maximise impact in future emergency situations.

6.6. The future malaria distribution in 2002

In Section 5.4 we suggested that the malaria emergency would probably start to abate in August if the usual seasonal decreases in temperature were manifested. Moreover, most facilities and all districts visited reported decreasing OP attendances in early August. August totals will be significant, however, as this month generally receives 8% of the annual malaria burden and this will be a high number of absolute cases in an "epidemic" year. It will be important to check that districts and facilities can still cope with the more routine malaria treatment burden after the excess demand in June and July.

7. Malaria treatment burden across Kenya

7.1. Malaria treatment burden across Kenya

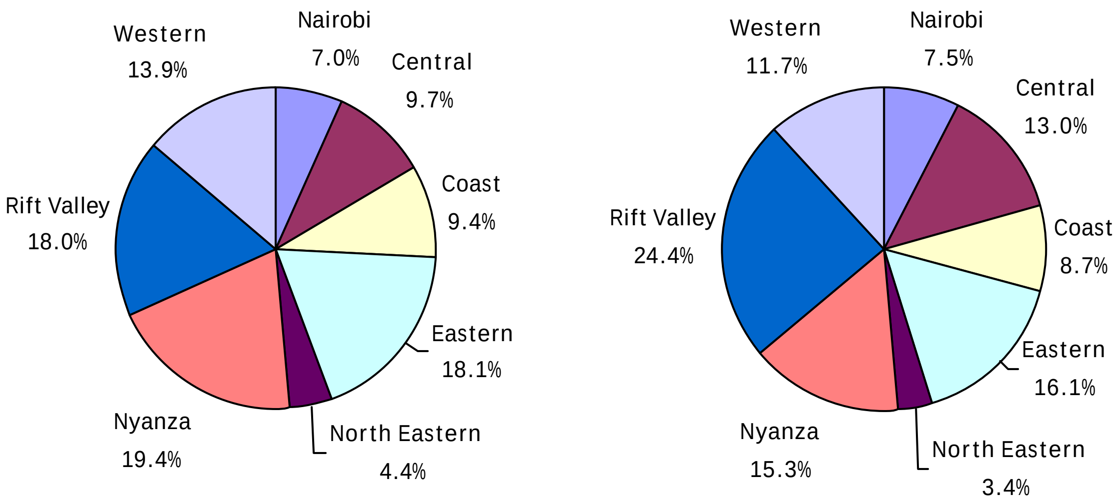
The findings of the HMIS report on causes of OP morbidity for the 1996-1999 period make stark reading (HMIS 2001). In Kenya malaria was the leading cause of OP hospital attendance in 1999, constituting 32% of all new cases reported, the leading cause of hospitalisation at 20% and the leading cause of death among all age groups. These figures did not change significantly in the three earlier years (1996-1998) evaluated in the report. Even with the caveats of reporting rates and diagnoses accuracy (see Section 6.2 and 8.5 respectively), the importance of malaria in the health-care burden of Kenya cannot be understated. The resources currently available for its control and management must be evaluated in this context.

7.2. Malaria treatment burden between provinces

The HMIS province data were adjusted as described in Section 6.2. In order to control for the number of facilities and population variation between areas a second adjustment was necessary. We first established the mean number of health facilities per person in Kenya (14.1 per 100,000) and adjusted the totals to this coverage ((OP malaria adjusted / health facilities per 100,000 in district) x 14.1). This allows control of variation in both facility number and population so that variation between districts and between years is more consistent without changing the overall level of malaria burden established in adjustment 1. It cannot be emphasised more strongly that these are relative estimates which serve only for comparison. A more detailed investigation of these data may be able to calibrate these estimates further (Omumbo *et al.* 1998; Snow *et al.* 1999) but this was not possible with the current constraints on time.

In order of malaria OP treatment burden the eight provinces of Kenya are as follows Nyanza, Rift Valley, Eastern, Western, Central, Coast, Nairobi, North Eastern (See Figure 7.2.1). These data refer to where malaria OP cases were treated and not necessarily where the infections were acquired. It should also be noted that there was very little variation in these treatment burden estimates between years, giving at least some confidence to comparisons of malaria OP distribution at the provincial scale.

Figure 7.2.1. The percentage of national malaria burden (left) and percentage of population (right) by province in Kenya for 1999.



If malaria transmission risk were equal across Kenya, population age structures were equivalent and people remained in their district to be treated, we would expect cases to be distributed in proportion to the population. The deviation between the percentage of observed malaria OP burden and percentage of population per district is therefore a crude indication of the increased or decreased risk at the provincial scale. In rank order Nyanza, Eastern, Western, North Eastern and the Coast province all manage more malaria OP per capita. Rift Valley, Central and Nairobi provinces manage less. These deviations are broadly in line with what we know of the transmission patterns across Kenya (Hay *et al.* 1998; Hay *et al.* 1998; Omumbo *et al.* 1998; Omumbo *et al.* 2002). Though most populous, the Rift Valley province, with 10 of the 17 MoH defined epidemic prone districts (4 are in Western and 3 in Nyanza), manages the least malaria OP cases per capita. To get the clearest idea of the contribution to the national malaria burden of the 17 MoH defined epidemic prone districts, however, it is necessary to move to the district level.

7.3. Malaria treatment burden between districts

The HMIS district data were adjusted as described in Sections 6.2. and 7.2. Average OP admissions were constructed for all reported data available during the 1996-1999 period. These data are ranked in order of decreasing percentage of annual malaria burden in the top histogram of Figure 7.3.1. and are shown above a similarly constructed histogram for the 1999 population. There are four districts for which no malaria OP treatment data was available between 1996-1999 which constitute 4% of Kenya's population and one of the highland districts, Butere.

When considered together the 17 MoH defined epidemic prone districts in the western highlands account for 27% of countywide malaria burden and contain 23% of the total population. It is clear from Figure 7.1, however, that the three Nyanza districts (Gucha, Kisii central and Kisii North (Nyamira)) contribute a third (9%) of this total while comprising only 5% of Kenya's population. This raises the question of whether these MoH defined districts are accurately defined and the wider utility of administrate boundaries to define broad areas of epidemiological similarity (Brooker *et al.* 2002). When ranked by a crude index of priority (simply the percentage of national malaria treatment burden – the percentage of national population) Central Kisii (2), Gucha (4), Nyamira (5), Trans Nzoia (8), Nandi (11), Lugari (16), Vihiga (19) are all relatively important and Kakamega (34), West Pokot (38), Uasin Gishu (43), Bomet (48), Kericho (50), Keiyo (51), Buret (52), Marakwet (54) are relatively unimportant. Note the brackets are the absolute rank among all 65 reported districts. By way of interest Bungoma (1) on the Kenya-Uganda birder ranks top and Nakuru (65) bottom.

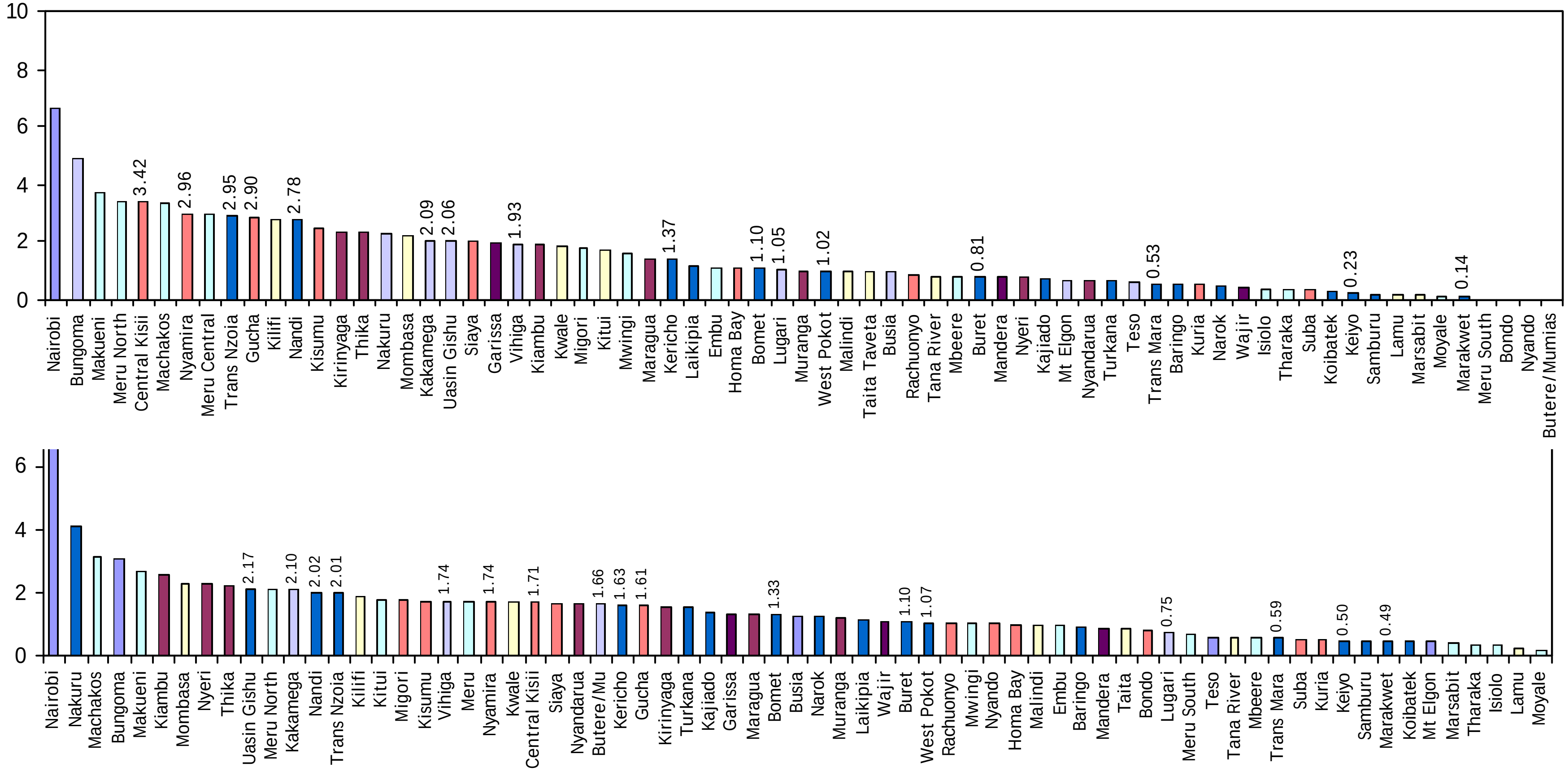
7.4. Malaria treatments burden *vs.* the distribution of health-care resources

These figures allow a very crude insight into the importance of the MoH defined epidemic prone districts of the western highlands. It is obvious that it is naïve to consider these districts as a cohesive epidemiological block. Again crudely, the lower altitude more western districts in the western highland belt tend to be more nationally important and the higher elevation more eastern districts relatively less.

Due to the time constraints some of the more rigorous checks necessary to check for biases in these data have not been completed. Given the large caveats (see section 6.4) these figures represent perhaps a first glimpse into priorities but need to be refined in an independent study (see Section 9).

Expenditure and from Gok and inter-sectoral partners should be guided primarily by the magnitude of the disease burden rather than the ability of a given districts to attract media attention. Ideally, it would be possible to relate the priority figures derived above to a full account of GoK-MoH and partner expenditure on malaria treatment and control by district to assess equity in the national health budget and look for routes to increasing the impact of existing spending. These data may be available at the Central Bureau of Statistics (CBS) and was still being pursued during the writing of this report.

Figure 7.3.1. The percentage of total OP malaria burden (%) in Kenya by district and the total population per district (millions) for 1999 is shown in the top and bottom histogram respectively. Both are in ranked in descending order. MoH defined highland districts have labels (e.g. Central Kisii has 3.42% of the national malaria treatment burden and 1.71% of the national population. Colour coding indicates province as in Figure 7.2.1. Note four districts recorded no malaria OP data between 1996-1999.



8. Determinants of the current crisis

As we have seen many factors have conspired to cause unusually severe "epidemic" conditions in the highlands of western Kenya in 2002. The rôle of climate is undeniable in providing permissive conditions for transmission but many other factors have contribute significantly to the establishment and onset of the epidemic. These are briefly reviewed.

8.1. Meteorology

Exceptional rainfall and its distribution between warm spells was highlighted by staff in most districts as the primary cause of the "epidemic". This conjecture is supported by examination of rainfall patterns, where in most districts exceptional totals were observed in April and May (see Section 5). The rôle of temperature conditions in the 2002 outbreak has currently not been evaluated.

8.2. Preparedness and population susceptibility

It was also reported in each of the districts that the relatively low levels of malaria in 2000 and 2001 led to a decrease vigilance and epidemic preparedness (less drug audits, less IRS (only 3.1% of homesteads were sprayed in Kisii and Gucha in 2001 (Anonymous 2002)), attention focussed on the recent measles eradication campaign *etc*.). Such conjecture is again supported by OP data with historically low levels in most districts in 2000 and 2001. These low levels will also have allowed the proportion of the population susceptible to malaria to have increased (Hay *et al.* 2000) making the population particularly vulnerable to increased transmission.

8.3. Drug resistance

There was considerable comment on perceived Sulfadoxine pyrimethamine (SP) treatment failures in all districts visited and this was also reflected in most of the UNICEF situation reports examined. The guesstimates of the District Medical Officers (DMOs) were in the order of 20-30% failure rates. The media has also raised a considerable amount of alarm over the use and efficacy of SP as first line treatment (Odhiambo 2002). SP and amodiaquine (AQ) are reported to be largely effective, however, in Kisii and Gucha with 93% and 100% acceptable clinical response (ACR) by day 14 of treatment, respectively (Anonymous 2002). The power of the media in influencing public perception should not be underestimated so it is with a matter of urgency that the current ACR for SP and AQ are re-evaluated in the highlands and the results articulated widely. At the time of writing up-to-date information on drug resistance in the western highlands were not available from http://www.eanmat.org and http://www.kmis.org due to a non-functioning web site and a non functioning data retrieval applet respectively. These obviously should be fixed, maintained and the information more widely disseminated on a routine basis.

8.4. Drug quality

The East African Network for Monitoring Antimalarial Treatment (EANMAT) also test the efficacy of "quality assured" SP and AQ products. Most drug access is from informal sector and brand ranges, costs and quality in this sector vary enormously. Abdinasir Amin (MPHG, KEMRI-WTCP) recently sampled wholesalers and retailers in Kisii district. Products performed very poorly with around 40% of SP and AQ branded products failing internationally accepted standards. This situation has also been raised as a problem by the media (Odhiambo 2002). The true situation should therefore be evaluated, documented, articulated and improved.

8.5. Case management and prescription practice

Case-management continues to be poor in most formal health facilities and at home. Recent monitoring and evaluation by MPHG-KEMRI-WTCP and the DoMC shows that in Kisii and Gucha less than 5% of febrile children access SP within 24 hours of disease onset (Zurovac *et al.* 2002). This must be improved. Furthermore, prescription practices were not always consistent with guidelines and there is massive over diagnosis of malaria, in some settings over 60% of malaria diagnoses are aparasitaemic (Zurovac *et al.* 2002). This will be exacerbated during "epidemics". Even when microscopy results were available 68% of slide negative patients were prescribed an anti-malarial. Better guidelines for clinicians on the use of blood slide microscopy are urgently needed. Note that anecdotes from UNICEF situation reports and direct consultations with health facility staff about donations of artemether from donors; chloroquine prescriptions to children in some facilities, SP and AQ combinations being prescribed elsewhere, also paint a rather haphazard picture of prescription practice.

8.6. Community perceptions, information and bed net use

A recent community survey in Kisii and Gucha shows that in the highland districts only 5.3% of the total population sleep under an net and that only 12.6% of these nets had been treated with an insecticide in the last 12 months (Anonymous 2002). There is massive room for improvement in ITN coverage and re-treatment rates.

Also worrying was that only 3.9% of homesteads in Kisii and Gucha had access to at least one type of information, education and communication (IEC) material on malaria. Common misconceptions on the causes of malaria infections are prevalent and articulated in the recent UNICEF situation reports including; congestion arising out of overpopulation, eating raw or roasted maize, being rained on, eating sugarcane, pollen from maize, eating jack fruit (*Ebirangwati*), getting sand from “Luoland” for building *etc*. There is obviously significant room for improvement in education.

8.7. Media perception and opinion forming

A brief review of the media interest in these epidemics was conducted. We sampled the online archives of the Daily Nation (URL: http://www.nationaudio.com/) from 01 May – 22 August 2002 inclusive. All articles that contained the words “malaria” and/or “epidemic” were read and those relating to the 2002 crisis in the Kenya western highlands archived. There were no articles in May or June, nineteen in July and two to-date in August.

A more thorough review is warranted but the articles start with a sensational reporting of deaths in affected districts (Kisii paradoxically received most attention while have the smallest problem among the districts we visited) with little attempt to calibrate this against “normal” conditions (Kiragu and Matoke 2002). All deaths are of course important but responsible management of malaria nationwide requires prioritising resources in space and time and hence requires a national and historical context. A series of articles then covers ideas on epidemic causation (Otieno 2002a), as well as, some severe critiques of national malaria control policy (Odhiambo 2002). Most articles provide very little evidence to support their various positions. Recriminations (Otieno and Matoke 2002) from the press and denials from the relevant ministries (Anonymous 2002b) quickly follow. Subsequently, media interest wanes rapidly as the epidemic subsides and the death toll abates. Conjecture about the effect of the 2002 El Niño, however, commences (Otieno 2002b).

This epidemic of reporting should be much more effectively managed and could be embraced as a cost-effective mechanism for getting important epidemiological information to a wide number of individuals countywide. Specific recommendations are presented in the following section.

8.8. Causation summary

These resurgences (Kisii/Gucha) and epidemics (Nandi/Kericho) follow a period of significantly enhanced rainfall in April and May. The development of epidemics subsequent to these favourable conditions is more to do with the current lack of capacity to implement national control guidelines (see 8.2-8.6), rather than any problem with the content or direction of the guidelines. It is not the guidelines but the budgets that need revision.

9. Recommendations

The following recommendations are a digest of the points raised throughout the body of this report and follow loosely the order in which they were discussed.

9.1. Operational

- The highlands of western Kenya demonstrate an epidemiology that is not unique and should continue to follow the MoH National Malaria Control strategy (guaranteeing people access to quick and effective treatment, ensuring the use of ITN and other vector control measures by the at risk communities and providing Intermittent Presumptive Treatment (IPT) to pregnant women) and epidemic preparedness and response guidelines (M.O.H 1999). The only refinement would be to concentrate central, provincial and particularly district level efforts at preparedness (IRS, net purchase and re-treatment advocacy, community mobilization and education, drug stock/efficacy/resistance audits, medical staff audits, retraining *etc.*) in the months of April and May BEFORE the predictable June and July resurgences.
- The only exception may be for proportionately more advocacy for IRS which one study has shown to be more cost effective than the distribution of nets in highland districts (Guyatt *et al.* 2002). UNICEF situation reports also indicate a surprising amount of community support for IRS. IRS has been shown to be most effective when vector populations are at seasonal lows, so these efforts should also be concentrated in April and May. Conversely, IRS has also been shown to be largely ineffective when an epidemic has already developed.
- Routine suspension of cost sharing for malaria treatment in May-June-July may encourage more prompt treatment of disease as a mid-way to mass drug administration (MDA). MDA has been shown to have been spectacularly successful in the Kericho tea estates in the 1940s (Strangeways-Dixon 1950) and in Nandi district in the 1950s (Roberts 1964a; Roberts 1964b; Roberts 1964c). Incidentally, the pyrimethamine based MDA in Nandi district was sponsored by UNICEF back in 1951.
- Leave should not be possible for key medical and administrative staff at the relevant districts, provinces and central levels in the months of June and July.
- The respective rôles of the DoMC, HMIS, DOMU and IDSR in this malaria emergency remain unclear. Increased transparency on responsibility and accountability of individuals in these administrative groups would be desirable for rapid identification of key personnel in future emergencies.
- The media play a very important role in shaping public opinion and thus ultimately influence control policy. A more comprehensive review of their rôle in this and previous emergencies would be extremely valuable to qualitatively determine their importance. Providing timely press releases on the evidence accumulating during an emergency would facilitate more control over the information being disseminated and be a cost-effective way to get disseminate information to the affected communities. A epidemiologist spokesperson, trained in media relations, should coordinate these messages and would be ideally located at DoMC or DOMU.
- A press release in relation to the El Niño phenomenon (that has captured the hearts an minds of so many) and the consequent risks of malaria epidemics in the latter part of 2002 and the beginning of 2003 should also be considered. Other areas in which good information are lacking in the public-domain are the basis of the national malaria control strategy, disease burden and prioritisation issues across the country and anti-malarial drug resistance and quality issues. This should also be rectified.
- Seasonal forecasting at the present time is not of sufficient temporal or spatial accuracy to provide valuable information. Monitoring seasonal forecast on-line is trivial, however, so should probably be evaluated periodically, if only to be able to respond to the media thirst for El Niño (see above).
- Monitoring rainfall may give some indication of particularly abnormal events and this could easily be done centrally by a locally trained epidemiologist at the DoMC. A warning would

simple magnify the a routine mobilisation organised in April and May at the district level. Most districts received significantly below average rainfall in June, July and early August so we should expect these epidemics to gradually abate. Trans Mara was the only significant exception and should continue to be monitored. The exceptional rainfall in Wajir also requires that this region should be inspected.

- Intensive investment in improving surveillance is unnecessary when the burden of disease is usually focussed in June and July. Advocating the importance of the existing records staff and improving their ability to implement simple epidemic detection techniques at the district level is justified, however, since the staff are already present, although are currently poorly supported and motivated.
- A routine move to weekly reporting in the months of May-June-July would enhance the ability at early detection of resurgences and epidemics in the future years.
- One substantial effort to collect all OP data for all districts for the 1996-2001 period archived at the HMIS would be highly worthwhile. This could act as a central reference database against which all new epidemics could be tested to rapidly evaluate their significance in future emergencies. The database should represent all districts not just those in the western highlands. This database would also help facilitate an evidence-based approach to distributing efforts and recourses equitably to the population of Kenya. Once completed the database could be easily and rapidly decentralised to any relevant location and organisation with computing facilities.
- The bottom line, however, is that a correctly managed health service, good community education and mobilisation, efficient distribution of ITNs and timely IRS would make these communities significantly less vulnerable to these resurgences. Any mechanism of early detection, early warning or surveillance is futile in the absence of such companion efforts. It is telling to contrast the experience of the Brooke Bond Tea Estate Central Hospital (Figure 6.3.19.) where prompt and appropriate treatment have essentially stopped the epidemic in its catchment with that of the wider population of Kericho district that have suffered massive morbidity (and probably mortality) in June and July of this year (Figure 6.3.16.).

9.2. Research

- More accurate malaria seasonality maps than are currently available (Hay *et al.* 1998; Hay *et al.* 1998) should be generated for which the timings of district interventions could be fine-tuned. This should be attempted nation-wide and integrated with current efforts to map parasite rate across the region. The abstraction of the HMIS data suggested in Section 9.1. would also provide the "training" data for this mapping exercise.
- If epidemic detection techniques continue to be advocated for resurgent outbreak environments they require further evaluation. Seasonality, secular trends and statistical assumptions all favour the detection of an epidemic. These difficulties are rarely articulated and should be the subject of a more rigorous modelling exercise to quantify their impact.
- El Niño and it effects on Kenyan rainfall patterns should be investigated further as a basis for educating the media and wider population on its importance (or lack off) in the generation of malaria epidemics in Kenya and its wider significance in public health.
- The Gates funded Highland Malaria Project (HIMAL), of which the consultant is a co-investigator, will be conducting an intensive study in Nandi and Gucha districts (Kenya) and Kabale and Rukungiri districts (Uganda) to support local epidemic preparedness in these areas. It will provide an answer to the more research orientated question of to what extent is MEWS possible when meteorological, entomological, parasitological and clinical data collection are comprehensive and rigorous. It will also incorporate a thorough economic evaluation component to gauge issues of sustainability and appropriateness in the longer term. It will be possible to evaluate more formally at what point increased sophistication trades off against increased information for control. Our best guess at present is the simpler the better.

10. Conclusions and summary

The highlands of western Kenya experience mesoendemic malaria transmission with acute seasonal variation so that 25% of the annual malaria burden is usually focussed in the months of June and July. Exceptional rainfall conditions coupled with a lack of epidemic preparedness in the districts lead to resurgent outbreaks in Kisii and Gucha and epidemics in Nandi and Kericho in June and July 2002. Given such emergency conditions, the reaction of GoK, UNICEF and partners was largely justified. The state of surveillance, however, is such that the real scale and extent of the 2002 "epidemic" will only be known retrospectively.

Inter-sectoral preparedness could have been better. Seasonal forecasts were wrong and are hence not useful in the short or medium-term. Rainfall anomalies for early warning were largely reliable, however, and central training at the DoMC for their future use and monitoring is advocated. All current indications (meteorological and epidemiological) were that these epidemics will naturally abate during August. Trans Mara was the exception. The current weak El Niño conditions, relative to 1998, are also not considered to be a substantial public-health threat but prudence recommends they should be monitored. Surveillance on monthly OP data was found to be an insensitive detection tool and the routine introduction of weekly recording in May, June and July suggested. Very simple methods at district and central levels could assist substantially in preparedness, for all districts in Kenya, based on the impressive data archive of the HMIS. There tools would allow GoK, UNICEF and partners to respond on the basis of evidence in future malaria emergencies. A rubric for completing this database is suggested.

The media played a prominent role in shaping public and political opinion during this "epidemic". They should be embraced in the future as a mechanism to disseminate useful information to communities in the midst of emergencies. As such significant efforts should be made to enlighten key health reporter in Kenya through a trained liaison person within DoMC and/or DOMU. Issues of disease burden, drug resistance and quality and the public-health significance of the El Niño are all areas of particularly weak reporting.

Highland malaria prevention and control is not a special case for the MoH with may of the contributory factors to epidemic being shared with the rest of Kenya. There is little access to preventative measures. Case-management at home is often delayed and access to effective first and second line drugs in informal sector compromised by poor quality products. Case-management in the formal sector continues to be poor and drug supply to this sector is erratic. With the possible exception of IRS the highlands are no different for the general desperate state of malaria control in Kenya. Further work on the equity of healthcare provision across Kenya is urgently needed to correctly prioritise those resources available for malaria intervention and control within and beyond the highlands. In essence, it is not control guidelines or preparedness plans that need revision but the budget allocations with which they are expected to be implemented.

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Finally, apologies to anyone I may have inadvertently missed and any mistakes left in this report are of course my own.

Annex 1. Suggested report distribution

It is requested that the following individuals, many of whom who helped with obtaining data for this report, be sent copies of this report in addition to the relevant individuals at UNICEF.

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Annex 2. Glossary

ACR	Acceptable Clinical Response
ADDS	African Data Dissemination Service
AMREF	African Medical and Research Foundation
AQ	Amodiaquine
CQ	Chloroquine
CSUM	Cumulative Sum
DDT	Dichloro-Diphenyl-Trichloroethane
DoMC	Division of Malaria Control
DOMU	Disease Outbreak Management Unit
DMO	District Medical Officer
EANMAT	East African Network for Monitoring Antimalarial Treatment
ENSO	El Niño Southern Oscillation
GCMs	General Circulation Models
GHARCOF	Greater Horn of Africa Climate Forum
GIS	Geographic Information System
GoK	Government of Kenya
HMIS	Health Management Information System
HIMAL	Highland Malaria Project
IEC	Information, Education and Communication
IDSR	Integrated Disease Surveillance and Response
IP	In Patient
IPT	Intermittent Presumptive Treatment
IRS	Insecticide Residual Spraying
ITN	Insecticide Treated Net
KCO	Kenya Country Office
KEMRI	Kenyan Medical Research Institute
KMD	Kenya Meteorological Department
MDA	Mass Drug Administration
MEWS	Malaria Early Warning System
MSF-F	Médecins Sans Frontières – France
MoH	Ministry of Health
MPHG	Malaria Public Health Group
NOAA	National Oceanic and Atmospheric Administration
OP	Out Patient
PR	Parasite Rate
RFE	Rainfall Estimate
SST	Sea Surface Temperature

SP	Sulfadoxine Pyrimethamine
RBM	Roll Back Malaria
UNICEF	United Nations Children Fund
URL	Universal Resource Locator
WFP	World Food Programme
WHO	World Health Organization
WTCP	Wellcome Trust Collaborative Programme

Annex 3. Consultancy timetable

Thursday 01 Aug. 2002. Travel day.	Travel from Oxford to Nairobi.
Friday 02 Aug. 2002. Day 1.	Orientation meetings at UNICEF and KEMRI-WTCP.
Saturday 03 Aug. 2002. Day 2.	Reading UNICEF situation reports and supporting literature. Prepare draft outline of report in response to ToRs. Preparation of ADDS rainfall estimate data for all districts. Collation of 1996-1999 OP malaria data from HMIS report.
Sunday 04 Aug. 2002. Day 3.	Write report scope and introduction, define structure. Further co-ordination meeting with UNICEF staff (Drs Melanie Renshaw, Catherine Solomon and Iyabode Olusanmi) to refine the aim and scope of the work plan.
Monday 05 Aug. 2002. Day 4.	Meeting with Dr Sam Ochola head of DoMC-MoH. Coordinate with Eric C. Were, Health Records and Information Officer, DoMC and collation archived malaria data. Prioritise highland districts to visit on the basis of amount of recent historical information available. Meeting with Dr Arthur-Ogara, HMIS to arrange retrospective time-series data for 1996-1999 from 17 DoMC epidemic prone districts and the three others of concern. Finish rainfall data retrievals and preparation of that report chapter.
Tuesday 06 Aug. 2002. Day 5.	Visit UNICEF to collect badge, advance and begin arranging travel details.
Wednesday 07 Aug. 2002. Day 6.	Visit the HMIS to organise data retrieval. Design rubric for data collection and initial processing while in field and explain to Mohammed Noor.
Thursday 08 Aug. 2002. Day 7.	Further preparations for field visit and collating existing information from available literature with respect to seasonal climate forecasting and the El Niño. Write this chapter of the report.
Friday 09 Aug. 2002. Day 8.	Liaison with UNICEF and leave for districts; Gucha, Kisii, Kericho and Nandi and overnight in Kericho.
Saturday 10 Aug. 2002. Day 9.	Visit Kisii district Medical Records and Information Officer to update data for all Kisii district OP (1997-2002) and further OP information for Kisii District Hospital, Keumbu Health Centre, Iyabe Dispensary and Itierio Mission Hospital. Visit Itierio Mission Hospital for slide confirmed in patient data. Visit Gucha District Hospital to arrange a meeting on Monday.
Sunday 11 Aug. 2002. Day 10.	Analyses of Kisii data and Kenya wide HMIS burden of OP malaria treatment by Province and District.
Monday 12 Aug. 2002. Day 11.	Visit Gucha District Hospital to collect data for all recorded Gucha district OP (1997-2002), as well as, OP information from Nduro Health Centre, Nyansakia Dispensary, Nymanche Health Centre and Tabaka Mission Hospital. Travel to Kapsabet.

Tuesday 13 Aug. 2002. Day 12.	Visit Kapsabet District Hospital data and abstract data for all reported OP of Kapsabet District (1997-2002), Kapkolei Dispensary, Kapsabet District Hospital, Mosoriot Rural Health Training Centre and St Joseph's Chepterit Mission Health Centre. Move to Kericho. Visit Kericho district MoH and Brooke Bond Tea Estate hospital to arrange for Wednesday morning visits.
Wednesday 14 Aug. 2002. Day 13.	Collate various Kericho data all district OP, OP data for Kericho District Hospital and the Brooke Bond Tea Estate (BBTE) Central Hospital. Return from western highlands to Nairobi.
Thursday 15 Aug. 2002. Day 14.	Presentations and briefings to UNICEF to communicate report findings and finish various administrative details.
Friday 16 Aug. 2002. Day 15.	Submit draft report and return to Oxford to complete report.
Friday 23 Aug. 2002. Day 22.	Submit final report.